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# Scientific Programme Abstracts

## Monday 21 May

### Workshop

#### **Scattered Radiation: do you know its contribution to dose in “low dose” examinations?**

##### **Invited Review**

**Scattered radiation: do you know its contribution to dose in “low dose” examinations?**

A Eyden and C Jeffery

*Canterbury Christ Church University College, Canterbury CT1 1QU, UK*

### Refresher Course

#### **Renovascular Hypertension**

##### **Invited Review**

**Role of captopril scintigraphy in screening and diagnosis**

A J W Hillson

*Department of Medical Physics, Royal Free Hospital, Pond Street, London NW2 2QG, UK*

##### **Invited Review**

**Role of CT angiography**

J Brink

*Department of Diagnostic Radiology, Yale University, 333 Cedar Street 2-332SP, New Haven, CT 06520, USA*

##### **Invited Review**

**Feasibility of screening for renal artery stenosis with MR angiography**

J F Meaney

*Department of Radiology, Leeds General Infirmary, Great George Street, Leeds LS1 3EX, UK*

##### **Invited Review**

**Angioplasty and stenting**

J F Reidy

*Department of Radiology, Guy's and St Thomas' NHS Trust, St Thomas' Street, London SE1 9RT, UK*

### Refresher Course

#### **Statistics for Ordinary Mortals**

##### **Invited Review**

**Cancer imaging: the significance of results**

R Reznek

*Academic Department of Radiology, St Bartholomew's Hospital, Dominion House, 59 St Bartholomew's Close, London EC1A 7ED, UK*

##### **Invited Review**

**Upsetting the statistical referee**

J M Bland

*Public Health Services, St George's Hospital Medical School, Cranmer Terrace, London SW17 0RE, UK*

### Refresher Course

#### **Common Paediatric Problems**

##### **Invited Review**

**Irritable hip**

L Berman

*Department of Radiology, Addenbrooke's Hospital NHS Trust, Hills Road, Cambridge CB2 2QQ, UK*

##### **Invited Review**

**Epilepsy in childhood**

W K Chong

*Great Ormond Street Hospital, Great Ormond Street, London WC1N 3JH, UK*

##### **Invited Review**

**Paediatric abdominal emergencies**

J Somers

*Department of Radiology, Nottingham City Hospital, Hucknall Road, Nottingham NG5 1PB, UK*

### Refresher Course

#### **Aspects of Lung Cancer Imaging**

##### **Invited Review**

**CT and MR staging**

P Taylor

*Manchester Royal Infirmary, Oxford Road, Manchester M13 9WL, UK*

##### **Invited Review**

**Percutaneous biopsy**

F V Gleeson

*Department of Radiology, Churchill Hospital, Old Road, Headington, Oxford OX3 7LJ, UK*

##### **Invited Review**

**PET**

E Patz

*Department of Radiology, Box 3808, Duke University Medical Centre, Durham, NC 27710, USA*

### Refresher Course

#### **Mechanisms, Signs and Symptoms of Trauma and the Implications for Imaging**

##### **Invited Review**

**Mechanisms, signs and symptoms of trauma and the implication for imaging**

B Cotton

*Department of Diagnostic Imaging, Alexander Wing, Royal London Hospital, London E1 1BB, UK*

### IT

#### **From PACS to EPR**

##### **Invited Review**

**Electronic health records, requests and reports: how do they fit?**

A Nowlan

*NHS IA, Aqueous II, Waterlinks, Aston Cross, Birmingham B6 5RQ, UK*

##### **Invited Review**

**Implications of PACS with EPR**

H U Lemke

*CARS 2001, Institute for Technical Information, Technical University Berlin, Franklinstrasse 28/29, Germany*

**Beyond RIS and PACS: IT solutions for total practice integration**

G Dombrowe and G Lewis

*Medical Engineering, Siemens plc, Bracknell, Berkshire RG12 8FZ, UK*

Over recent years there has been impressive progress in the adoption of Radiology Information Systems and, to a lesser extent, departmental and hospital-wide PACS systems. What has generally not been achieved, however, is the creation of fully integrated systems that support all aspects of departmental workflow. This paper describes an innovative approach, which achieves total integration of all components—imaging equipment, communication devices, workstations and the Web—leading to better patient management and improved productivity.

**Implementation of a cancer centre wide oncology information system to support and inform patient care**

D Guthrie, M Roberts and W V Steele

*Derby Cancer Centre, SDAH NHS Trust—DRI site, Derby DE1 2QY, UK*

The Derby Cancer Centre uses Clinical Oncology MAISY — a custom-designed, paradox-based clinical information and administrative system devised originally by the Clinical Oncology Department at Derbyshire Royal Infirmary in partnership with the software writers, CompuCorp. Meeting the needs of NHS IMT strategy principles and the new RCR Oncology Information Systems guidance, this system now effectively provides an electronic information system for the management of cancer care. The system acknowledges the overlapping needs of clinicians, secretarial and other staff, with information only needing to be input once, but enabling access by all appropriate members of the multidisciplinary team. Network access has now been extended to 100 terminals sited across the Cancer Centre in medical, surgical and oncology clinics, wards, the radiotherapy department and offices. Key elements of the patients history, diagnosis and staging, treatment and follow up once captured, are immediately available online across the network. Key features of the system include: interface with hospital PAS for direct download of common data; integral interface with MS Office for production of notes, annotations, discharge summaries, spreadsheets *etc.*; comprehensive, user-defined dataset (including ICD10 codes) enabling double-click data entry; integral production of routine and *ad hoc* management and contracting reports; and support of data capture for local and national (*e.g.* RCR) audit requirements. MAISY has now been used successfully for over 7 years by clinical, managerial, secretarial and audit staff to input, view, report and analyse history, diagnostic, treatment and outcome data, accumulating a valuable dataset of almost 10 000 patient records.

**Refresher Course****Barium Enema Studies: lower limb studies**

Invited Review

**Barium enema studies**

J L Bewell

*St James' University Hospital Trust, Lincoln Wing X-ray Department, Beckett Street, Leeds LS9 7TF, UK*

Invited Review

**Lower limb Doppler—the method of choice**

T Richman

*Department of Ultrasound, Poole Hospital, Longfleet Road, Poole BH15 2JB, UK***Refresher Course****Images and Quality**

Invited Review

**What is image quality and how do you measure it?**

P F Sharp

*Department of Biomedical Physics and Engineering, University of Aberdeen, Foresterhill, Aberdeen AB25 2ZD, UK*

Invited Review

**The link between patient dose and image quality**

D Sutton

*Department of Medical Physics, Ninewells Hospital, Dundee DD1 9SY, UK*

Invited Review

**How do we achieve optimization?**

C J Martin

*Department of Health Physics, North Glasgow University Hospitals, Western Infirmary, Glasgow G11 6NT, UK***Workshop****Creating PowerPoint Presentations: beginner****How to create PowerPoint presentations: beginner**

M Tatlow

*Division of Professions Allied to Medicine, Faculty of Health Sciences, South Bank University, London SE1 0AA, UK***Workshop****Scattered Radiation: do you know its contribution to dose in "low dose" examinations?**

Invited Review

**Scattered radiation: do you know its contribution to dose in "low dose" examinations?**

A Eyden and C Jeffery

*Canterbury Christ Church University College, Canterbury CT1 1QU, UK***Workshop****MR of the Upper GI Tract**

Invited Review

**Cholangiography**

D J Lomas

*Radiology Department, Box 219, University of Cambridge, Cambridge CB2 2QP, UK*

Invited Review

**MR pancreatography**

J Healy

*Department of Radiology, Chelsea & Westminster Hospital, 369 Fulham Road, London SW10 9NH, UK***Keynote Lecture****Diagnosis of Renal Masses: MR and PET vs helical CT**

Invited Review

**Diagnosis of renal masses: MR and PET vs helical CT**

M J Lee

*Radiology Department, Beaumont Hospital, Beaumont Road, Dublin 1, Ireland***Keynote Lecture****3D Ultrasound: current and future prospects**

Invited Review

**3D ultrasound—current and future prospects**

L Berman

*Department of Radiology, Addenbrooke's Hospital NHS Trust, Hills Road, Cambridge CB2 2QQ, UK*

## Keynote Lecture

### Diagnosing Non-accidental Injury

#### Invited Review

#### Diagnosing non-accidental injury

H Carty

Department of Clinical Radiology, Alder-Hey Children's Hospital, Eaton Road, Liverpool L12 2AP, UK

## Keynote Lecture

### PET: current practice and future applications

#### Invited Review

#### PET: current practice and future applications

E Patz

Department of Radiology, Box 3808, Duke University Medical Centre, Durham, NC 27710, USA

## Keynote Lecture

### Acute Spinal Trauma: early management in a district general hospital

#### Invited Review

#### Acute spinal trauma—early management in a district general hospital

M Woodford

Salisbury District Hospital, The Duke of Cornwall Spinal Treatment Centre, Salisbury SP2 8BJ, UK

## Scientific Session

### Head and Neck

#### Staging head and neck cancer: CT or MRI, or both?

D Pickuth, G Peters, H Frimmel and R P Spielmann

Department of Radiology, Martin-Luther-University, Halle 06112, Germany

**PURPOSE:** Pre-treatment imaging is essential for correct T and N staging and proper treatment of head and neck cancer. The aim of this study was to prospectively evaluate the accuracy of CT and MRI in staging head and neck tumours using a new standardized examination protocol and a clinically oriented reporting protocol. The protocols emphasize the specific information that needs to be conveyed to the referring otolaryngologist. **PATIENTS AND METHODS:** 50 consecutive patients with head and neck cancer underwent both CT and MRI, performed within 1–2 days of each other with no intervening therapy. Tumour volume, local extent, spread into soft tissues, invasion into bony structures, relationship to neurovascular bundles, extension across midline and lymph node involvement (location, size, appearance) were determined in all patients. Images were reviewed by three radiologists and correlated with findings at subsequent operative resection. **RESULTS:** For T and N staging of head and neck tumours, the overall accuracy of CT was 86% compared with 82% for MRI. CT was superior in the assessment of bone invasion. In contrast, MRI had a better soft tissue contrast than CT. Motion artefacts due to respiration movement or random patient movement (swallowing, coughing) degraded 10% of the MRI studies. MRI findings caused an overestimation of tumour volume and invasion in 15%. **CONCLUSION:** In this era of cost concern, it is a good principle to perform one cross-sectional study that accurately stages the disease for the lowest price. Our results indicate that CT is the method of choice for staging head and neck tumours. With CT, adequate images can be obtained in all patients and in less time. In some patients, an additional MRI study is needed to resolve specific issues that would have consequences for treatment (e.g. submucosal spread, muscle invasion).

#### SPECT imaging in oral squamous cell carcinoma: a quantitative analysis of mandibular invasion

R Hanlon, H Lewis-Jones, J Woolgar and M Skarratts

Department of Radiology, University Hospital Aintree, Fazakerley, Liverpool L9 7AL, UK

**PURPOSE:** To assess the accuracy of single photon emission computed tomography (SPECT) in predicting the area of tumour involvement of

the mandible by oral squamous cell carcinoma. **METHOD:** 27 patients with oral squamous cell carcinoma were assessed pre-operatively with SPECT and MRI of the mandible, whole body bone scintigraphy and orthopantomography. The imaging data were then evaluated. For each patient and each imaging modality, the area of bone involvement was recorded on a diagram of the mandible traced from the orthopantomogram (OPG) and these areas were calculated. The SPECT images were correlated with the OPG to determine whether or not the increased uptake was due to periodontal disease. The actual area of bone involvement was determined at histology and was recorded on the same scale diagram of the mandible as that used for the imaging data. The imaging and histology results were compared. **RESULTS:** The sensitivities and specificities, respectively, of each imaging modality were: SPECT 100% and 79%; bone scintigraphy 100% and 93%; MRI 93% and 85%; orthopantomography 53% and 93%. SPECT overestimated the area of bone involvement by an average of 6 cm<sup>2</sup>, MRI by 6.3 cm<sup>2</sup> and bone scintigraphy by 2.9 cm<sup>2</sup>. The OPG underestimated the area of bone involvement by an average of 4.6 cm<sup>2</sup>. **CONCLUSION:** Compared with conventional bone scintigraphy, SPECT imaging is over sensitive and less specific at predicting the area of mandibular involvement by oral carcinoma. We conclude that SPECT imaging confers no additional benefit over combined conventional scintigraphy and orthopantomography in staging oral carcinomas.

#### Comparison of MR, CT and ultrasound for the detection of necrosis in metastatic neck nodes

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**PURPOSE:** The presence of necrosis is the most reliable sign of a metastatic lymph node in the neck but the best imaging modality for the detection of necrosis is unknown. The purpose of this study is to compare MR, CT and ultrasound for the detection of necrosis. **METHODS:** 10 patients with a primary head and neck carcinoma were entered into the study. Each patient underwent CT with contrast enhancement, MR using a surface coil to produce a T<sub>1</sub> weighted sequence pre and post contrast and a T<sub>2</sub> weighted sequence with fat suppression, and high resolution ultrasound. The imaging findings were correlated with pathological examination of the surgical specimen. In cases where there was more than one node of a similar size in a given region of the neck, the surgical specimen was dissected under ultrasound guidance to ensure the correct radiological-pathological correlation of each individual node. **RESULTS:** 35 metastatic nodes were examined, of which 21 showed necrosis on pathological examination. The necrosis was detected by all three modalities in 12 nodes and missed by all three modalities in 3. In the latter cases, the areas of necrosis were less than 2 mm in size. In the remaining six cases, CT missed necrosis in three, ultrasound in three and MR in one. In addition, MR, ultrasound and CT incorrectly diagnosed necrosis in three nodes in which the focal abnormality was caused by keratinizing or non-keratinizing tumour. **CONCLUSION:** No one single modality is superior and the pitfalls of each imaging modality will be discussed.

#### An audit of the use of MRI as first line neuroimaging for inpatients with clinically suspected acute stroke

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**AIMS:** In June 2000 a joint decision was taken between the departments of radiology and neurology to change from CT as first line imaging for in-patients with clinically suspected stroke, to MRI. Sequences were limited to Turbo Gradient Echo T<sub>2</sub> weighted study and diffusion sequence (B0, B500, B1000 and ADC map). The goals of the audit were; to evaluate what percentage of patients were meeting the audit standard of MR as first line neuroimaging; to evaluate what percentage of patients required repeat imaging (either CT or MRI); and a comparison of initial clinical and radiological diagnosis with final clinical diagnosis. **RESULTS:** Of 62 patients undergoing neuroimaging for suspected CVA, 75.8% underwent MR with diffusion weighted imaging as a first line investigation. Eight (12.9%) patients underwent repeat neuroimaging with CT. **CONCLUSION:** The use of diffusion weighted MRI as a first line investigation in patients with a clinical diagnosis of stroke is achievable in the district general

hospital setting. Diffusion weighted imaging is reliable in making the correct diagnosis, but a small number of patients required re-imaging with CT to clarify the radiological findings.

#### **Use of 2D time-of-flight MRA for patients with clinically suspected carotid stenosis as part of a stroke clinic**

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Patients with suspected stroke or transient ischaemic attack were initially clinically assessed and referred for same day MR neuroimaging. Patients who were thought to be at risk of carotid disease, and were clinically fit for carotid surgery, had a 2D time-of-flight study of the carotids and were included in the study. Immediately following imaging, patients were reviewed for treatment planning. Patients with stenosis approximating to 70% were recalled for first pass gadolinium MRA of the carotids at a later date, and if stenosis confirmed, were referred for carotid endarterectomy. We review the results of patients who had carotid studies to evaluate: the percentage of patients who had no significant stenosis; the percentage of patients requiring further carotid imaging; and the percentage of patients referred for endarterectomy. 84 patients have been referred from the one stop clinic for imaging, of which 69 had carotid studies. Six of these patients were shown to have a carotid stenosis of at least 70%. No patient had a carotid artery occlusion. Five patients have been recalled for first pass gadolinium MRA.

#### **MR sialography: a useful addition to examination of the major salivary glands?**

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**PURPOSE:** To investigate prospectively the added value of MR sialography in routine MRI for salivary gland investigation. **METHODS:** MR sialography was added to the MR examination of 36 consecutive referrals for suspected salivary disease. Standard examination was achieved by a four-sequence protocol of sectional images. MR sialograms were obtained by bilateral sagittal oblique slabs. Reading of the sectional images and the MR sialograms was carried out separately by one radiologist and the readings were combined to compare the added value of the MR sialogram. **RESULTS:** Sectional MRI showed extrinsic lymphadenopathy (9), sialectasis (8), calculi (5), neoplasm (2), lymphocyte infiltration (2) and fatty infiltration (1). Normal appearances were detected in nine patients. Findings on MR sialography concurred with the sectional images in all cases. Abnormal findings on MR sialography were limited to main duct dilatation, sialectasis and calculi. MR sialography made no contribution to the demonstration of masses. MR sialograms provided clearer demonstration of a calculus in one patient and of sialectasis in another, but apart from this gave no added information and in no case did the MR sialographic findings contribute further to the management of the patient. In a significant number of patients, demonstration of the duct system was superior on sectional images. **CONCLUSION:** MR sialography appears to make no significant contribution to investigation results compared with a comprehensive sectional examination of the salivary glands by MRI.

#### **Keynote Lecture**

### **Role Development in Angiography: nurse-performed diagnostic angiograms**

#### **Invited Review**

#### **Role development in angiography: nurse-performed diagnostic angiograms**

T Lloyd-Jones  
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#### **Keynote Lecture**

### **Progress in MRI of Free Radicals**

#### **Invited Review**

#### **Progress in MRI of free radicals**

D Lurie

*Department of Biomedical Physics and Engineering, University of Aberdeen, Forsterhill, Aberdeen AB25 2ZD, UK*

#### **Workshop**

### **Scattered Radiation: do you know its contribution to dose in "low dose" examinations?**

#### **Invited Review**

#### **Scattered radiation: do you know its contribution to dose in "low dose" examinations?**

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#### **Scientific Session**

### **Genitourinary (1)**

#### **Multislice helical CT in imaging of the urinary tract: preliminary experience**

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**AIMS:** Multislice helical CT, introduced in late 1998, has been a major leap forward in CT technology. It allows high quality volume imaging with excellent 3D and multiplanar image reconstruction. The aim of this work is to present the potential applications, advantages and limitations of using this new technology in imaging the urinary tract. **MATERIALS AND METHODS:** A total of 10 cases referred for multislice CT of the urinary tract were reviewed. The presenting symptoms ranged from neurogenic bladder with recurrent stone formation (four cases), routine review of upper tracts (two cases) and non-specific abdominal pain (four cases). The examination involved contiguous scanning of the whole abdomen 20 min after intravenous injection of 50 ml non-ionic contrast medium (300 mgI ml<sup>-1</sup>), employing a collimation of 2.5 mm/slice thickness during a single breath-hold using a SOMATOM plus 4-volume zoom multislice CT scanner (Siemens). Contiguous axial images (5 mm slice thickness) of the entire abdomen and pelvis as well as contiguous coronal images (5 mm slice thickness) of both kidneys were reconstructed and provided on the hard copies. Selected sagittal images (5 mm slice thickness) of the affected kidney were also provided in some cases. **RESULTS:** Volume imaging with multiplanar image reconstruction provided accurate assessment of the urinary tract. **CONCLUSION:** Multislice helical CT provides excellent anatomical information of the urinary tract and helps in planning treatment, particularly in patients with intrarenal and perinephric infection. In all cases, excellent anatomical display of the upper tracts was achieved. Absence of control images prior to CT made assessment of calculi in the urinary tract difficult. The technique can be used as the main imaging examination in the assessment of recurrent urinary infections, haematuria as well as renal masses.

#### **MRI of potential renal donors: MRA, MRV and MRU**

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**PURPOSE:** To assess the feasibility of performing magnetic resonance angiography (MRA), magnetic resonance venography (MRV) and magnetic resonance urography (MRU) as a single examination in potential renal donors, and to evaluate the diagnostic accuracy of MRI compared with surgical findings. **METHOD:** 42 subjects were evaluated with a 1 T Siemens MR system in a body array coil. Sequences were performed during breath-hold with no special preparation. Renal anatomy was assessed by axial scans followed by MRA, MRV and MRU. Images were displayed using maximum intensity projection and

multiplanar reformatting. RESULTS: Surgical correlation was possible in 29 of the 42 potential donors. Surgery was performed on the left in 19 donors and on the right in 10. MRI findings resulting in the choice of right-sided surgery included double left renal arteries in seven donors and the presence of complex left venous anatomy in two donors. A right kidney was also selected for donation owing to the presence of right renal cysts. MRU demonstrated a dilated calyx and cortical scarring in one case, resulting in donor exclusion. In 27/29 donors, MRA and surgery were in agreement with regard to the number of hilar arteries. MRA missed one small polar artery, which was ligated at surgery. MRV was accurate in depicting the main and extrarenal veins in all cases. CONCLUSION: MRI has the potential of becoming the primary imaging technique in the assessment of potential renal donors, eliminating the use of ionizing radiation as well as reducing the number of examinations and the cost of imaging.

#### **MRI of the paravaginal fascia and urethra in women with urinary stress incontinence**

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PURPOSE: This study aims to describe the MRI features of the paravaginal fascia and urethra in women with genuine stress incontinence (GSI) compared with continent controls. PATIENTS AND METHODS: 6 continent controls and 10 patients with GSI were studied. All controls and patients underwent MRI using a purpose-designed endovaginal coil. Following a urinary continence questionnaire, a urogynaecological clinical examination was done. GSI was diagnosed by urodynamic studies. The paravaginal fascial distribution was noted and the anterior paravaginal fascial volume associated with the urethra (uPFV) was computed. In addition, the urethral length above the pubococcygeal line (PCL) compared with its total anatomical length was expressed as a percentage ratio. RESULTS: The paravaginal fascia was found to be a consistent MRI feature in all women regardless of their age, parity, hormonal status, hysterectomy or continence status. Its distribution was variable, being mainly around the bladder base and upper third of the vagina laterally. Anterior midline distribution was comparatively limited. The mean uPFV was 5.4 cm<sup>3</sup> in continent controls compared with 3.6 cm<sup>3</sup> in patients with GSI ( $p=0.022$ ). The mean ratio (%) of urethral length above the PCL was 0.84 (84%) in continent controls compared with 0.57 (57%) in patients with GSI ( $p=0.0000$ ). CONCLUSION: These results suggest a significant association between uPFV and continence status, patients with GSI having a reduced uPFV. Also, patients with GSI have more than 40% of their urethral length below the PCL in the supine position at rest, thus confirming urethral hypermobility.

#### **A study investigating whether muscle bulk is increased in patients with testicular cancer**

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PURPOSE: It has been postulated that exercise and increased muscle bulk are risk factors for testicular cancer, possibly mediated via increased serum androgens. Several authors have also suggested that exercise may even confer a protective effect. This study determines whether patients diagnosed as having testicular cancer have an increased muscle bulk when compared with age- and sex-matched controls from a cohort of patients with Hodgkin's lymphoma. METHODS: 67 sequential patients (age range 17–56 years) with a diagnosis of Hodgkin's, seminoma and teratoma had their initial CT scans examined. 19 were diagnosed as having teratomas (age range 17–33 years), 15 had seminomas (age range 21–56 years) and 33 had Hodgkin's lymphoma (age range 17–36 years). Measurements consisted of the sum of the maximum diameter of psoas muscles, and the maximum anteroposterior diameter of their rectus abdominis and gluteus maximus muscles, measured by two investigators blind to the diagnosis of the patients. RESULTS: Variation of muscle measurements within the groups was 54%. The mean sum of the muscle measurements was 22.9 cm, 23.3 cm and 22.3 cm, respectively, for Hodgkin's, seminoma and teratoma. Average interobserver variation was found to be 4%. T-test analysis was performed on each of the groups. No significant difference amongst the groups was found. CONCLUSION: This technique measuring muscle bulk in patients identified as being within a high risk group has not, to our knowledge, been attempted before and may prove to be a helpful technique in the future.

#### **Comparison of multislice CT angiography with transfemoral DSA in renal artery stent evaluation**

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PURPOSE: Follow-up of renal artery stents for patency is usually performed using transfemoral digital subtraction angiography (DSA). A prospective trial was carried out to assess the role of multislice computed tomography angiography (MCTA) in the evaluation of renal artery stents, using DSA as the gold standard. MATERIALS AND METHODS: 14 consecutive patients (12 male, 2 female) with 16 renal artery stents (12 native and 4 transplant renal arteries), aged between 32 and 74 years (mean 60.1 years), referred to the radiology department for stent follow-up prospectively underwent both MCTA and DSA. The MCTA was performed as an outpatient procedure on a Marconi Mx 8000 multislice CT scanner. The scan parameters used included 1.0 mm nominal slice width, pitch of 0.875 and exposure factors of 230 mAs and 120 kV. 120 ml of contrast medium (Omnipaque 300) were injected intravenously at a rate of 3.5 ml s<sup>-1</sup>, with a scan delay of 25 s. In two patients with poor cardiac reserve, bolus tracking was used to find the optimum scan delay. The images were reconstructed on standard resolution and 512 × 512 matrix, and multiplanar reconstructions and maximum intensity projection were used for diagnosis. The DSA was performed with standard views for the native vessels and the appropriate modified views for the transplant arteries. RESULTS: The MCTA and DSA images were each interpreted by two radiologists. The results showed high correlation between the two modalities. In some cases, minimal soft tissue thickening was identified on MCTA within the stents, which we believe may represent mild neointimal hyperplasia (NIH). CONCLUSION: MCTA shows good correlation with DSA in the evaluation of renal artery stents. It therefore provides a less invasive outpatient alternative to the conventional transfemoral angiography for follow-up evaluation of renal artery stent patency in native and transplant kidneys.

#### **Renovascular disease associated with neurofibromatosis and the role of percutaneous transluminal renal angioplasty**

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PURPOSE: Renovascular disease (RVD) in neurofibromatosis presents a difficult management problem alongside hypertension. The aim of this study was to review the role of percutaneous transluminal renal angioplasty (PTRA) in patients with neurofibromatosis and hypertension. METHODS: Over the past 20 years, 11 patients (6 female) with neurofibromatosis and RVD have been treated at our institution. Their mean age at presentation was 7.5 years (range 1 month–26 years). All patients had severe hypertension at presentation (mean blood pressure 154/104). RESULTS: At angiography, 26 renal arteries were identified in the 11 patients. Four patients also had mid-aortic syndrome. 25 renal stenoses were seen and 11 of these were suitable for angioplasty. A total of 16 angioplasties were performed (6 patients). Of the 11 patients, 5 were managed with combinations of PTRA, surgery and antihypertensive medication, 2 with PTRA, 2 with surgery and 2 with surgery plus medication. Overall, PTRA, either alone or in combination with surgery, produced improvement or cure in 56% of cases. No major complications were seen in this study. If surgery was subsequently required, prior angioplasty had no detrimental effect. CONCLUSION: Treatment of RVD in patients with neurofibromatosis is a challenging prospect. PTRA, we believe, can be helpful in achieving control of hypertension and preserve functioning renal parenchyma. A team approach (radiologist, surgeon and nephrologist) is recommended to optimize outcome.

#### **Endovascular embolisation of varicoceles: resorption of tungsten coils in the spermatic vein**

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PURPOSE: To investigate whether resorption of tungsten coils occurs in patients with varicoceles treated by endovascular embolisation of the spermatic vein. METHODS: Patients who had previously undergone varicocele embolisation were requested by letter to attend the radiology department. Blood levels of tungsten were compared with a

group of controls. Fluoroscopic images of the coils were taken and compared with those obtained during the original procedures. RESULTS: 19 patients attended whose embolisation procedure had been performed 19–57 months (mean 40 months) previously. Blood levels of tungsten were raised in 18 patients compared with the controls. Radiographic evidence of loss of substance of the coils was seen in four patients. CONCLUSION: Tungsten coil resorption occurs in varicocele embolisation. In view of the unknown long-term effects of raised blood tungsten levels and the availability of alternative embolisation agents, we feel that it is unwise to persist in the use of tungsten coils in this application.

#### **A review of linograms and snaring of central venous haemodialysis catheters**

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PURPOSE: Amongst haemodialysis patients there is a small proportion who require renal replacement therapy using a long-term tunnelled central venous catheter. The continued maintenance of this venous access may be problematic, particularly as relatively high flow rates are required to attain adequate dialysis. Problems include the formation of a fibrin sheath or thrombus at the catheter tip. In these patients, radiological snaring and stripping of the line may be performed. METHODS: We reviewed all requests for "linography" and all snaring procedures over 1 year. RESULTS: There were 20 distinct radiological episodes for 14 different patients (3 males, average age 25 years; 11 females, average age 62 years). In nine cases a linogram was performed but did not proceed to snaring. In 11 cases (8 patients) a linogram with snaring was performed. Indications for snaring and stripping were demonstration of a filling defect or fibrin sheath, or an inability to flush the catheter ports. Of these eight patients, seven had internal jugular lines. One case had a subclavian line. In the 11 cases of snaring, the central venous catheter was used for dialysis for a further 115 days (range 20–277 days). We conclude that radiological snaring of failing central venous haemodialysis catheters is associated with prolonged use of these catheters for dialysis.

### **Scientific Session**

#### **Radiology Audit and Management**

##### **CT reporting: do registrars make mistakes and does it matter?**

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PURPOSE: To determine the accuracy of registrar CT reporting. METHODS: Over 6 months a single consultant reviewed all the CT scans reported by registrars in one radiology department. After recording a provisional registrar report, each scan was jointly reviewed by the consultant and registrar. The consultant's opinion was regarded as the gold standard. Data collected included whether the error was significant and led to a change in patient management, and whether the mistake made was the failure to detect an abnormality or misinterpretation of the scan. RESULTS: 331 scans were included in the study. There was an overall error rate of 21.5%. A significant error, leading to a change in management, was made in 10% of reports. 2.1% of reports had insignificant errors. 69.0% of errors made were the failure to detect an abnormality. CONCLUSION: This study demonstrates that registrars make a significant number of errors affecting patient management when reporting CT scans, and that all scans should be reviewed by a consultant.

##### **Learning styles in radiology: creating a climate for learning**

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INTRODUCTION: We teach as we learn, but individual learning styles are diverse. Unless we recognize this, we may limit the opportunities for others to learn with us. This study assesses the range of learning styles in a radiology department. METHOD: Kolb's learning style inventory was circulated to departmental faculty and radiology residents from the university rotation. The questionnaire assesses how

much emphasis learners place on four different learning modes (concrete experience, reflective observation, abstract conceptualization and active experimentation). An individual's learning style is identified either as converger, diverger, assimilator or accommodator, with varying degrees of polarization. RESULTS: 19 replies were received (6 faculty and 13 residents). These showed a great diversity in learning, particularly among faculty, where 5 of the 6 showed strong emphasis of their learning style. No single style came close to encompassing the group. The residents were less diverse as a group and, although the results suggested greater emphasis on active experimentation, the results do not bear statistical analysis. Further inferences from this small group might be misleading. CONCLUSION: When you teach, remember that the majority of your audience may not learn the way you do.

##### **Accuracy of out of hours emergency CT head scan interpretation: junior radiologist vs clinician**

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PURPOSE: To compare the accuracy of out of hours emergency CT head scan interpretation by junior radiologists and clinicians. METHODS: A prospective study of reports on 43 out of hours emergency CT head scans, issued separately by the referring clinician and the on-call junior radiologist, was performed. Neurosurgical inpatients and polytrauma cases were excluded from the study. Both reports were then benchmarked against the formal report by a consultant neuroradiologist. Inaccuracies were graded according to the possible effect on subsequent patient management. RESULTS: Inaccurate reports were issued in 28% (12/43) of the cases reported by the clinicians and 14% (6/43) of the cases reported by the junior radiologists. 20% of the inaccurate reports issued by the clinicians were major errors that could have a significant adverse effect on patient management. No such major errors were made by the junior radiologists. CONCLUSION: The study is still on-going, with the aim of including 200 cases prior to presentation. The provisional results of this 10% pilot study indicate that clinicians are more prone to giving inaccurate out of hours emergency CT head scan reports than junior radiologists.

##### **Clinical governance in action: radiological error review at the Walsgrave Hospital NHS Trust**

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A formalized system of reviewing apparent radiological errors in a large District General Hospital is outlined. METHOD: The system involves confidential and anonymous reporting of apparent errors to the Lead Audit Radiologist. The radiographs in question are subsequently peer reviewed in either a quiz or discussion format, at regular monthly audit meetings. A consensus opinion is reached in the discussion and a majority decision reached when the quiz questionnaires are analysed. RESULTS: Of the 78 cases reviewed between April 1999 and April 2000, only 30% were classified as errors. No significant differences in error rate between different consultants have as yet been shown. Plain film examples are shown to illustrate the type of perceptual errors that we have encountered.

##### **Undergraduate education in radiology**

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AIMS: To establish the role of radiology teaching in undergraduate teaching in UK medical schools and, if radiology is taught, by whom. METHODS: A questionnaire was sent to 25 heads of education of UK medical schools. The questionnaire had five sections asking about (1) X-ray interpretation, (2) radiological anatomy, (3) clinical attachments in radiology, (4) teaching of radiation protection and (5) other formal radiology teaching. RESULTS: Completed questionnaires were received from seven medical schools and replies in other formats from two further schools. (1) X-ray interpretation was taught in all schools that replied, predominantly but not exclusively by radiologists. A range of total teaching time, from 8–32 hours, was identified. (2) Radiological anatomy was taught in all schools that replied, with teaching by radiologists and anatomists. Exposure ranged from three lectures to full integration into anatomy teaching. (3) 6/9 schools had formal clinical radiology attachments. (4) 6/9 schools had teaching of radiation

protection in the curriculum. (5) Regarding other teaching, one school has an intercalated degree with a strong radiology component and one school has teaching in nuclear medicine. CONCLUSION: Of the schools that replied, radiology was identified in most responses as an important aspect of undergraduate education, particularly in the teaching of anatomy and problem-orientated clinical skills. A wide variety of approaches to teaching of radiology was revealed. Some schools are developing clinical imaging as a major thread or vertical theme. It is therefore likely that radiologists will be more involved in undergraduate teaching in the future.

#### **A&E abdominal films: are RCR guidelines followed?**

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Plain abdominal films (PAFs) in Accident and Emergency (A&E) departments are of low diagnostic yield. Despite Royal College of Radiologists' (RCR) guidelines, PAFs are overutilized in A&E departments. Previous studies have looked at the variation of PAF interpretation but not at the variation of indication or documentation of interpretation with respect to A&E experience. PURPOSE: To determine the appropriateness of request and documentation of findings of referring doctors with regard to A&E experience. METHODS: Over 6 weeks, a list of PAFs requested by the A&E department of Belfast City Hospital was obtained. Charts were reviewed, radiographic findings of the A&E doctor recorded and the appropriateness of the indication determined using RCR guidelines. The doctors were grouped according to A&E experience: Group 1 (<6 months A&E work), Group 2 (6 months–1 year A&E work), Group 3 (>1 year A&E work), Group 4 (1 year A&E work part-time equivalent, *i.e.* GP). RESULTS: 100 PAFs were requested, representing 2% of the total attendance (5274). 58% were not indicated.  $\chi^2$  testing using 10% probability showed a significant difference between Group 1 and Groups 2, 3 and 4 regarding appropriate radiograph requesting. A significant difference was not shown between Groups 2, 3 and 4. No significant difference was demonstrated between any groups regarding documentation of radiographic findings. CONCLUSIONS: Most PAFs requested were not indicated. There is a statistically significant improvement in appropriate requesting of PAFs following 6 months full-time A&E work, but no difference after this initial 6 months. No significant improvement in documentation is shown with increasing experience. The IRMER (2000) regulations indicate that the practitioner has a responsibility for the justification of a procedure. The RCR guidelines must be followed in most cases if an exposure is to be justified. This is clearly not the case at present, especially for less experienced doctors who make up a significant number of A&E practitioners.

#### **Does reporting of plain chest radiographs affect the immediate management of patients admitted to a medical assessment unit**

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PURPOSE: With the increasing burden of work in radiology, some departments have already stopped reporting inpatient plain radiographs unless specifically asked to. Our aim was to determine whether reporting of plain chest radiographs affects the immediate management of patients admitted to a medical assessment unit. METHODS: During a 3-month period we prospectively evaluated 200 patients who had a plain chest radiograph on admission. After the post-oncall ward round, an independent medical registrar reviewed the notes, retrieving relevant clinical details. The plain chest radiographs were reported independently by a trainee radiologist and a consultant radiologist. The clinical notes and radiologists' consensus report were reviewed and any impact on immediate management was assessed. RESULTS: There was 93% agreement between trainee and consultant radiologists (95% CI 89–96%). The oncall medical team documented reports in 70% (140/200). There was disagreement between radiologists and physicians in 49% of reported films (95% CI 40–57%). The radiologists' report led to a direct change in the immediate management of 22 (11%) patients. CONCLUSION: Only 70% of films had documented reports in the clinical notes despite this being a legal requirement. Radiology reporting does lead to direct changes in patient management. Chest radiographs of patients admitted to a medical admissions unit should be reported by a radiologist.

#### **Barium enemas by a junior registrar: are patient radiation doses acceptable?**

A Doss

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AIMS: The aims were to audit a junior radiologist's screening times and dose-area product (DAP) during barium enema examination and to assess whether there is a difference in patient exposure between a digital and non-digital screening system when a junior radiologist performs a barium enema. METHODS: A prospective audit of barium enemas performed by the author on a digital and non-digital screening system was carried out from July 2000 to November 2000. After each examination, patients were asked their body weight, and comments about the examination, screening time and DAP were recorded. Diagnostic studies for patients whose body weights ranged from 50–90 kg were chosen for the analysis. A total of 32 eligible patient data were analysed. The percentage of studies with DAP readings less than 3500 cGy cm<sup>2</sup> was calculated. A comparison of screening times and DAP between the digital and non-digital systems was made. RESULTS: 78.1% of the 32 eligible patients were subjected to a DAP of less than 3500 cGy cm<sup>2</sup>, which conforms to the recent NRPB guidelines (2000) that state that 75% of DAP from barium enemas should be less than 3500 cGy cm<sup>2</sup>. The results also show that with a digital screening system 83% of the DAPs were less than 3500 cGy cm<sup>2</sup> compared with 75% with a non-digital screening system. The screening times in the non-digital system were considerably longer than those of the digital screening system. CONCLUSION: The radiation doses to patients from barium enemas performed by junior radiologists in training are within current national (UK) guidelines. A digital screening system significantly lowers screening times compared with a non-digital screening system and reduces patient radiation exposures.

## Scientific Session

### Paediatrics

#### **MRI hip appearances in paediatric rheumatic disorders**

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PURPOSE: To describe the spectrum of abnormalities seen on MRI performed for hip disease in paediatric rheumatic disorders and to correlate these findings with the clinical diagnoses and disease status. MATERIALS AND METHOD: A retrospective review of case notes and MRI examinations (performed on a 1.5 T Siemens machine) was undertaken. The images were independently read by two radiologists blinded to the clinical findings. 40 patients, who underwent 50 MRI examinations, were included in the study. RESULTS: The group studied were subdivided into 25 cases of JIA (comprising 5 with systemic onset, 8 polyarticular, 3 oligoarticular and 9 with spondyloarthropathy), 5 cases of mixed connective tissue disease and 10 cases of non-rheumatic disease. In those individuals with JIA, MRI showed symmetrical synovial thickening/enhancement in 53/66 hips as well as bony erosion (39/66), effusions (39/66) and AVN (15/66). Patients with HLA B27+ spondyloarthropathy showed asymmetrical synovial changes (2/6) or effusions alone (5/6). Those with HLA B27– spondyloarthropathy demonstrated marked muscle atrophy in 13/16 hips, with associated asymmetrical synovial changes in 12/16. Connective tissue disorders were associated with only mild synovial changes (5/10), and non-rheumatic disorders were either normal or had simple effusions (12/24). CONCLUSIONS: Synovial thickening and enhancement was a strong indicator of active JIA. Different patterns of disease were seen in different subtypes of JIA, in particular HLA B27– spondyloarthropathy uniquely demonstrated marked muscle atrophy. These identifiable patterns of disease suggest MRI has a diagnostic role in paediatric rheumatic hip disorders, their classification and outcome.

#### **Does the comparison view help the radiologist or emergency physician in paediatric elbow trauma?**

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PURPOSE: To determine whether a comparison view of the uninjured elbow improves diagnostic accuracy amongst those who share a role

in diagnosing elbow trauma in our hospital. **METHOD:** 39 consecutive cases of elbow trauma in children aged 2–13 years who attended A&E were collected over a 3-month period. Standard radiographic views of the injured elbow (IE) and of the uninjured elbow (UE) for comparison were taken in accordance with local practice for elbow trauma in this age group. Views of the IE were reviewed first without and subsequently with the use of the comparison view of the UE. The observers were A&E SHOs, A&E staff grades, radiology SpR and consultant radiologists. Interobserver agreement and diagnostic accuracy was measured with respect to the final radiological diagnosis. Confidence in the diagnosis was also scored. All cases were followed up at between 3 months and 6 months. **RESULTS:** Diagnostic accuracy and confidence in the diagnosis were both improved by use of the comparison view in most of the junior staff but not in consultant radiologists. Diagnostic accuracy was poorer amongst junior staff than amongst consultant radiologists regardless of availability of the comparison view. **CONCLUSION:** Routine use of the comparison view has been largely discredited previously. Whilst a comparison view may improve accuracy in our junior staff, a radiological report is almost certainly of greater value to the patient and at no extra radiation dose.

#### Value of the disrupted "x-sign" in plain film assessment of paediatric elbow trauma

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**PURPOSE:** A retrospective study was performed to determine the sensitivity and specificity of the disrupted "x-sign" (the "x" being formed by the junction of the radial fossa with the cortical margin of the distal humeral metaphysis) in the assessment of plain films in paediatric elbow trauma. **METHOD:** The plain radiographs of 166 children (age <16 years) attending the accident and emergency departments of Barts and The London Hospital NHS Trust with elbow injury were examined. Three radiologists reviewed the films. The radiographs were examined for: (i) presence of anterior fat pad (AFP); (ii) presence of posterior fat pad (PFP); (iii) integrity of the anterior humeral line (AHL); (iv) integrity of the "x-sign"; and (v) evidence of cortical break. Films taken at a later date to clarify the presence or absence of a fracture were also examined. **RESULTS:** Adequate anteroposterior and lateral radiographs were obtained in 166 patients. There were 62 fractures of which 51 were supracondylar. Of the supracondylar fractures, 28 (55%) had an elevated AFP, 37 (73%) had a PFP, 27 (53%) had disrupted AHL and 42 (82%) had a disrupted "x-sign". Of the 104 elbows with intact cortex and no callus on follow-up radiographs 11 (11%) demonstrated elevated AFP, 10 (10%) had a PFP, none had a disrupted AHL and 11 (11%) had a disrupted "x-sign". **CONCLUSION:** The disrupted "x-sign" is a useful radiological sign in the diagnosis of supracondylar fractures.

#### CT findings in childhood pleural empyema

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**PURPOSE:** To illustrate the CT appearances of childhood empyema and to define its role in the management of this condition. **METHODS:** A retrospective review of the medical and radiological records of 57 consecutive children with clinically diagnosed empyema was performed. **RESULTS:** Following inadequate response to medical treatment, 23 patients (10 male, 13 female) underwent evaluation with contrast enhanced CT. Mean age of the patients was 6.58 years (range 1–15 years). CT findings included effusions in all children, classified as large (greater than 3 cm maximal diameter) in 12 (52%) cases, medium (1–3 cm) in 8 (34.8%) cases and small (less than 1 cm) in 3 (13%) cases. All patients had closed chest tube drainage as part of their medical management. The underlying lung parenchyma was noted to show enhancing consolidation in 13 (56.5%) patients and to be low attenuating in 2 (8.7%) cases. Atelectasis was seen in 8 (34.8%) patients. An enhancing pleural rind was seen in 74% of patients (17 cases), all of whom subsequently underwent surgical decortication. Lymphadenopathy was noted in 34% of patients and in all except 1 case affected the pre-tracheal group of nodes. All patients were discharged home well, with almost complete resolution of their changes

as judged by chest radiography at 6-month follow-up. **CONCLUSION:** CT has a useful role in children with pleural empyema who fail to recover with standard medical management. Low attenuation pneumonia may recover and does not presage cavitation. No patient had an associated lung abscess. The presence of a pleural rind predicts the need for early surgical referral for thoracotomy and decortication.

#### Intussusception practice and outcome at a tertiary referral paediatric centre: an audit

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**AIMS:** To review our intussusception practice and outcome. **METHODS:** We retrospectively reviewed 59 consecutive patients referred for pneumatic reduction between May 1998 and June 2000. Ultrasound technique, sensitivity and specificity were assessed. The numbers of successful, negative and failed pneumatic reductions were recorded. **RESULTS:** 70% of pneumatic reductions were successful. 66 pneumatic reductions were performed: 57 intussusceptions and 9 negative pneumatic reductions. 56 ultrasounds were performed. There were no false positive ultrasound examinations, although there were 2 (3.5%) false negative examinations. All negative ultrasounds underwent pneumatic reduction, with screening times <1 min in 89%. The mean screening time for a successful reduction was 3.7 min; 72% were reduced in under 5 min. The mean time for an unsuccessful pneumatic reduction was 10.5 min; 80% had screening times >5 min. 28% of the failed reductions required surgical resection. 50% were manually reduced (40% were difficult and 12.5% ileo-ileal). 1 patient (6%) had a successful delayed pneumatic reduction. There was a single complication (1.7%), a perforation occurring after 35 s. Three patients had repeat pneumatic reductions for an initial failed attempt. One was successfully reduced, one required a right hemicolectomy. **CONCLUSIONS:** Reported success rates vary from 70–90%; our success rate was 70%. We conclude that 62% of failed pneumatic reductions were unlikely to be successful, regardless of the screening times and pressures employed. Since surgical practice at our institution is to proceed to laparotomy after a failed pneumatic reduction, the numbers undergoing more than one pneumatic reduction were small. Ultrasound was sensitive and specific nevertheless, and was operator dependent, with a false negative rate of 3.5%. Where clinical suspicion remains high, intussusception can be excluded by rectal air insufflation with screening times under 1 min.

#### MRI on the neonatal intensive care unit

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**AIM:** To update our previous report on a dedicated magnetic resonance (MR) scanner adjacent to the neonatal intensive care unit after 2 years experience. **MATERIALS AND METHODS:** A Niche MR scanner (0.2 T field strength, 15 mT m<sup>-1</sup> gradient strength) using a loop RF coil was installed in an area 100ft square. Images were obtained in axial and coronal planes. Spatial resolution was 1 mm in plane, with 5 mm slices. Each baby had an ultrasound scan for comparison. Two groups were studied: Group 1 included infants with no neurological symptoms and Group 2 included patients who had known or suspected intracranial pathology. **RESULTS:** A total of 134 babies were included in this study from September 1998 to May 2000. 89 babies were Group 1 neonates, 40 being pre-term and 49 being term infants. 3/89 (3.4%) scans were unreportable due to movement artefacts. All but one had a normal examination. All MR examinations in Group 2 were reportable (*i.e.* 0% failure rate). In 0/43 (0%) the brains were normal on both modalities. In 14/43 (32.6%) the brains were abnormal and both modalities gave equivalent information. In 24/43 (55.8%) cases MR gave more information when compared with ultrasound, including 13 where ultrasound was normal. In 5/43 (11.6%) ultrasound showed grade one germinal matrix haemorrhage not seen on MR. The  $\chi^2$  test for MR detecting more pathology than ultrasound was highly significant ( $p < 0.001$ ,  $\chi^2 = 16.86$ ,  $df = 1$ ). **CONCLUSION:** Low field strength MR scanning provides a valuable additional imaging technique on the SCBU.

### Treatment of testicular varicocele by coil embolisation in young patients

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AIM: There is still some controversy surrounding the early treatment of varicocele in the paediatric population. The aim of our study was to show that radiologically guided testicular vein embolisation is an effective alternative to the conventional surgical approach. METHODS: Between 1985 and 2000, 60 patients, mean age 13.5 years (range 9–18 years), were referred for varicocele embolisation. All patients had been assessed by the paediatric urologist and had ultrasound scans. The majority of procedures, (55), were performed using light sedation and local anaesthetic on an outpatient basis. 5 patients required a general anaesthetic. In all patients, a testicular venogram was obtained first and then embolisation was performed using various sized coils. Patients were initially followed up in clinic. Late follow-up was obtained through telephone interviews and questionnaires. Clinical outcome was graded as "good", "moderate" or "poor" according to various criteria. RESULTS: The technical success rate for testicular vein occlusion was achieved in 55 patients (90%). 46 patients (76%) had a "good" clinical outcome. 5 patients (8%) reported recurrence of the varicocele and were operated upon. In 5 patients embolisation was not feasible because of multiple collateral vessels or venous spasm. 4 patients were lost to follow up and were not included in the final result. CONCLUSION: Given the convenience of performing the procedure on an outpatient basis, the rapid recovery time, and long-term success with low complications rate compared with surgical ligation, we believe testicular vein embolisation is the treatment of choice for testicular varicocele in this age group.

## Scientific Session Chest (1)

### Gastro-oesophageal stent placement for palliation

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AIM: To review our 4-year experience of gastric and oesophageal stenting in a DGH. METHODS: Data were retrieved from 40/43 stented patients. There were 28 males and 12 females, mean age 69 years (range 39–91 years). 9 patients had dysphagia for solids, 3 for semi-solid food, 7 for fluids, and 17 had total dysphagia; no severity was recorded in 4 patients. Three patients had recurrence following surgery; the others were inoperable. 36 patients had primary oesophageal/gastric tumours and 4 had lung cancer (including two fistulae). Tumours were of the distal third in 17 patients, the gastro-oesophageal junction (GOJ) in 8, the mid third in 7, the proximal third in 1, entirely in the stomach in 5 and anastomotic recurrences in 2. RESULTS: All patients had successful stent placement. There were five migrations (three at the GOJ, one lower third and one body of the stomach) and one perforation. 17 patients had no dysphagia, 13 had some dysphagia for solids and 2 for fluids (one vocal cord palsy); there were no data in 8 patients. Six patients required multiple stents at the initial procedure (two stents in five patients and three stents in one patient). Four patients required further stent placement. Six patients had post-stent dilation. Mean initial length of stay was 11 days (range 0–36 days). 17 patients had no further admission, 14 were re-admitted once and 9 on two further occasions. Mean total stay was 19 days (range 0–98 days). 15 patients died in hospital, 7 immediately after stenting. 66% survived >1 month following stenting (range 2 days to >300 days). CONCLUSION: Gastro-oesophageal stenting is safe, effective and worthwhile. Uncovered stents should be avoided. Covered stents should be avoided at the GOJ/proximal stomach.

### A comparison of the Ultraflex and Flamingo Wallstent in palliation of lower third oesophageal cancer

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INTRODUCTION: Palliation of lower third malignant oesophageal strictures with metallic stents is complicated by increased stent

migration rates and poor configuration below the diaphragm when the distal stent opposes the gastric wall. PURPOSE: To compare the efficacy and security of two different newer types of flared, self-expanding, metallic, covered oesophageal stents in patients with lower third malignant oesophageal strictures. MATERIALS AND METHODS: 37 patients with inoperable disease were randomized and received either an Ultraflex (n=19) or Flamingo (n=18) covered oesophageal stent. All procedures were performed in the Interventional Radiology suite using fluoroscopy. Dysphagia before and after stent placement was scored on a 5-point scale, and the incidence of early (<30 days) and late complications was compared between the two groups. RESULTS: The initial technical success was 100% in both groups. Significant improvement in the dysphagia score was demonstrated with both types of stent at short- and long-term follow-up. No significant difference was seen in the improvement of dysphagia between the two groups ( $p>0.05$ ). The early (migration, severe reflux and perforation) and late (haematemesis and tumour ingrowth) complications were similar in the two groups. CONCLUSIONS: Both Ultraflex and Flamingo covered stents are safe and effective in the treatment of malignant strictures of the lower third of the oesophagus. The Ultraflex stent offers the advantage of increased flexibility. The Flamingo stent offers the advantage of more accurate positioning. A brief discussion of the relative merits of the two stent types is given.

### The imaging implications of an open access chest pain clinic

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BACKGROUND: An open access chest pain clinic was set up to facilitate rapid diagnosis of coronary disease. 556 patients were seen at the clinic in the first year. METHODS: Patients were initially screened by questionnaire and then interviewed and examined by a doctor. Exercise testing, clinical examination and routine blood tests for risk factors were the core diagnostic elements. Patients were then selected for cardiac imaging and therapy. RESULTS: 18% of patients were referred for coronary angiography on the basis of positive exercise test. 9% of patients were referred for cardiac echo for suspected valve disease and assessment of cardiac function. 4.85% were referred for isotope stress perfusion scanning. 2.34% of patients had peripheral vascular disease, of which 45% had a history of major cardiac disease. CONCLUSIONS: Open access chest pain clinics can expect to generate significant imaging workloads. As new imaging techniques for coronary disease become accepted, the emphasis on the use of traditional imaging techniques may change.

### Morphological determinants and functional significance of traction bronchiectasis in patients with idiopathic pulmonary fibrosis

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PURPOSE: To evaluate the morphological determinants and physiological significance of traction bronchiectasis seen in patients with cryptogenic fibrosing alveolitis (CFA). METHODS: CT scans of 212 patients with CFA (158 males; age  $62.2 \pm 10.6$  years) were independently reviewed by two radiologists. The extent or severity of CT abnormalities (including the severity of traction bronchiectasis (0, none; 1, mild; 2, severe)) were quantified at five levels. RESULTS: Traction bronchiectasis was demonstrated in 202/212 (95%) patients (mean severity score  $3.7 \pm 2.0$ ). Increasingly severe traction bronchiectasis was independently associated with increasing disease extent ( $p<0.0005$ , regression coefficient (RC) 0.055, 95% CI 0.046 to 0.065), a higher coarseness score ( $p<0.0005$ , RC 0.18, 95% CI 0.09 to 0.28) and the absence of emphysema ( $p<0.0005$ , RC -0.03, 95% CI -0.044 to -0.017). Extent of CFA and emphysema were the major determinants of functional impairment. However, increasingly severe traction bronchiectasis was also independently related to decreased DL<sub>CO</sub> ( $p<0.005$ , RC -1.7, 95% CI -2.8 to -0.6), FVC ( $p=0.02$ , RC -2.0, 95% CI -3.7 to -0.3) and arterial pO<sub>2</sub> ( $p<0.0005$ , RC -0.31, 95% CI -0.48 to -0.14). CONCLUSIONS: Traction bronchiectasis is a CT feature in the majority of patients with CFA and is associated with

added functional impairment for a given extent of fibrosis. However, the severity of traction bronchiectasis on CT is substantially reduced when associated with concurrent emphysema.

#### **Initial evaluation of technetium-DTPA pulmonary clearance studies in radiation pneumonitis**

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**PURPOSE:** To evaluate the detection and distribution of radiation pneumonitis using  $^{99m}\text{Tc}$ -DTPA pulmonary clearance. **MATERIALS AND METHODS:** Clearance of  $^{99m}\text{Tc}$ -DTPA administered by aerosol is a sensitive technique for the detection of change in alveolar epithelial permeability as occurs in response to radiation. We prospectively examined the utility of this test in patients undergoing radiotherapy for carcinoma of the bronchus. Clearance studies using a proprietary generator and nebulizer (Amertec) were obtained before treatment, immediately after treatment, and 1 month and 4 months later. Clinical assessment, pulmonary function tests and high resolution CT (HRCT) were carried out at similar times. Data were compared for the presence, severity and time of appearance of changes. **RESULTS:** Of 13 patients entered into the study, 1 died and 4 were withdrawn on medical grounds. Of the remaining eight patients, seven showed definite changes in pulmonary clearance, which occurred by the post-treatment examination in five. Clearance in one patient remained unchanged. A striking observation was abnormal clearance in the untreated lung in all patients, which was sometimes more pronounced than in the treated lung. No correlation was observed with radiation dose and treatment regimen. Overall, pulmonary clearance was the most sensitive technique; three patients showed changes on HRCT later than changes in clearance. **CONCLUSIONS:** This study provides evidence supporting the view that pulmonary irradiation has a systemic, in addition to local, effect. This pilot study suggests pulmonary clearance is currently the most sensitive means of evaluating altered alveolar permeability in radiotherapy.

#### **Comparison of digital chest radiographs with conventional radiographs for visualization of the horizontal fissure and its clinical significance**

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**PURPOSE:** A good quality chest radiograph is expected to show the normal anatomical landmarks. One of the very useful anatomical landmarks for the interpretation of chest radiographs is an interlobar fissure of the lung, which has an average thickness of 0.2 mm, and this could be used as an objective test for the quality of chest radiographs. The aim of this study was to compare digital chest radiographs with conventional radiographs for visualization of the horizontal fissure. **MATERIAL AND METHOD:** 300 normal digital chest radiographs obtained on our new digital radiography system (Canon CXDI-11) were assessed for visualization of the interlobar horizontal fissure. **RESULTS:** The study showed that the fissure was visible in 77% of digital films compared with the reported incidence of 52% on conventional radiographs. Mann-Whitney *U*-test showed that there was a significant association between age and visualization of the horizontal fissure, the fissure being better shown in the older age group. **DISCUSSION:** The digital images were shown to provide good image quality, improved contrast and wider latitude. There are other distinct advantages of digital radiography, e.g. image post-processing and image manipulation including magnification, image rotation, annotation and zoom facilities. Various examples of accessory fissures of lung on digital films will be shown, along with the clinical relevance of each case.

#### **Transthoracic ultrasound of the diaphragm in malignant pleural effusion**

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**PURPOSE:** To evaluate the role of transthoracic ultrasound of the diaphragm in patients with suspected malignant pleural effusion. **METHOD:** 20 patients presenting with suspected malignant pleural

effusions were examined with thoracic ultrasound. The diaphragm was subjectively assessed and the diaphragm thickness was measured. The presence or absence of non-diaphragmatic pleural nodularity or thickening was also noted. **RESULTS:** Malignancy was proved either cytologically, histologically or thoracoscopically in 19/20 patients. In one patient with a proven primary malignancy, pleural fluid cytology was repeatedly negative. In 10/20 patients the diaphragm thickness measured at least twice (range 4–9.5 mm) that of a published normal mean figure (2 mm). In 14/20 patients the diaphragm appeared subjectively abnormal. In 15/20 patients the non-diaphragmatic pleura appeared normal, with no evidence of nodularity. Of these 15 patients, the diaphragm was abnormal in 11 and normal in 4. **CONCLUSION:** Malignant pleural effusions are commonly associated with diaphragm thickening and/or nodularity as detected by thoracic ultrasound. In patients with suspected malignant pleural effusions and ultrasonographically normal non-diaphragmatic pleura, diaphragm assessment may be of value in predicting the presence of malignancy.

## **Scientific Session**

### **Professional and Educational Aspects**

#### **Work in Progress**

##### **Professional role model identification by diagnostic and therapy radiographers: a study of Sydney**

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**PURPOSE:** The objective of this research is to determine how diagnostic and therapy radiographers identify role models within their workplace environment. Social and psychological identification of desirable professional characteristics comes from either identification of belonging to a group or from recognizing similarities between the individual and the group that is most admired. It can be postulated that obstacles to professional growth may rest with behavioural models accepted by the workplace or by the radiographers themselves. **METHOD:** A pilot study was conducted with eight target centres, representing diagnostic and therapy workplaces ranging from large teaching hospitals to small community hospitals (with the inclusion of two private hospitals). These centres were all located within the Sydney Area Health Services. The research methodology consisted of a structured interview. A hierarchical percentage of participants, ranging from chief/manager, charge/senior, junior and recently graduated diagnostic and therapy radiographers, were asked to participate in the interview process. **DISCUSSION:** The benefits of this research are to advance the attainment of professional growth by diagnostic and therapy radiographers by identifying the characteristics of a role model and their relative strengths. The results demonstrate a mismatch between the ideal characteristic composition and the self-perception of the participants as a professional role model.

#### **Work in Progress**

##### **The radiographer's role in child protection**

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**PURPOSE:** To devise a holistic picture of the extent to which diagnostic radiographers approach child protection issues. Also to explore the profile of radiographers within the radiography profession and amongst other agencies as to their role in the chain of evidence relating to child protection issues with children who present at the Imaging Department with suspected non-accidental injury. **METHOD:** A qualitative methodology was used throughout the study. Initially, trigger questions were used in a focus group scenario with paediatric radiographers to formulate issues and potential areas of investigation regarding radiographers and their involvement in child protection. An interview schedule was developed from the findings of the focus groups. The above was used as a basis for semi-structured interviews using a snowball sampling technique with paediatric radiographers across the country. Participant observation was used in Social Services, Police and Court settings to look at child protection issues. The results were triangulated against each other. A way forward to actively engage radiographers in child protection is currently being developed.

### Work in Progress

#### The impact of intrinsic and extrinsic variables on diagnostic radiographer-patient interactions

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**PURPOSE:** This research consisted of two distinct stages. The first stage identified the way in which radiographers interact, and an observation schedule was designed to conduct further research in this area. The second stage made use of this observation schedule and aimed to assess the impact of variables, *e.g.* time constraints, on radiographer interaction styles. **METHODS:** In stage 1, a descriptive study design was employed to identify radiographer interactions. Stage 2 used a predictive study design to assess the impact of nine independent variables on these interactions. In stage 1, radiographer-patient interactions were observed. The results of these observations were analysed and an observation schedule was designed. Subsequent interviews validated the results with radiographers self-reporting what had been observed. In stage 2, structured observations of radiographer interactions took place. Notes were made on nine independent variables thought to affect radiographer interactions. These results were analysed using  $\chi^2$  analysis. **RESULTS:** Stage 1 revealed that radiographers interact using five interaction styles. These "interaction styles" are categorized according to Berne's Transactional Analysis Theory and are known as: nurturing parent; critical parent; adult; free child; and adapted child.  $\chi^2$  analysis demonstrates that patient throughput ( $p=0.002$ ), communication level ( $p=0.000$ ), modification of radiographic technique ( $p=0.002$ ), years qualified ( $p=0.020$ ), age of the patient ( $p=0.000$ ), age of the radiographer ( $p=0.000$ ) and gender of the radiographer ( $p=0.001$ ) were significant in the choice of interaction style. No significance was found between gender of the patient ( $p=0.357$ ) or ethnicity of the patient ( $p=0.067$ ).

### Work in Progress

#### Changes in the learning styles of radiography students: a longitudinal study

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**PURPOSE:** This work is a continuation of that presented last year and explores the learning style preferences of student radiographers and whether this style changes as they progress through their undergraduate radiography education programme. Data from the beginning of each of 3 years of one cohort have now been obtained. **MATERIALS AND METHOD:** Learning style questionnaires (Kolb Learning Style Inventory 1985) were distributed to the 1998 cohort of undergraduate radiography students at the beginning of their radiography education and again at the beginning of their second and third years of study. From this, learning style preferences were ascertained. **RESULTS:** 17 students were common to all three groups. Eight students changed their learning style between Levels I and II but retained that style between Levels II and III. Four students retained the same style between Levels I and II but changed their style between Levels II and III. One student moved between three different styles, three students retained the same style throughout and one student changed style between Levels I and II but returned to the original style by the beginning of Level III. The predominant learning style preference at Level III was converger (47.1%,  $n=8$ ). The remainder were assimilators (29.4%,  $n=5$ ), accommodators (17.6%,  $n=3$ ) and divergers (5.9%,  $n=1$ ). This spread reflects the preferred learning style of radiographers. **CONCLUSIONS:** Over the period of data collection, the group has shown a tendency towards the convergent style, a style typical of those in technical professions. The study is due to be completed later this year when the sample group approach graduation.

### Work in Progress

#### Help or hindrance: RDAs' views of an NVQ

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**PURPOSE:** To establish the views of Radiology Department Assistants (RDAs) on the impact of the National Vocational Qualification (NVQ) in Diagnostic and Therapeutic Support (D&TS) on their work role. **METHOD:** The University Hospitals of Leicester NHS Trust offered its first D&TS NVQ in November 1999. This first cohort of

RDAs ( $n=9$ ) were asked to write a short essay at this time, outlining their expectations of the NVQ. These essays were analysed by the author and categories were developed. The five categories represented areas of anticipated benefit and were used to generate a simple questionnaire with forced-response Likert scaling. The questionnaire was administered to the RDAs ( $n=8$ ) after they had completed approximately two-thirds of the NVQ. **RESULTS:** At the beginning of the course, the RDAs described overwhelmingly positive expectations. The five areas of anticipated benefit that emerged at this time were: "increased knowledge, increased skill, closer team working, improved patient care and greater personal satisfaction". A further category (improved study skills) was added by the author. After two-thirds of the course had been completed, the questionnaire elicited a range of responses. The only area in which all respondents gave a positive response was "increased knowledge". Categories that scored the next highest were "greater personal satisfaction" and "improved study skills". The "improved patient care" category received the lowest score. **CONCLUSION:** Although a small-scale study, this work highlights the mismatch between RDAs expectations before commencing an NVQ and the impact of the qualification on their work role.

## Scientific Session

### Radiography Management

#### A decade of quality management system implementation in radiology

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In April 1990, a plan was put into action to implement the first quality management system in a British radiology department. Two departments started the programme, St George's Hospital, London and Bristol Royal Infirmary. This paper discusses the continued working of the programme at Bristol Royal Infirmary. The project involved all levels of staff in the X-ray department, leading to quality manuals in all aspects of the working of the department. After 18 months, the Bristol Royal Infirmary X-ray department was assessed by BVQI and accredited to standard BS 5750 (1987). In subsequent years there have been surveillance visits every 6 months and re-assessment every 3 years. Minor non-compliance has been noted at some visits and the department has been able to correct these problems on all occasions. The programme has proved to be popular with staff. This quality assurance programme pre-empted many of the changes subsequently introduced by clinical governance. It is now of considerable benefit in developing strategies, since most of the requirements run in tandem and the groundwork is already in place. The programme is also proving to be useful in working towards the requirements of the new ionising radiations regulations (IRR99 and IRMER2000). Problems can be met in implementation of such a system and it is most imperative that management is committed to the programme.

#### Multipurpose C-arm fluoroscopy systems for both conventional and interventional examinations

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**PURPOSE:** To assess whether multipurpose C-arm fluoroscopy systems are as "universal" as claimed. **METHOD:** KCARE evaluators assessed five multipurpose systems as part of a comparative project for the Medical Devices Agency. The assessment covered the use of the units for both conventional and interventional examinations. These evaluations included: observing the systems in use; an ergonomic assessment; and in-depth discussions with the users. **RESULTS:** The current multipurpose C-arm fluoroscopy systems were found to be more than adequate for the majority of examinations traditionally performed on conventional RF systems. The only major exception was barium enemas, where most users considered the tables to be too narrow for safe manoeuvring of the patients during the examination. The main limitation to the use of the systems as an angiography unit is the level of software installed and the ancillary equipment purchased. A number of manufactures offer both conventional and/or interventional systems to suit the users needs. **CONCLUSION:** Multipurpose C-arm fluoroscopy systems have an important role to play in smaller

departments in filling the gap between RF units and dedicated angiography systems. In larger departments they can fulfil most of the functions of an RF unit and can be used as a back-up to the angiography system.

#### **Does manual handling training influence attitudes and beliefs towards patient handling?**

F G Canning

*Department of Radiography, City University, London EC1M 6PA, UK*

**PURPOSE:** There is controversy in the literature regarding the success of manual handling training courses. Thus, the purpose of this study was to determine whether such training positively influenced the attitudes and beliefs of staff towards patient handling. **METHODS:** Pre- and post-training assessments of attitudes and beliefs were obtained by a quasi-experimental design. This involved administration of a questionnaire directly before and after training to 161 trainees over five centres in London and the south-east. This was followed up with a semi-structured interview to five respondents. Wilcoxon tests were performed on the pre- and post-training scores. Mann-Whitney and Kruskal-Wallis tests were performed on the different occupational groups. **RESULTS:** The results support the notion that training courses positively affect attitudes and beliefs towards patient handling. In addition, nurses appear to have considerably more training than other health care workers. However, behaviour on returning to work appears to be influenced by a range of factors, including availability of equipment, adequacy of training, environmental constraints and the attitudes of colleagues, especially older colleagues. **CONCLUSION:** The benefit of training may be short lived if not reinforced, particularly where there is inadequate equipment and a poor ergonomic environment.

#### **Direct access pre-clinic neurological scanning: a waiting list initiative**

S Messer, C Grist, J Henson, S Wimalaratna and A Troughton

*Department of Radiology and Neurology, Princess Margaret Hospital, Swindon SN1 4JU, UK*

**PURPOSE:** In the Swindon & Marlborough NHS Trust, there are heavy demands on the neurological outpatient service. We describe an initiative aimed at reducing the number of neurological outpatient appointments, and hence shortening the waiting list. This is achieved by offering a pre-clinic CT or MRI scan for patients presenting with specific neurological symptoms. **METHOD:** The neurologist, in conjunction with GPs and a consultant radiologist, identified a number of clinical criteria for patients in whom a negative pre-clinic scan would obviate the need for an outpatient appointment. These involved patients in whom the following conditions needed to be excluded and yet in whom there was a low suspicion of pathology: CVA, dementia, headaches, demyelinating disease, space-occupying lesion and epilepsy. Those patients with a negative scan result would then continue to be treated by their own GP. Referral guidelines were sent to GPs allowing them direct access for pre-clinic scanning of those patients meeting the clinical criteria. The scan request forms were then reviewed and protocolled by a radiologist before the patient being booked for a scan. **RESULTS:** 61 (61%) of the referrals for this scheme proved to be normal and no outpatient appointment was considered necessary. **CONCLUSION:** When appropriate guidelines can be agreed by neurologists, GPs and radiologists, pre-clinic scanning limits the number of outpatient referrals and hence reduces the length of neurological outpatient waiting lists.

#### **What takes time in CT scanning?**

J M Bell, B Ying and C Keirl

*X-Ray Department, Musgrove Park Hospital, Taunton TA1 5DA, Somerset, UK*

**PURPOSE:** A time and motion study was undertaken to determine the proportions of time taken by the different activities involved in CT scanning. The objective was to identify areas where organizational or staffing changes could improve efficiency. **METHOD:** An independent researcher spent a week based in the CT room recording the timing of events. During this week, 71 outpatients and 43 inpatients were scanned. The largest categories were head scans (47%), thoracic scans (11%) and abdominal plus pelvic scans (16%). **RESULTS:** In a 43¼ h working week, 86% of time was spent examining patients. The

other 14% was spent getting patients in and out of the CT room and in gaps between patients. 48% of the time examining patients represented data acquisition and image reconstruction; the remainder was spent getting patients on and off the table, giving iv contrast medium and awaiting radiologists' decisions regarding contrast administration or scan completion. Inpatient head scans took significantly longer than outpatient scans, although this difference disappeared if a post-contrast scan was also performed. Inpatient abdominal and pelvic scans took significantly longer than outpatient scans. Many patients had more areas scanned than were allowed for in the booking schedule. Most of these had additional scans after iv contrast medium; others had abdominal scans extended to include the pelvis. 34% more scans were performed than had been booked. Gaps between patients were shortest when the scanner was staffed by one radiographer and one healthcare assistant. **CONCLUSION:** As a result of this study, changes have been made to booking practices and staff rotas.

#### **Imaging and oncology: the future development of occupational standards**

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*Department of Radiography, University of Hertfordshire, College Lane, Hatfield, Hertfordshire AL10 9AB, UK*

Results of a 1-year project funded by the NHSE Eastern Region education innovation fund, exploring the potential for the continued development of occupational standards in imaging and oncology, will be presented. **PURPOSE:** The project had three main aims, which were to establish: whether employees within imaging and oncology supported the development of specific occupational standards; the level of existing knowledge that practitioners had regarding occupational standards; what occupational standards are currently available that could be implemented in imaging and oncology. **METHODS:** Two nationwide surveys of employees within imaging and oncology were undertaken ( $n=816$  and  $n=1062$ , respectively), followed by a series of focus groups to further develop themes and ideas. Ways of disseminating information about occupational standards were also examined within the focus groups. **RESULTS:** Despite development of occupational standards being government led, the report found widespread confusion regarding the application of occupational standards. Employees also identified resources as a major factor influencing development and implementation. **CONCLUSIONS:** Situations that would lead to development and implementation of occupational standards in imaging and oncology are identified as: specific skill areas involving all health personnel regardless of background, *i.e.* health promotion; service delivery where multi-professional foci have developed, *i.e.* diagnostic ultrasound; changes that are implemented by the government, *i.e.* the breast screening programme; service delivery where stress within the profession has motivated the need to structure changes, *i.e.* the cancer therapist. The report recommends that future development of occupational standards may be best managed by incremental change.

#### **Recruitment from Black and minority ethnic communities to health care professions**

R Klem and J Notter

*Faculty of Health and Community Care, University of Central England in Birmingham, Birmingham B42 2SU, UK*

This paper reports the findings of a study within the West Midlands based on action research and funded jointly by the NHSE Equal Opportunities Unit and NHSE West Midlands. Recruitment to radiography and other careers in the NHS is currently of national concern, particularly given developments in service delivery and anticipated expansion following publication of the NHS Plan for England. Meeting the need requires strategies that ensure access to all possible sources of recruits. Given that Britain is a culturally diverse society, it is implicit that such strategies include those that facilitate recruitment from all sections of the community. This study explored factors affecting recruitment and retention of individuals from Black and minority ethnic communities to nursing and professions allied to medicine (PAMs). Interviews with community groups and analysis of students' education and training experiences informed the development of questionnaires that were distributed to a wider population to identify knowledge about, and perceptions of, health care careers within Black and minority ethnic communities. Focus group interviews with 170 students and survey responses from over 500 members of minority ethnic

communities provided rich and detailed insight into attitudes within the communities and within the NHS. Analysis of these data resulted in recommendations for both the education sector and the NHS in addressing issues associated with recruitment, specifically from Black and minority ethnic communities, but also to support recruitment to health care professions more generally.

#### Questioning the value of CPD

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<sup>1</sup>Division of Professions Allied to Medicine, South Bank University and <sup>2</sup>Radiography Department, City University, London, UK

This paper presents the results of collaborative research undertaken in association with the Society of Radiographers to assess attitudes towards mandatory CPD (now and after the introduction of a mandatory policy). **METHOD:** A questionnaire was designed and piloted and then posted to 250 radiographers randomly selected from the CPD register. 141 questionnaires were returned, of which 128 were usable. **RESULTS:** The study showed that 65% of radiographers felt that CPD should be mandatory, but that only 26% of respondents felt that all radiographers undertook CPD. A significant difference in attitude towards mandatory CPD existed between those undertaking CPD and those who were not ( $p=0.027$ ). Also noted was that 69% of radiographers expected clinical governance to impact positively on CPD behaviour, but only 40% of respondents were currently recording CPD. Of those who were recording CPD, 71% were using a paper-based system, and only one respondent was using the COR PDM. **CONCLUSION:** The percentage of radiographers stating that CPD should be mandatory is higher than previous UK studies and may indicate an increasing acceptance of CPD. The low number of radiographers that felt all radiographers were doing CPD may question the value and worth that radiographers place on it and introduces a fundamental need to demonstrate worth to increase positive attitudes and hence participation in CPD. This study raises some new issues in the field of CPD, which are essential considerations if radiography is to move forward in the CPD arena.

### Scientific Session

#### Modelling Imaging Systems

##### The effect of noise sources on the detective quantum efficiency of digital mammography detectors

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We have measured the signal and noise transfer properties of a number of detectors used for digital mammography. These detectors use different X-ray phosphors and means of coupling the phosphor to the optical read-out device. We have examined the effect of the X-ray phosphor material and screen configuration (front or back) on the transfer of signal and noise by the X-ray detector. A theoretical model was used to predict the shape of the MTF and X-ray quantum noise power spectrum. The effect of the coupling efficiency of light from the phosphor to the optical read-out device and the detector gain was quantified. The effect of the various noise sources on the spatial frequency dependent detective quantum efficiency of the different detectors will be illustrated.

##### Simulation of Leeds N3 test object to investigate fluoroscopic frame averaging

<sup>1</sup>A J Reilly, <sup>2</sup>D G Sutton and <sup>1</sup>C L Lyon

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**PURPOSE:** Averaging fluoroscopy frames reduces the level of Poisson noise in an image, although the consequent motion "smearing" artefact becomes more pronounced as the number of averages increases. Monte Carlo simulations have been run using a mathematical model of the Leeds N3 test object (TO.N3) to determine the optimum number of averages. **METHOD:** TO.N3 consists of discs of different materials and thicknesses embedded in a block of PMMA. In the model, the nature of these discs is unimportant as long as the correct contrasts

are reproduced under standard conditions (70 kV, 2 mm added Cu filtration). All discs were modelled as 2 mm of Al, and the desired contrasts were obtained by varying the density of the discs. Densities were calculated using our previously published model of an image intensifier system working under automatic brightness control (ABC). This was also employed to determine the mA necessary for generating a 1/30th s fluoroscopy frame by the Monte Carlo simulation. Threshold contrast and overall noise level were calculated for different numbers of frame averages. **RESULTS:** Although it was found that threshold contrast does not vary significantly with the number of averages, the overall noise level decreases with increasing averages, tending asymptotically towards that of a no noise image. Between four and eight averages were optimal, with many more frames being required before significant further improvement was obtained. **CONCLUSION:** The optimum number of frame averages has been determined for a particular system based on consideration of noise level alone. There is no advantage of taking more averages, since this will exacerbate the smearing effect whilst achieving negligible improvement in noise level.

##### Optimization: utilization of Monte Carlo methods to generate images and to calculate doses in diagnostic radiology

<sup>1</sup>A J Reilly, <sup>2</sup>D G Sutton and <sup>1</sup>C L Lyon

<sup>1</sup>Department of Bio-Medical Physics and Bio-Engineering, Aberdeen Royal Infirmary, Aberdeen AB25 2ZD and <sup>2</sup>Department of Medical Physics, Ninewells Hospital & Medical School, Dundee DD1 9SY, UK

**PURPOSE:** Optimization requires an investigation of the balance between patient dose and image quality. A framework has been developed for using Monte Carlo methods to generate full field of view images and to calculate doses in a simulated system. This has been utilized specifically to model an image intensifier, but can be applied to other systems. **METHOD:** Transport of photons from the X-ray tube to the image receptor is performed by the Monte Carlo code MCNP and the simulation is run until the dose distribution at the surface of the receptor is calculated to better than 1%. Poisson noise is added by a generator function, and other noise sources can be considered in a similar manner. A dose-response function is used to calculate a display parameter. When modelling an image intensifier, the input phosphor is considered a rectangular slab of CsI of dimensions 23 cm × 23 cm × 0.055 cm, with doses calculated in a 1024 × 1024 voxel grid. To facilitate parallel computing, the image is divided into 64 squares, each of which is generated independently. A sigmoid response function determines the grey level of TV pixels from the dose in each voxel during a 1/30th s fluoroscopy frame. **RESULTS:** Doses calculated in a variety of geometries were in excellent agreement with experimental results. Approximately 12 h were required to produce an image of a test object when running 10 workstations in parallel. **CONCLUSION:** The model can be used to calculate doses and to generate images. By considering operator-response curves, it will be possible to apply the model to the optimization of radiological procedures.

##### Medical rapid prototyping

P Diamantopoulos and J D Richardson

Biomedical Modelling Unit, School of Engineering, University of Sussex, Brighton BN1 9QT, UK

**PURPOSE:** CT and MRI provide valuable high resolution images of internal structures of the human body for diagnostic purposes. This work describes how medical scanner data can be used to produce physical hard copies of the human anatomy via rapid prototyping (RP) techniques. **METHOD:** Medical images can be utilized from most CT or MRI scanners. Format recognition for most native scanner formats is available for processing data. Regions of interest are automatically segmented, visualized and exported in a format acceptable to common RP systems. The physical anatomical models are produced by stereolithography and developed in Stereocool, a special medical grade resin that can be selectively coloured. **RESULTS:** Medical RP models (biomodels) can accurately represent the human anatomy and allow the selective colouring of tissues of interest. The colouring can be used for marking specific regions (e.g. tumour, fracture, bone calcification, dental root). Biomodels deliver visual and tactile information for diagnostic, therapeutic and didactic purposes. They are used for planning and rehearsing complex surgery and they act as a master or negative for the design of (customized) implants. **CONCLUSION:**

Medical RP can offer enormous potential in medicine. The tangible three-dimensional (3D) information of a solid model combined with selective colouring represents the most advanced real-time 3D representation of anatomical structures as well as the ultimate diagnostic and pre-operative planning tool. The described process is rather new and still unknown to many people working in the medical sector but applications in various medical fields have been investigated and have shown many benefits.

### **Integrating medical imaging and applied engineering technologies**

P Diamantopoulos and J D Richardson

*Biomedical Modelling Unit School of Engineering University of Sussex, Brighton BN1 9QT, UK*

**PURPOSE:** Medical imaging and engineering design technologies have been two distinctive areas of work. The communication of data between the two fields would greatly facilitate the analysis of anatomical systems for many purposes including pre-operational planning and design of custom made implants. The aim of this work has been to identify a practical and accurate method for the interface of medical imaging data to computer aided design (CAD), finite element analysis (FEA) and rapid prototyping (RP) environments for the visualization, simulation and model generation of anatomical structures. **METHOD:** CT and MRI medical images of Siemens, GE, Elcinct, and Philips scanners, representing different anatomical areas, provided the input data. A system of software titles was developed and examined for communicating the data to FEA, CAD and RP environments. **RESULTS:** Medical imaging data of the skull, spine, shoulder, knee and hip were successfully interfaced, visualized, modelled and simulated in an engineering software environment. RP physical models of the scanned anatomy were developed. **CONCLUSION:** A practical and accurate software system was identified for the interface of medical imaging data to an engineering environment. The described system can successfully be used for the realistic modelling and simulation of various body structures. It is possible to use the developed procedures within a hospital environment and introduce new ways of visualizing and using medical scanner data. The identified method can be applied for diagnosis, pre-operative planning, implant design and educational purposes.

### **Low energy electronic portal imaging using high energy bremsstrahlung beams**

S Fiampouri, P M Evans, A E Nahum and F Verhaegen  
*Physics Department, Institute of Cancer Research, Sutton SM2 5NG, UK*

**PURPOSE:** The contrast available in megavoltage portal imaging is intrinsically limited by the design of the accelerator target, which absorbs most of the low energy photons, and by the relatively low attenuation by the body of high energy photons. To improve the image quality, an "imaging" operating mode on the linear accelerator (linac) encompassing the optimum combination of bremsstrahlung target and detector, taking into account the patient's thickness, has been investigated. **MATERIALS AND METHODS:** A 4 MeV unflattened photon beam produced by an external thin, medium Z target (1.6 mm Cu) was configured in an SL25 accelerator. Images of a contrast phantom taken with the experimental beam and with the treatment 6 MV photon beam were compared. Monte Carlo simulations were used for the investigation of the influence of target parameters on image contrast. Simulated spectra produced by targets with a wide range of atomic numbers and thicknesses were used to calculate signal on detector from different tissue-equivalent absorbers. Theoretical contrast was calculated from signals from water of varying thickness and from bone embedded in water. **RESULTS:** The contrast increased as the target atomic number and thickness decreased. For W, Cu and Al targets, the contrast produced by 1 cm bone embedded in 11 cm water was 3.3%, 4.2% and 5.5%, respectively. This effect decreased with increasing total attenuator thickness. Varying the thickness of the target affected the image contrast less than the atomic number. Initial results showed that changing the bremsstrahlung target of the linac could significantly improve the contrast of portal images if the detector is sensitive to the low energy photons.

### **3D rotational angiography: is there significant distortion?**

<sup>1</sup>R R Bridcut, <sup>1</sup>R J Winder, <sup>1</sup>A Workman and <sup>2</sup>P Flynn  
*<sup>1</sup>Northern Ireland Regional Medical Physics Agency and <sup>2</sup>Department of Neuroradiology, Royal Victoria Hospital, Belfast BT12 6BA, UK*

**PURPOSE:** The purpose of this project was to determine the degree of geometrical distortion in a 3D image volume generated by a digital fluorography system with rotational image acquisition capabilities. 3D imaging is important in neuroangiography for the measurement of cerebral aneurysms, the determination of the optimum projection for visualisation and planning for interventional procedures. To enable spatially accurate 3D reconstruction, the system must correct for geometrical distortion in the image intensifier and deviations in gantry motion. **METHODS:** All measurements were made on a Philips Integris BV5000. 3D volumes were reconstructed from 100 X-ray projections acquired over a 180° arc. A phantom was constructed to assess geometrical distortion in the three dimensions. This consisted of 1 mm diameter ball bearings embedded in Perspex in a cubic lattice configuration. The ball bearings were placed at 2 cm intervals over a 12 cm cubic volume. Distortion was assessed by taking measurements between points of known separation and also using a differential distortion measurement. **RESULTS:** The mean error in the 3D location of objects was found to be 0.4 mm, with a maximum error of 1.4 mm. The mean distortion was found to be 0.3%, with a range from -1.0% to +2.3%. **CONCLUSION:** A phantom has been developed to enable assessment of the distortion in 3D images from a 3D rotational angiography system. The 3D images were found to have clinically insignificant distortion, enabling distance measurements to be used with confidence to aid intervention.

### **Workshop**

#### **How Do I Do It? Practical tips in thorax intervention**

**Invited Review**

**Central line insertion**

J E Jackson

*Department of Radiology, Hammersmith Hospital NHS Trust, Du Cane Road, London W12 0HS, UK*

**Invited Review**

**Thoracic biopsy and drainage**

F V Gleeson

*Department of Radiology, Churchill Hospital, Old Road, Headington, Oxford OX3 7LJ, UK*

### **Royal College of Radiologists**

#### **Tesla Lecture**

**Eponymous Lecture**

**Imaging the prostate—opportunities and dilemmas**

H Hricak

*Department of Radiology, Memorial Sloan Kettering Centre, New York, NY 10021, USA*

Advances in medical imaging, including the development of new modalities and improvements in established methods, are driven by clinical requirements and the demand for patient-specific therapy. As sophisticated treatments are developed, dependence on medical imaging is increasing. Expectations are also changing, with evaluation of "biological tumour volume" and molecular imaging becoming the goals of the new millennium. The role of imaging in prostate cancer diagnosis, treatment and surveillance is continually evolving. Imaging recommendations range from denial to strong advocacy for imaging prior to therapy decision. Considering the disagreement about prostate cancer detection and choice of treatment, the debate regarding imaging is not surprising. Bone scan and CT supplement clinical and biochemical evaluation (PSA, prostate acid phosphatase) in the search for suspected metastatic disease, with accepted appropriateness criteria for their use. Guidelines for evaluation of locoregional extent, however, have not been established and the diagnostic efficacy of both TRUS and MRI remains debatable. Although endorectal MRI shows the most promise for local staging, its role is controversial due to its high cost and variable diagnostic accuracy. The recent

development of MR spectroscopic imaging expands the diagnostic assessment beyond anatomical information. MR spectroscopic imaging provides metabolic information specific to the prostate through the detection of the cellular metabolites citrate, creatine and choline. The information obtained from this new technology may allow an expanded assessment of tumour aggressiveness and the attendant risk of disease progression.

## Workshop

### Creating PowerPoint Presentations: intermediate/advanced

How to create PowerPoint presentations: intermediate/advanced

M Tatlow

*Division of Professions Allied to Medicine, Faculty of Health Sciences, South Bank University, London SE1 0AA, UK*

## Workshop

### Continuing Professional Development

Invited Review

Continuing professional development—what happens next?

S Kelly

*Manchester, UK*

## Controversy

### Is Spiral Unenhanced CT the Imaging Method of Choice in Ureteric Calculi?

Invited Review

The urologist's requirements

H Whitfield

*Urology Department, Middlesex Hospital, Mortimer Street, London W1N 8AA, UK*

Invited Review

Advantages of spiral unenhanced CT

S C Rankin

*Radiology Department, Guy's & St Thomas' NHS Trust, St Thomas' Street, London SE1 9RT, UK*

Invited Review

A district general hospital radiologist's perspective

C George

*Radiology Department, Epsom General Hospital, Epsom Healthcare Trust, Dorking Road, Epsom KT18 7EG, UK*

## Advances

### Computer-aided Diagnosis

Invited Review

Computer-aided diagnosis—future possibilities

S Astley

*Imaging Science and Biomedical Engineering, University of Manchester, Stopford Building, Oxford Road, Manchester M13 9PT, UK*

Invited Review

Do radiologists need computer assistance in reading films?

P J Robinson

*Department of Clinical Radiology, St James' University Hospital Trust, Beckett Street, Leeds LS9 7TF, UK*

Invited Review

Evaluating radiologists' reading performance—how can they be helped?

A G Gale

*Institute of Behavioural Studies, University of Derby, Kingsway House, Kingsway, Derby DE22 3HL, UK*

Invited Review

Computer-aided detection in clinical radiology

R Castellino

*Atherton, CA 94027, USA*

## Advances

### MRI of Tumour Angiogenesis: research or clinical tool

Introduction

J Husband

*Department of Radiology, Royal Marsden NHS Trust, Downs Road, Sutton, Surrey SM2 5PT, UK*

Invited Review

Techniques and results in pelvic cancer

J O Barentsz

*Department of Radiology, University Hospital Nijmegen, PO Box 9101, Nijmegen 6500 HB, The Netherlands*

Invited Review

Techniques and results in breast cancer

L W Turnbull

*Centre for MR Investigations, Hull Royal Infirmary, Anlaby Road, Hull HU3 2JZ, UK*

Invited Review

Future applications of multifunctional MR studies

A S K Dzik-Jurasz

*Academic Department of Radiology, Institute of Cancer Research, Royal Marsden Hospital, Downs Road, Sutton SM2 5PT, UK*

Invited Review

Therapeutic implications

A Padhani

*The Paul Strickland Scanner Centre, Mount Vernon Hospital, Rickmansworth Road, Northwood HA6 2RN, UK*

## Debate

### Pulmonary Embolism

Invited Review

CT of pulmonary embolism

D Hansell

*Radiology Department, Royal Brompton & Harefield NHST, Sydney Street, London SW3 6NP, UK*

Invited Review

Pulmonary embolism—VQ

A M Peters

*Department of Nuclear Medicine, Addenbrooke's Hospital NHS Trust, Hills Road, Cambridge CB2 2QQ, UK*

Invited Review

MR of pulmonary embolism

C Herold

*Department of Radiology, General Hospital, University of Vienna, Währinger Guertel 18-20, Vienna A-1080, Austria*

## Debate

### A Global Perspective

Invited Review

The USA perspective

R Carlton

*Radiological Sciences Box 910, Arkansas State University, Chickasaw Hall, 106 N Carraway Road, Arkansas, AR 72467, USA*

**Invited Review****The Australian perspective**

T Smith

*Faculty of Medicine and Health Sciences, The University of Newcastle, Newcastle, New South Wales, Australia***Invited Review****The UK perspective**

R Price

*Department of Radiography, University of Hertfordshire, College Lane, Hatfield AL10 9AB, UK***History Session****The Centenary of Röntgen's Nobel Prize****Invited Review****Röntgen and the Nobel Prize**

A Thomas

*Department of Clinical Radiology, Bromley Hospitals NHS Trust, 17 Cromwell Avenue, Bromley, Kent BR2 9AJ, UK***Invited Review****Röntgen's other experiments**

P Dawson

*Department of Radiology, The Middlesex Hospital, University College London Hospitals, Mortimer Street, London W1N 8AA, UK***Invited Review****Early radiation protection guidelines**

P Hollaway

*Royal Surrey County Hospital, St Luke's Wing, Egerton Road, Guildford GU2 5XX, UK***Invited Review****The origins of neuroradiology**

I Isherwood

*University of Manchester, Woodend House, Strines Road, Disley, Cheshire SK6 7GY, UK***Invited Review****Early Birmingham radiologists—Dr John****Hall-Edwards**

A K Banerjee

*Birmingham Heartlands Hospital, 11 Greswolde Road, Solihull B91 1DZ, UK***Advances****Technological Update (1)****Invited Review****Direct digital**

K A Bergin

*X-ray Department, Addenbrooke's Hospital NHS Trust, Hills Road, Cambridge CB2 2QQ, UK***Invited Review****Software issues and radiation dose**

M Hayball

*Radiology Department, Papworth Hospital, Cambridge CB3 8RE, UK***Scientific Session****Digital Technology for Radiographic Imaging****Digital technology for radiographic imaging**

C P Lawinski

*KCARE, King's College Hospital, London, UK*

Computed radiography has been available for a number of years and is now routinely used in many X-ray departments. As part of the

continuing trend towards digital imaging, many manufacturers offer systems for direct digital radiography in which the acquired image is rapidly displayed at an associated workstation. Three main types of digital detector are currently in use. (i) Charged coupled device (CCD) based systems: an intensifying screen is coupled to a CCD camera through a minifying lens system or fibre optic bundle. Larger field sizes may require an array of CCDs and the image is "stitched" together. An alternative approach employs a scanning beam technique in conjunction with a moving linear CCD array. (ii) Amorphous silicon systems: a caesium iodide phosphor screen is coupled directly to an amorphous silicon plate that incorporates a photodiode/thin film transistor (TFT) array. (iii) Selenium based systems: an amorphous selenium semiconductor X-ray absorber is coated over a TFT array; a phosphor screen is not required. This has the potential to improve image resolution as there is no light spread associated with the use of a phosphor. Both the amorphous silicon and selenium systems are often referred to as flat panel detectors. In general radiography, early developments were directed towards dedicated chest imaging systems. More recently, digital bucky assemblies have been mounted in conventional X-ray tables or on universal U-arm supports. Following development for radiography, flat panel detectors are available for fluoroscopic procedures in place of the conventional image intensifier. Small field digital mammography systems, all using detectors based on CCD technology, are available from many manufacturers. The primary use is for stereotactic localization techniques. Two designs of full field digital mammography system have been recently introduced. One of these is based on a CCD array, the other on an amorphous silicon flat panel detector.

**A comparative evaluation of full field digital mammography units**

D Smith, C P Lawinski, A Mackenzie and D S Evans

*KCARE (King's Centre for the Assessment of Radiological Equipment), King's College Hospital (Dulwich), London, UK*

Full field digital mammography units have been under development for some years and are now being marketed in the UK as a possible alternative to conventional film-screen systems. There are several different types of digital detector available for use in mammographic imaging, which can be separated into two different categories: indirect and direct. Indirect detectors require the use of a scintillator to convert the X-ray photons into light; direct detectors do not require a scintillator. The current indirect detectors are based on either charge coupled device (CCD) or amorphous silicon technology. Direct detectors are based on amorphous selenium. All of the units are supplied with an acquisition workstation. In some cases a review workstation can also be purchased as an additional cost option. Reporting is performed from either soft copy (review workstation monitor) or hard copy images. KCARE has carried out an evaluation of full field digital mammography units in terms of image quality using a range of standard test objects and breast doses. The results of these evaluations will be discussed and, where possible, compared with film-screen systems.

**Full field digital mammography: a quantitative comparison of CCD vs amorphous silicon**

D S Evans, A Mackenzie and A Workman

*<sup>1</sup>King's Centre for the Assessment of Radiological Equipment (KCARE), King's College Hospital, London and <sup>2</sup>Northern Ireland Regional Medical Physics Agency (NIRMPA), Forster Green Hospital, Belfast, UK*

**PURPOSE:** To objectively compare the properties of two technologies used for full field digital mammography: charge coupled devices (CCDs) and amorphous-silicon-based systems. **METHODS:** The imaging properties of technologies used for full field digital mammography have been compared in terms of pre-sampled modulation transfer function (MTF), noise power spectrum, detective quantum efficiency (DQE) and threshold contrast detail detectability (TCDD). **RESULTS:** The pre-sampled MTFs for the two systems were very similar, although the amorphous silicon system was better for frequencies less than approximately 3 cycles mm<sup>-1</sup>. The MTF of the amorphous silicon system was better than 25% at the Nyquist frequency and was maintained beyond this frequency. This can result in considerable aliasing in the image. The high contrast limiting spatial resolution was measured at 11 lp mm<sup>-1</sup> for the CCD-based system and 5 lp mm<sup>-1</sup> for the amorphous silicon system. The DQE results were better for the

CCD system, both in terms of the low frequency peak DQE and the variation with frequency. Both of the digital systems maintained a high level of peak DQE across a wide exposure range. TCDD results demonstrate that the amorphous silicon system provides better image quality than the CCD. It should be noted that the CCD system only allowed hard copy reporting, without the ability to window and level the data, and therefore this technology can potentially produce improved image quality. CONCLUSION: The objective measures of imaging performance indicate that the two technologies produced similar results. These results compared well with published film-screen quantitative data.

#### **Image quality and receptor dose for film-screen and digital chest systems**

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*King's College Hospital (Dulwich), East Dulwich Grove,  
London SE22 8PT, UK*

**PURPOSE:** A variety of technologies are currently used for digital chest imaging. The imaging properties of the detectors must be quantified to allow comparison of the technologies and optimization of the dose and image quality. **MATERIALS AND METHODS:** Film-screen, computed radiography (CR) and a range of digital detectors (a-selenium, a-silicon and charged selenium drum) were tested using a contrast detail test object (CDRAD) in a low scatter configuration for a range of exposures and kV. The high contrast spatial resolution and receptor dose were also measured. **RESULTS:** The film-screen system showed superior high contrast spatial resolution of 7.5 lp mm<sup>-1</sup> compared with digital systems, which varied from 3.6 lp mm<sup>-1</sup> (a-silicon) to 4.5 lp mm<sup>-1</sup> (CR). However, the improved signal-to-noise ratio for direct digital systems allowed better visualization of the smallest low contrast detail sizes. The a-silicon and a-selenium detectors allowed the greater contrast detail visualization, while the 400 speed film and charged selenium drum were similar, and the 200 speed CR system was significantly lower. The receptor doses measured varied from 2.4–8.6 mGy. However, it was found that the digital systems could still provide good image quality for lower doses. **CONCLUSIONS:** The a-silicon and a-selenium detectors showed the best image quality. The digital systems have the advantage of window and levelling and are therefore highly suitable for chest imaging where a wide range of intensities require visualization. There is scope for optimization of dose and image quality, as the digital systems were operating at higher exposure levels than for film-screen.

#### **Optimizing high kV chest radiography using computed radiography with a threshold contrast detail test object**

A Mackenzie, D S Evans and D J Hodson  
*King's College Hospital (Dulwich), East Dulwich Grove,  
London SE22 8PT, UK*

**PURPOSE:** To examine the relationship between dose and image quality for high kVp chest computed radiography (CR) and to optimize this in comparison with film-screen imaging. **MATERIALS AND METHODS:** An AGFA ADC CR system with a nominal 200 speed was compared with an AGFA 400 speed film-screen system. A contrast detail test object (CDRAD) with 10 cm of Perspex was imaged over a range of dose levels for film and CR. The CDRAD was scored and a single image quality factor (IQF) was obtained from the threshold contrast detail detectability curve relative to a reference curve to the AEC dose. Variation of image quality for both CR and film were examined. **RESULTS:** The receptor dose was measured as 3.8 µGy for both CR and film under AEC control. The IQF for CR showed a linear increase between 1.6 µGy and 8.0 µGy, whilst film showed an IQF curve peaking at about 4 µGy. Under AEC control, the IQF for film was about 30% greater than for CR, which would correspond to an equivalent CR receptor dose of 7 µGy. However, the difference in IQF is reduced for doses lower and higher than 3.8 µGy. **CONCLUSIONS:** This method shows the relationship of image quality between film and CR for a range of doses and detail sizes. Initially for this system, the CR image quality appears to be considerably lower compared with film. However, the final optimization will depend on the clinical requirements, in particular for chest imaging, which covers a wide range of densities.

### **Workshop** **Continuing Professional Development** **Invited Review**

**Continuing professional development—what happens next?**

S Kelly  
*Manchester, UK*

### **Refresher Course** **MR in Gynaecological Disorders**

**Invited Review**  
**Cancer of the ovary**

H Hricak  
*Department of Radiology, Memorial Sloan Kettering Centre,  
New York, NY 10021, USA*

**Invited Review**  
**Malignant disease of the cervix and uterus**  
R Reznek

*Academic Department of Radiology, St Bartholomew's  
Hospital, Dominion House, 59 St Bartholomew's Close,  
London EC1A 7ED, UK*

**Invited Review**  
**Benign disease**

J Olliff  
*Department of Radiology, Queen Elizabeth Hospital,  
Edgbaston, Birmingham B15 2TH, UK*

### **State of the Art Symposium** **Multihelical CT: application and impact**

**Invited Review**  
**Multidetector helical CT: application and impact**  
J Brink

*Department of Diagnostic Radiology, Yale University, 333  
Cedar Street 2-332SP, New Haven, CT 06520, USA*

**Invited Review**  
**We don't have it—we can do well without it**  
C George

*Radiology Department, Epsom General Hospital, Epsom  
Heathcare Trust, Dorking Road, Epsom KT18 7EG, UK*

### **Refresher Course** **Staging Head and Neck Cancer**

**Invited Review**  
**Oropharynx and pharynx**

R J Johnson  
*Radiology Department, Christie Hospital NHS Trust, Wilmslow  
Road, Manchester M20 4BX, UK*

**Invited Review**  
**Parotid and paranasal sinuses**

S C Rankin  
*Radiology Department, Guy's & St Thomas' NHS Trust,  
St Thomas' Street, London SE1 9RT, UK*

### **Refresher Course** **Obstructive Lung Disease**

**Invited Review**  
**Imaging the large airways**

S R Desai  
*Department of Radiology, King's Healthcare NHS Trust,  
Denmark Hill, London SE5 9RS, UK*

**Invited Review**

**Small airways disease: a spectrum**

P Taylor

*Manchester Royal Infirmary, Oxford Road, Manchester M13 9WL, UK*

**Invited Review**

**Emphysema and lung volume reduction surgery**

R J H Robertson

*CT Department, St James's University Hospital Trust, Beckett Street, Leeds LS9 7TF, UK*

**Refresher Course**

**The Arthritides and the Problems They Pose**

**Invited Review**

**The arthritides and the problems they pose**

P Stone

*Department of Radiology, Medway Maritime Hospital, Windmill Road, Gillingham ME7 5NY, UK*

**Osteoporosis Session**

**Approaches to Fracture Clinic**

**Invited Review**

**The evidence for fracture risk prediction using peripheral devices: a systematic review**

J Truscott

*Department of Radiology, Leeds General Infirmary, Great George Street, Leeds LS1 3EX, UK*

**Invited Review**

**The role of axial densitometry in osteoporosis**

E McLoskey

*Department of Human Metabolism, Royal Hallamshire Hospital, Glossop Road, Sheffield S10 2JF, UK*

**Advances**

**Technological Update (2)**

**Invited Review**

**DICOM issues and radiation dose**

*Siemens Medical Solutions*

**Invited Review**

**The practicalities of computed radiography**

P Gould

*Radiology Department, Scunthorpe & Goole NHS Trust, Cliff Gardens, Scunthorpe, South Humberside DN15 7BH, UK*

**Refresher Course**

**Radiation Physics and Dosimetry**

**Invited Review**

**Just what are we measuring?**

S Green

*Department of Medical Physics & Clinical Engineering, Queen Elizabeth Hospital, Metchley Lane, Edgbaston, Birmingham B15 2TH, UK*

**Invited Review**

**Monte Carlo simulation at diagnostic energies**

R A Price

*Physics Department, Clatterbridge Centre for Oncology, Clatterbridge Road, Bebington, Wirral CH63 4JY, UK*

**Invited Review**

**Dosimetry in CT**

P Shrimpton

*NRPB, Population Exposure Department, Chilton, Didcot, Oxon OX11 0RQ, UK*

**Workshop**

**Continuing Professional Development**

**Invited Review**

**Continuing professional development—what happens next?**

S Kelly

*Manchester, UK*

Tuesday 22 May

## Workshop

### Vascular Ultrasound

#### Invited Review

##### Practical lower limb venous ultrasound

D Goss

*Vascular Laboratory, King's Healthcare NHS Trust, Denmark Hill, London SE5 9RS, UK*

## Refresher Course

### MR for Pelvic Floor Prolapse

#### Invited Review

##### Posterior prolapse: rectum

S Halligan

*Department of Radiology, St Mark's Hospital, Watford Road, Harrow HA1 3UJ, UK*

#### Invited Review

##### Anterior prolapse of bladder and uterus

A Maubon

*Département de Radiologie, CMC Beau Soleil, Service du Prof Rucanet, 119 ave de Locleve, Montpellier 3400, France*

#### Invited Review

##### MR anatomy of the pelvic floor

R J Johnson

*Radiology Department, Christie Hospital NHS Trust, Wilmslow Road, Manchester M20 4BX, UK*

## Refresher Course

### Diffuse Interstitial Lung Disease

#### Invited Review

##### Imaging asbestos-related lung disease in the 21st century

S J Copley

*X-ray Department, Royal Brompton & Harefield NHST, London SW3 6NP, UK*

#### Invited Review

##### The idiopathic interstitial pneumonias

D Hansell

*Radiology Department, Royal Brompton & Harefield NHST, Sydney Street, London SW3 6NP, UK*

#### Invited Review

##### High resolution CT of paediatric interstitial lung disease

S J Copley

*X-ray Department, Royal Brompton & Harefield NHST, London SW3 6NP, UK*

## Refresher Course

### Evaluation of Indeterminate Lesions in the Cancer Patient

#### Invited Review

##### Lung

S Padley

*Department of Radiology, Chelsea & Westminster Hospital, 369 Fulham Road, London SW10 9NH, UK*

#### Invited Review

##### Adrenal

R Reznik

*Academic Department of Radiology, St Bartholomew's Hospital, Dominion House, 59 St Bartholomew's Close, London EC1A 7ED, UK*

#### Invited Review

##### Bone

M Davies

*MRI Centre, Royal Orthopaedic Hospital, The Woodlands, Bristol Road South, Birmingham B31 2AP, UK*

#### Invited Review

##### Brain

J Britton

*Atkinson Morley's Hospital, 31 Copse Hill, London SW20 0NC, UK*

## Refresher Course

### Imaging of Soft Tissue Injuries

#### Invited Review

##### Imaging of soft tissue injuries

W Gibbon

*Department of Radiology, Leeds General Infirmary, Great George Street, Leeds LS1 3EX, UK*

## Refresher Course

### Clinical Governance: current issues

#### Invited Review

##### National issues

P Armstrong

*Academic Department of Radiology, St Bartholomew's Hospital, Dominion House, 59 Bartholomew's Close, London EC1A 7BE, UK*

#### Invited Review

##### Departmental issues

A B Ayers

*Medical Directors Office, Guy's & St Thomas' NHS Trust, Counting House, St Thomas' Street, London SE1 9RT, UK*

#### Invited Review

##### Errors in radiology

P J Robinson

*Department of Clinical Radiology, St James' University Hospital Trust, Beckett Street, Leeds LS9 7TF, UK*

## Scientific Session

### Vascular and MRI

#### Evaluation of multislice spiral CT angiography for the assessment of peripheral artery disease

R Puls, N Hosten, H Steinkamp, F Knollmann, M Werk, B Gebauer and R Felix

*Strahlenklinik (Radiology), Humboldt University Berlin, Charité, Campus Virchow Klinikum, Berlin 13353, Germany*

**PURPOSE:** To evaluate 3D multislice CT angiography for the assessment of relevant stenoses of pelvic arteries and arteries of the lower extremity in patients with peripheral artery occlusive disease compared with conventional angiography. **METHODS:** For this study, we examined 31 patients with peripheral artery occlusive disease. All patients underwent multislice spiral CT angiography and conventional angiography. Multislice CT angiography was performed with a Somatom Plus 4 Volume Zoom (Siemens, Erlangen, Germany). After test bolus injection of 20 ml Ultravist 370 (Schering AG, Berlin, Germany), an additional 150 ml were injected with a flow rate of 3 ml s<sup>-1</sup> and a scan delay of 20–35 s, depending on individual blood circulation time. Collimation was 4 x 2.5 mm with a pitch of 6. Reconstructed slice width was 3 mm. 3D reconstructions of pelvic arteries and lower extremity arteries were performed using a volume

rendering technique on a 3D Virtuoso workstation (Siemens, Erlangen, Germany). Standard digital subtraction angiography was performed within 1 day. RESULTS: For the assessment of therapeutically relevant stenoses (over 50% reduction in luminal diameter), multislice CT achieved the following results compared with conventional angiography for the diagnosis of stenosis: sensitivity 86%; specificity 86%; and accuracy 72%. CONCLUSIONS: Multislice spiral CT angiography of pelvic arteries and lower extremity arteries represents a reliable means for the detection of relevant stenoses in patients with peripheral occlusive artery disease.

#### **Fast CT angiography of the thoraco-abdominal aorta** A E Healey, C Sampson, S McDonald, J A Holemans and H E Fewins

*Radiology Department, The Cardiothoracic Center Liverpool, Thomas Drive, Liverpool L14 3PE, UK*

PURPOSE: This study examines the potential of CT angiography to replace conventional angiography in the assessment of thoraco-abdominal aortic disease. MATERIALS AND METHODS: Over 3 years, 52 patients (age range 35–86 years, mode 68 years) underwent 59 examinations for suspected aneurysmal disease or dissection of the thoraco-abdominal aorta. 36 of these were scanned on a single slice spiral scanner (3 mm slice thickness, pitch 1.5) and 23 were scanned on a quad multislice spiral scanner (2.5 mm slice thickness, pitch 5.0). 100 ml of iodinated contrast medium (250 mg ml<sup>-1</sup>) were given intravenously at 3 ml s<sup>-1</sup> via a pump injector. Images were acquired from the level of the arch vessels to the aortoiliac bifurcation. The images were reconstructed on a workstation to give oblique coronal and sagittal planes through the origins of the major arteries. Diameter of the aorta, involvement of the major vessels and the presence of thrombus were noted. 11 patients underwent conventional angiography. RESULTS: There were 47 thoracic aneurysms (diameter range 3.5–10 cm), 10 extended into the abdominal aorta and 8 had dissections. Mural thrombus was present in 14 cases and peri-aortic haematoma in 1 case. In 26, the branch arteries were involved. In the remaining 12 scans there was 1 dissection, 3 periaortic haematomas, 1 pericardial TB, 1 mural thrombus and 1 aortic root abscess; 5 scans were normal. CONCLUSION: CT angiography with oblique reconstructions gives more information than the conventional aortogram and can detect unsuspected pathology. However, as yet it cannot replace coronary angiography, which may be required in some cases.

#### **Retrograde vs antegrade arterial puncture for infrainguinal angioplasty**

R Uberoi and L Wilkinson

*X-Ray Department, Queen Elizabeth Hospital, Gateshead, Tyne & Wear NE9 6SX, UK*

PURPOSE: To compare traditional direct antegrade puncture with a retrograde puncture technique for infrainguinal angioplasty. METHODS: Following informed consent, patients undergoing infrainguinal angioplasty were randomized to either direct antegrade puncture or retrograde puncture of the femoral artery. Following retrograde puncture, the guidewire was "turned" and placed into the superficial femoral artery using a curved catheter (Simmons 1 or SoS Omni). A sheath was placed and the angioplasty was carried out as standard. The total time for gaining access, the screening time, the radiation dose as well as standard demographic data including height and weight were recorded for each patient. RESULTS: 56 patients have been randomized in the study, 35 patients to retrograde puncture and 21 patients to antegrade puncture. There were 26 males and 9 females in the retrograde group, and 13 males and 9 females in the antegrade group. Mean procedure time, screening time, radiation dose, height and weight were 8.36 min (range 5–18 min), 2.18 min (0.8–6.1 min), 8373 mGy, 173 cm (149–204 cm) and 78 kg (55–100 kg) for retrograde puncture, and 8.14 min (3–27 min), 0.89 min (0.1–2.9 min), 1057 mGy, 172 cm and 67.8 kg for antegrade puncture, respectively. An average of 1.1 (1–2) punctures was required to gain access for retrograde puncture and 1.8 (1–5) for antegrade puncture. Two small haematomas and a venous puncture occurred post antegrade puncture and a single small haematoma following retrograde puncture. CONCLUSION: Retrograde puncture is technically easier, with fewer complications, but it does result in a higher radiation dose.

#### **The long-term outlook for patients undergoing subintimal angioplasty**

<sup>1</sup>D J Tawn, <sup>2</sup>P Tisi, <sup>2</sup>S D Parvin and <sup>2</sup>S G Darke

*Departments of <sup>1</sup>Radiology and <sup>2</sup>Surgery, Royal Bournemouth Hospital, Bournemouth BH7 7DW, UK*

Data are presented on the outcome of 166 subintimal angioplasty procedures on 156 patients (88 men, 68 women). RESULTS: The technical success rate of 85% compares favourably with figures from Leicester (Bolia et al). However, long-term patency rates are disappointing at 47.8% at 1 month, 33% at 1 year and 24% at 2 years. Limb salvage rates are very encouraging at 98% at 1 month, 88% at 1 year and 86.7% at 2 years. These figures in patients with limb-threatening critical ischaemia are 97.5% at 1 month, 85.6% at 1 year and 83.5% at 2 years. CONCLUSION: Percutaneous intentional subintimal angioplasty therefore has a place in the treatment of patients with critical leg ischaemia.

#### **What pressure does your angioplasty balloon achieve?**

M A Al-Attar and K S Blanshard

*Radiology Department, University Hospitals of Leicestershire, Leicester LE5 4WQ, UK*

METHOD: This was a blinded prospective study to measure *in vitro* balloon pressure during normal and maximal inflation. Eight operators with a variable level of experience were invited to participate in the study. A commercially available high pressure balloon (rated burst pressure 20 atmospheres) was connected to a calibrated manometer and to an inflation device. The operator was asked to estimate normal and maximum inflation pressures, and then to apply such inflation pressures to the test equipment. The mean of three working and of three maximum inflation pressures were calculated. RESULTS: Most operators achieved a pressure within 2 atmospheres of their estimated value. Two operators who achieved a pressure well beyond their estimate ( $\pm 6$  atmospheres) had only limited experience in balloon angioplasty. These differences were not statistically significant ( $p > 0.5$ ). CONCLUSIONS: Experienced operators are able to predict the balloon working pressure to within 2 atmospheres. Using standard manual inflation devices, no operator was able to achieve in excess of 16 atmospheres. Although there was no statistically significant difference between the estimated and achieved pressures for less experienced operators, the use of a pressure gauge in this latter group remains advisable, as some angioplasty balloons have rated burst pressures below 16 atmospheres.

#### **Effect of arterial resistance on angioplasty balloon inflation: an experimental study**

M Shehab and M R Rees

*Department of Radiology, University of Bristol, Bristol BS2 8HW, UK*

BACKGROUND: Previous studies have shown that quantitative angiography overestimates the degree of stent expansion and an underdeployed stent can be overlooked. We have developed a device that can monitor the pressure and volume generated in an angioplasty balloon and have used this device to determine whether a balloon is fully inflated. METHODS: Balloon pressure–volume curves were recorded in digital and analogue modes. 5–9 mm balloons were inflated in air to obtain reproducible pressure–volume curves and were then inflated in 49 explanted pig carotid arteries. The pressure–volume curve obtained when the balloon was inflated in the artery was recorded. The diameter of each carotid artery was measured with intravascular ultrasound whilst the artery was perfused with saline. RESULTS: The pressure–volume curve depended on the ratio of artery size to balloon size. If the artery diameter was smaller than the balloon diameter, the curve was shifted to the left compared with the curve in air. This shift was proportional to the balloon:artery ratio, *i.e.* a balloon with a nominal diameter of 6 mm at 6 atmospheres required a pressure of 14 atmospheres to reach the same volume in a 3 mm artery. Even differences in balloon/artery size of 10% resulted in a higher pressure required to achieve nominal volume. CONCLUSIONS: This experiment demonstrates the importance of fluid volume measurement during balloon deployment. It also demonstrates that relying on pressure measurement alone, which is the only factor measured during an angioplasty procedure, can be misleading.

**Post-mortem imaging of the fetal central nervous system: does it provide accurate and valuable information?**

E H Whitby, M N Paley, M Evans and P D Griffiths  
MRI Department, Floor C, Royal Hallamshire Hospital,  
Glossop Road, Sheffield S10 2JF, UK

**PURPOSE:** To develop MR techniques suitable for imaging the post-mortem fetal CNS and to compare the results with the conventional autopsy. Conventional autopsy has recently had a bad press, and parents often do not wish the pathologists to retain organs or tissues to allow fixation and accurate examination. As a consequence, pathologists have difficulty in assessing the fetus, especially the brain and spinal cord. **METHODS:** Parental consent was obtained for all fetuses referred for imaging and autopsy. Imaging was performed 4–24 h prior to the autopsy. The same clinical details were available to the radiologist and the pathologist. Post-mortem imaging consisted of high resolution fast spin echo sequences giving  $T_2$  weighted images of the brain and/or spinal cord in three orthogonal planes. **RESULTS:** 38 fetuses have been imaged, with a range of pathologies imaged, e.g. holoprosencephaly, spina bifida and chiari malformations, hydrocephalus, schizencephaly and a large AVM as well as normal brains in fetuses with other abnormalities, e.g. diaphragmatic hernia. The MR results were compared with the formal autopsy report and gave equivalent information on macroscopic detail in all organ systems imaged, apart from the CNS where in the cases of hydrocephalus, holoprosencephaly and schizencephaly the structural abnormalities were better visualized and described by MR than formal autopsy. **CONCLUSION:** MR autopsy provides more macroscopic detail and structural information on the CNS than formal autopsy. For other organ systems it appears to provide equivalent information to the formal autopsy.

**In utero MRI with post-mortem follow-up**

E H Whitby, M N Paley, M Evans, S Rutter, N D Davies,  
A Sprigg, I D Wilkinson, K Frost and P D Griffiths  
MRI Department, Floor C, Royal Hallamshire Hospital,  
Glossop Road, Sheffield S10 2JF, UK

**AIM:** To develop techniques for MRI of the post-mortem fetus and to compare these with the results of ultrafast MRI of the fetus *in utero*. **METHODS:** *In utero* MRI is a rapidly developing technique owing to the recent advances in technology allowing rapid acquisition of images, effectively freezing fetal motion. We have previously reported our initial experiences of *in utero* MRI (Br J Obstet Gynecol 2000, in press), which suggest that *in utero* MRI is probably more accurate than antenatal ultrasound. To validate the *in utero* MRI, there must be follow-up of the baby *ex utero* or by autopsy. Six women with a fetus known to have a severe central nervous system abnormality, who had already decided to terminate, were asked to join the study. Antenatal MR single shot fast spin echo imaging was performed 1–4 days prior to termination, and post-mortem MRI was performed the day after termination. This consisted of high resolution fast spin echo sequences giving  $T_2$  weighted images. **RESULTS:** The final diagnoses, based on autopsy were: holoprosencephaly (2), isolated hydrocephalus (2), meningeal angiodysplasia and dilated vein of galen (1), and myelomeningocele and chiari 2 malformation (1). Antenatal ultrasound agreed with the final diagnosis in 3/6, *in utero* MRI in 6/6 and post-mortem MRI in 6/6. **CONCLUSION:** *In utero* MRI is a useful additional imaging modality to antenatal ultrasound in patients with any degree of uncertainty over the diagnosis. Post-mortem MRI had perfect correlation with autopsy.

**Work in Progress**

**Pre- and post-operative assessment of Leriche syndrome using the transbrachial approach**

I Tilea, D C Bratu, L Cozlea, A Alecu, R Motoc, C Sandor,  
M Dragan, T Craciun, A Fridrik, D L Cozlea and A Fanea  
Clinica Medicala II, Compartiment Cardiologie, Spitalul Clinic  
Judetean Targu-Mures, Universitatea de Medicina si Farmacie  
Targu Mures, Romania

For complex angiographic examinations, the transbrachial approach is used in our clinic to assess patients with Leriche syndrome pre- and post-operatively. **MATERIALS AND METHODS:** Between January 1997 and December 2000, 352 patients were admitted to our clinic with symptomatic peripheral artery disease for angiographic examination. Patients were assessed using classic methods (physical

examination, A/B index, Doppler). In 11 (3.125%) patients, possible Leriche syndrome was diagnosed. These patients were examined using the transbrachial approach for the distal aorta, the pelvic arteries and the arteries of lower limbs. Patients were studied at various times pre- and post-operatively. A GE DF 3000 machine was used for acquisition of the images and the contrast medium Iopamiro 300 was delivered using a high pressure pump. Angiography was electively performed with 5 F or 6 F catheters via the left brachial artery. **RESULTS AND DISCUSSION:** The contrast quality of the arterial bed was high. This method proved to be a safe and reliable alternative. The complications were in common limits, without any major events. The transbrachial approach in assessment of Leriche syndrome is very important to determine clinical patterns and locations of the lesions. It is easier and safer than translumbar angiography completed with "open" artery angiography. Follow-up determined that Y type aortofemoral bypass achieves the best results. The outcome of axillary-femoral bypass grafts was worse than Y bypass.

**Refresher Course**

**Breast Treatment Techniques**

**Invited Review**

**Breast treatment techniques**

E A Winfield

Marie Curie Research Unit, Mount Vernon Hospital,  
Northwood, Middlesex HA6 2RN, UK

**Invited Review**

**Breast treatment techniques**

E M Donovan

Joint Department of Physics, Royal Marsden NHS Trust,  
Downs Road, Sutton SM2 5PT, UK

**Refresher Course**

**Multislice CT: problem or opportunity**

**Invited Review**

**The clinical perspective**

S Golding

Department of Radiology, John Radcliffe Hospital, University  
of Oxford, Headington, Oxford OX3 9DU, UK

**Invited Review**

**The technical perspective**

K Geleijns

Radiology Department, Leiden University Medical Centre,  
PO Box 9600, Leiden, The Netherlands

**IT**

**From Medical Signals and Images to Clinical Knowledge (1)**

**Image deconvolution as an aid to feature**

**identification: a clinical trial**

<sup>1</sup>W J M van der Putten, <sup>2</sup>T Doherty, <sup>3</sup>A Shearer and

<sup>3</sup>P McCarthy

<sup>1</sup>Medical Physics and <sup>2</sup>Radiology, University Hospital Galway  
and <sup>3</sup>Information Technology, National University of Ireland,  
Galway, Ireland

**PURPOSE:** Various techniques for deconvolving digital X-rays have suffered from problems of increasing the background noise within the images. The work here demonstrates that application of Bayesian deconvolution techniques with wavelet denoising can lead to image enhancement both in terms of improved spatial resolution and contrast. **METHOD AND MATERIALS:** The image processing method involves a technique called regularized deconvolution, which involves iteratively deconvolving an image with a measured point spread function. A wavelet denoising algorithm is applied between iterations. Images were recorded using an Agfa computed radiography system. The point spread function was obtained from a standard Philips Bucky Diagnost system. **RESULTS:** To evaluate the clinical usefulness of the technique, a random selection of radiographs were chosen, representing a cross-section of clinical case load. An evaluation and

scoring system was devised based on image quality criteria as published by the European Union. All images were reviewed on a monitor under identical viewing conditions. Radiologists scored both processed and unprocessed images with regard to visibility of anatomical detail and image quality including noise. **CONCLUSIONS:** Quantifiable improvements in overall image sharpness and noise quality were noted by the radiologists and will be presented. Typically, a 10–20% improvement in combined resolution and contrast was obtained. It has been demonstrated that image enhancement techniques, such as suitably chosen deconvolution, can lead to images with improvement spatial resolution and noise characteristics that are clinically preferred over non-enhanced images.

#### **Evaluation of the role of image rotation in visual analysis of 3D images**

G Hamilton, S R Watt-Smith, D Dobson, T R Bowles and S J Golding

*Department of Radiology, University of Oxford and Department of Oromaxillary Surgery, John Radcliffe Hospital, Oxford, UK*

**PURPOSE:** To determine the value of vertical axis rotation in extracting information from 3D images. **METHODS:** Image data were obtained from 10 patients with facial fracture or neoplasm. 3D image files were created from high resolution CT of the face using in-house software and displayed in three different viewing modes: (1) seven static images at 30° intervals of rotation about a central vertical axis (S); (2) continuous rotation of the image (AR); and (3) an interactive display allowing the viewer to position the reconstruction in any chosen orientation (UP). A viewing panel of 18 medical students was recruited to answer a standard series of questions on each image relating to 3D aspects of anatomy and pathology, and to indicate subjective preferences for each viewing mode. Images were viewed under standardized conditions, in random order to avoid “learning” effects. Responses were compared with a gold standard reading, and scores were analysed by generalized linear models and generalized estimating equations. **RESULTS:** AR and UP modes were found on both objective and subjective measures to be significantly better than the S mode in providing information. No significant difference was found between AR and UP scores, although the UP mode was subjectively preferred by viewers. **CONCLUSION:** Addition of vertical axis rotation to the display of 3D CT significantly improves the ability of viewers to extract useful information.

#### **Invited Review**

##### **Projects and results at University College London**

<sup>1</sup>A Todd-Pokropek and <sup>2</sup>A D Linney

*<sup>1</sup>Department of Medical Physics and Bioengineering, University College London, Gower Street, London WC1E 6BT and <sup>2</sup>Department of Medical Physics, University College London, 11–20 Copper Street, London WC1E 6JA, UK*

#### **Invited Review**

##### **Projects and results at the University of Manchester/ Model-based interpretation of medical images**

C Taylor

*Department of Imaging Science & Bioengineering, University of Manchester, Oxford Road, Manchester M13 9DP, UK*

#### **Workshop**

##### **Creating PowerPoint Presentations: beginner**

##### **How to create PowerPoint presentations: beginner**

M Tatlow

*Division of Professions Allied to Medicine, Faculty of Health Sciences, South Bank University, London SE1 0AA, UK*

#### **Workshop**

##### **Vascular Ultrasound**

#### **Invited Review**

##### **Practical lower limb venous ultrasound**

D Goss

*Vascular Laboratory, King's Healthcare NHS Trust, Denmark Hill, London SE5 9RS, UK*

#### **Workshop**

##### **Carotid Vessels: imaging and intervention**

#### **Invited Review**

##### **Carotid stents and cerebral protection**

P Gaines

*Sheffield Vascular Institute, Northern General Hospital, Herries Road, Sheffield S5 7AU, UK*

#### **Invited Review**

##### **Ultrasound imaging**

W R Lees

*Imaging Department, The Middlesex Hospital, Mortimer Street, London W1N 8AA, UK*

#### **Invited Review**

##### **MRI**

N M Antoun

*Radiology Department, Addenbrooke's Hospital NHS Trust, Hills Road, Cambridge CB2 2QQ, UK*

#### **Keynote Lecture**

##### **The Failing Renal Transplant: imaging and intervention**

#### **Invited Review**

##### **The failing renal transplant: imaging and intervention**

H Irving

*Department of Clinical Radiology, St James' University Hospital Trust, Beckett Street, Leeds LS9 7TF, UK*

#### **Keynote Lecture**

##### **Embolisation Techniques in the Thorax**

#### **Invited Review**

##### **Embolisation techniques in the thorax**

J E Jackson

*Department of Radiology, Hammersmith Hospital NHS Trust, Du Cane Road, London W12 0HS, UK*

#### **Keynote Lecture**

##### **Acute Abdominal Complications of Treatment in the Cancer Patient**

#### **Invited Review**

##### **Acute abdominal complications in treatment of the cancer patient**

J A Spencer

*Department of Radiology, St James' University Hospital Trust, Leeds LS9 7TF, UK*

#### **Keynote Lecture**

##### **Where Are We Now? Results of a UK-wide survey**

#### **Invited Review**

##### **Where are we now? Results of a UK-wide survey**

J R McConnell

*Division of Radiography, University of Bradford, Unity Building, 25 Trinity Road, Bradford BD5 0BB, UK*

#### **Keynote Lecture**

##### **Cost Effective Radiology—achieving the best: the UK experience**

#### **Invited Review**

##### **Cost effective radiology—achieving the best: the UK experience**

A K Dixon

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## Scientific Session

### MRI

#### Investigation of microstructured materials applied to MRI

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**PURPOSE:** Microstructured materials ( $\mu$ SMs) are materials with very unusual permeabilities in the range of frequencies of relevance in MRI and this study was undertaken to evaluate their potential in MRI.  $\mu$ SMs for RF frequencies are composed of resonators that must be electrically insulated one from another, and have dimensions much smaller than the wavelength of the radiation in use. Typical materials contain no ferromagnetic materials, yet they can have a permeability that is significantly greater than 1, and so provide a method of guiding RF flux. They can also have negative permeability, the implications of which have yet to be explored. **MATERIALS AND METHODS:**  $\mu$ SMs were formed from "swiss roll" material as described by Pendry et al (IEEE Trans Microwave Theory and Tech 1999;47:2075), and their magnetic properties were determined using laboratory test gear. The material was tested on a Marconi Medical 0.5 T scanner, with images being acquired to demonstrate its characteristics. **RESULTS:** Images were acquired that showed that  $\mu$ SM could be used to enable a coil to recover signals from distant objects in a way that was not possible without its use. Values for permeability were obtained that showed a useful increase in permeability at 21.3 MHz. **DISCUSSION:** Preliminary indications are that  $\mu$ SMs can deliver at least some of the benefits that may be expected from them. As yet their design is quite primitive compared with what may be hoped for in future. If real improvements are achieved, these materials could play a significant role in MRI.

#### Ex vivo testing of mechanical heart valves at 4.7 T: a study of magnetic field interactions

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**PURPOSE:** MRI of patients with biomedical implants continues to be a major concern for MR health care workers. Previous research, however, has shown that bioprosthetic heart valves are considered safe for patients undergoing MRI at 1.5 T or less. However, as higher strength magnets become more commonplace in clinical diagnosis and interventional MRI procedures, the effect on prosthetic heart valves must be considered. The aim of this study was to use *ex vivo* testing techniques to determine the safety aspects of magnetic field interactions on a number of mechanical heart valve prostheses subjected to a 4.7 T magnet. **METHODS:** *Ex vivo* testing was performed on 10 mechanical heart valve prostheses using previously described techniques for the evaluation of magnetic field interactions (deflection, torque). **RESULTS:** All heart valve prostheses displayed interaction with the magnetic field at 4.7 T. Deflection of the valve prostheses ranged from 0–7° and the torque effect was small. **CONCLUSIONS:** Based on these results, the heart valve prostheses tested should not present a hazard to patients with regards to displacement or dislodgement in the MRI environment of 4.7 T or less.

### Work in Progress

#### Can MRI replace herniography in the evaluation of patients with equivocal clinical findings of groin hernias: a pilot study

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**PURPOSE:** To compare contrast herniography and MRI in the diagnosis of groin hernias in patients with equivocal clinical findings. **METHOD:** 22 patients (age range 21–72 years; 4 women, 18 men) had MRI of both groins immediately prior to herniography. All patients had axial  $T_2$  weighted images and 15 had  $T_1$ ,  $T_2$  and  $T_2$  weighted fat

saturated axial images and  $T_2$  weighted express axial images during Valsalva manoeuvre in the prone position. **RESULTS:** 12 inguinal hernias (2 direct, 9 indirect and 1 combined direct and indirect) were seen at herniography, of which 4 were correctly identified by MRI. There were six false positive and eight false negative MRI findings. A single femoral hernia was correctly identified by MRI. One patient had osteitis pubis, which may account for their symptoms. There was a sensitivity of 0.3, a specificity of 0.8, a positive predictive value of 0.4 and a negative predictive value of 0.8 for inguinal hernias. **CONCLUSION:** MRI does not appear to be an accurate means of diagnosing inguinal hernias in patients with equivocal clinical findings.

### Keynote Lecture

#### The Role of Genetics in Breast Cancer: diagnosis and treatment

##### Invited Review

##### The role of genetics in breast cancer diagnosis and treatment

R M L Warren

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### Keynote Lecture

#### Medical Image Modelling and Surgical Planning

##### Invited Review

##### Medical image modelling and surgical planning

E Berry

Medical Physics Department, Leeds General Infirmary, The Welcome Wing, Great George Street, Leeds LS1 3EX, UK

### IT

#### From Medical Signals and Images to Clinical Knowledge (2)

##### Invited Review

##### Projects and results at the University of Oxford/

##### Medical signal processing

M Brady and L Tarassenko

University of Oxford, Parks Road, Oxford OX1 3PJ, UK

##### Invited Review

##### Projects and results at King's College London/ Aligning images, soft tissue deformation and image guided interventions

D Hawkes and D Hill

Division of Radiological Sciences & Medical Engineering, Guy's & St Thomas' NHS Trust, London SE1 9RT, UK

### Workshop

#### Vascular Ultrasound

##### Invited Review

##### Practical lower limb venous ultrasound

D Goss

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### Scientific Session

#### Genitourinary/Cardiovascular

##### DCE-MRI of the prostate: correlation with PSA and Gleason grade

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**PURPOSE:** The factors distinguishing prostate tumours that metastasize from those that remain latent are poorly understood but of great importance for the provision of evidence-based care. This retrospective study compares prostate specific antigen (PSA) level and

Gleason grade with dynamic contrast enhanced MRI (DCE-MRI) analysed using both lesion encompassing regions of interest (ROIs) and selective sampling. **METHODS:** 78 patients with biopsy-proven prostate carcinoma (48–82 years; median PSA value 45.7 ng ml<sup>-1</sup>) underwent DCE-MRI using a 1.5 T IGE scanner. T<sub>2</sub> weighted FSE images were used for tumour localization and slice selection. DCE-MRI was carried out using a FSPGR sequence (0.1 mmol Gd-DTPA kg body weight). 35 sequential images were obtained at a temporal resolution of 9 s. ROIs encompassing benign prostatic hyperplasia (BPH), normal peripheral zone (PZ) and tumour were drawn manually and further examined using an automated technique that selected the most enhancing 3 × 3 pixel square. Both data sets were analysed using a 2-compartment pharmacokinetic model to quantify amplitude, exchange rate, washout and distribution volume. **RESULTS:** Highly significant differences in maximum enhancement index, amplitude, exchange rate and distribution volume were obtained between whole and 3 × 3 pixel ROIs containing tumour or normal PZ, and BPH or normal PZ. No correlation was obtained between PSA/Gleason grade and contrast uptake parameters. Although highly significant differences in PSA and Gleason grade were obtained between groups with and without metastases, no significant alteration in DCE-MRI parameters was detected. **DISCUSSION:** Although useful for staging purposes, DCE-MRI does not correlate with PSA or Gleason grade and is not an independent predictor of metastatic potential.

#### **The significance of focal lesions during transrectal biopsy of the prostate**

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**PURPOSE:** Ultrasound guided transrectal biopsy of the prostate gland has become standard urological practice in the diagnosis of prostate carcinoma. Sextant biopsy, with or without additional lesion directed core biopsy, is usually performed. Herein we assess the significance of focal lesions on ultrasound and study its association with the histological outcome. **METHOD:** Data were prospectively acquired over a 29 month period on 222 patients (age range 49–90 years) referred for transrectal ultrasound guided biopsy performed by a single radiologist. A standard sextant biopsy with additional cores from a focal lesion, if present, was performed. **RESULTS:** Focal lesions were identified in 76 of 222 patients. Prostatic carcinoma was present in 51.3% (39 of 76) of patients with focal lesions. Of the patients without an apparent focal lesion, 26% (38 of 146) had histological evidence of cancer ( $p < 0.005$ ). The mean Gleason's score in both groups was 6.7. Only 5 of 73 patients with a focal lesion had evidence of cancer within the nodule without evidence of carcinoma in the remaining gland. 63.1% (48 of 76) of patients did not have malignancy within the focal nodule. The mean nodule diameter was 9.3 mm. Cancer within the gland +/- nodule was detected in 9 of 31 (29%) nodules of less than 10 mm, 26 of 40 (65%) nodules between 10–20 mm and 4 of 5 (80%) nodules greater than 20mm. **CONCLUSION:** Presence of a focal nodule on ultrasound significantly increases the risk of finding prostate cancer in the remaining gland, although the majority of nodules themselves are non-malignant. There appears to be increased frequency of cancer detection with increasing nodule size

#### **Measurement of ventricular volumes by gated perfusion scanning**

M R Rees, V Parkin and F Zanani

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**PURPOSE:** To measure left ventricular ejection fraction, end systolic volume and end diastolic volume in patients who undergo gated perfusion scanning. **MATERIALS AND METHODS:** 52 patients (28 female, 24 male) underwent gated perfusion scanning using a technetium-based agent. Rest and stress scans were reconstructed using two different 3D reconstruction programs (QGS and Multi DJM). Results for gated and average volumes and ejection fraction were compared. 3D volume rendered images were also reconstructed along with conventional perfusion maps. **RESULTS:** The following issues affected the quality of the results: volume of perfused myocardium; asymmetrical ventricular anatomy; and volume of the ventricle. Where the ventricle showed good perfusion of the heart, the 3D programs show close agreement with each other and with results from other imaging

modalities where these were carried out. Where there was a significant perfusion deficit, both programs tended to overestimate the ejection fraction and underestimate the ventricular volume. Differences between the programs were greatest where there was a perfusion deficit. The programs did give clinically helpful results in patients with small or no significant perfusion deficit through a range of ejection fractions (32–83%). **CONCLUSION:** Although volumetric analysis of the left ventricle is a useful parameter that can be determined on gated perfusion scanning, care must be taken to allow for perfusion deficits and ventricular asymmetry in determining these results.

#### **Myocardial perfusion imaging: do the new techniques of gated SPECT and attenuation correction improve results?**

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**PURPOSE:** Myocardial perfusion imaging (MPI) has progressed significantly in recent years owing to advances in radiopharmaceutical development, instrumentation, and image analysis and display. Simultaneous transmission imaging using gadolinium rod sources now enables elimination of focal defects caused by overlying structures such as breast and liver. Gated SPECT permits display and comparison of rest and stress end diastolic images, thereby maximizing the visible myocardial circumference whilst minimizing motion "blur" inherent in non-gated images. It also facilitates the depiction of functional data, including real-time display of left ventricular contraction, viewed from different angles and overlaid, if required, to show areas of infarction or ischaemia, polar parametric images (for example of wall thickening), together with ejection fraction and end diastolic values. **METHODS:** To assess the validity of attenuation correction (AC), 47 patients with known transmural infarction (27 anterior, 20 posterior) producing defects visible on rest MPI were compared with a control group of 47 normal non-infarct patients with attenuation defects in the same two locations. The overall accuracy of MPI after AC in distinguishing genuine defects was 78% in the anterior wall and 80% inferiorly. In a separate study of 25 patients referred for MPI with a high likelihood of significant coronary disease, 48% showed features of ischaemia on gated stress/rest MPI compared with 36% if the corresponding non-gated images were used. **DISCUSSION:** Over 1000 new-style MPI studies have now been performed on our Siemens ECAM system. The new technology works, but familiarization through personal experience and evaluation is essential.

#### **Incidence of cardiovascular disease in two age- and sex-matched populations: implications for peripheral angioplasty**

H K Cheow and M R Rees

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**AIMS:** To determine the incidence of coronary disease, cerebrovascular disease and peripheral vascular disease in two age- and sex-matched populations presenting with cardiovascular disease. **METHODS:** A population of patients who had undergone angioplasty treatment for peripheral vascular disease were matched for age and sex with a population of patients attending a chest pain clinic. There were 88 male and 50 female patients in each group (age range 48–81 years; mean age 66.7 years for the female patients and 64.9 years for the male patients). Each group was scored for the presence of coronary disease, peripheral vascular disease and cerebrovascular disease. **RESULTS:** 34% (47/138) of the patients with peripheral vascular disease had evidence of symptomatic coronary disease and 11% (15/138) had evidence of cerebrovascular disease. Of the patients presenting to the chest pain clinic, 5/138 had evidence of symptomatic cerebrovascular disease and 2/140 had evidence of peripheral disease. When patients without strongly positive exercise tests were excluded, leaving 44 cases of definite coronary disease requiring treatment, the percentage of peripheral vascular disease was 2.3% (1/44) and the percentage of cerebrovascular disease was 9.1% (4/44). **CONCLUSIONS:** The incidence of coronary disease in our group of patients with peripheral vascular disease was very high. The incidence of cerebrovascular disease was the same in both groups if only strongly positive exercise tests were taken into account. The incidence of peripheral vascular disease in the chest pain group was very low. The study does indicate a need for awareness of the consequences of coronary disease when treating patients with peripheral disease.

### **Selective angiography and venous sampling in the localization of parathyroids prior to re-exploration parathyroid surgery**

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**PURPOSE:** To retrospectively review the accuracy of angiography and venous sampling in locating parathyroid tissue in patients with recurrent or continuing hyperparathyroidism after previous parathyroid surgery and prior to re-exploration. **METHODS:** 26 patients with hyperparathyroidism and a history of previous neck surgery who underwent angiography and venous sampling between January 1993 and July 1998 were included in this analysis. Results were compared with ultrasound, sestamibi nuclear medicine scans and surgical findings. **RESULTS:** 29 selective parathyroid arteriograms and venous samplings were performed in 26 patients. 20 patients had 21 cervical re-explorations. In 19 of these re-explorations, abnormal parathyroid tissue was retrieved, the site of which was accurately determined pre-operatively by angiography in 84% and by venous sampling in 94%. When angiography and venous sampling were taken together, the correct site was identified in 95% of patients. Ultrasound was performed in 15 patients, with 7 lesions identified, 5 of which were in the correct site. 13 patients had sestamibi scans, identifying 7 lesions, 6 of which were correct compared with surgical findings. **CONCLUSION:** Selective angiography and venous sampling is an accurate method of establishing the site of abnormal parathyroid tissue. Both ultrasound and sestamibi scans were extremely poor at localizing parathyroid tissue in this group of patients.

### **Relationship of raised cholesterol and its treatment to progressive peripheral vascular disease**

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**AIMS:** To evaluate the relationship between progression of peripheral disease and raised cholesterol in a population of patients who had undergone angioplasty for peripheral vascular disease. **METHODS:** 140 patients (89 male, 51 female) who underwent peripheral angioplasty were followed up for up to 2 years, and recurrence and progression of disease were noted. Cholesterol levels and whether the patient was treated for high cholesterol were also noted. **RESULTS:** 31/51 female patients were found to have high cholesterol levels (>5); of these patients, 9/31 were treated with a statin. All but seven of the female patients were treated with anti-platelet medication. 59/89 male patients were found to have high cholesterol levels. Of these, 17/59 patients were treated. All but 17 patients were treated with anti-platelet medication. Of the patients who had progression of disease, 12 male patients had raised cholesterol and were not on medication, but only 4 patients who had progression of disease and had raised cholesterol were in the treated group. Of the female patients, three patients who had raised cholesterol and were treated showed progressive disease. 10 patients who had progressive disease and had raised cholesterol were not on treatment. Only one patient had progressive disease and normal cholesterol, however this patient was on a statin for previously raised cholesterol. **CONCLUSION:** There is a clear relationship in this group between raised cholesterol and progressive disease. The role of treatment in preventing disease progression is not clear but appears to be contributory.

## **Scientific Session Chest (2)**

### **Fine needle aspiration of lung lesions: a new safe technique using CT guidance**

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**BACKGROUND:** Fine needle aspiration (FNA) has long been established as a safe method of obtaining a tissue diagnosis from a lesion within the lung. The rate of complications is related to the time the needle is within the lungs, whether a fissure is traversed and the number of passes performed. **METHODS:** This study discusses the results of 100 consecutive FNAs using a modified CT approach designed to reduce the time the needle is within the lungs. The same operator

performed 100 lung biopsies using CT guidance. After informed consent, the site of entry is initially identified and marked in the conventional way using a Somatom plus 4 spiral CT scanner (Siemens). The machine is then prepared to perform a small spiral scan across the region of interest, and the 22 G Crown biopsy needle is advanced. The machine moves automatically to the starting position and a spiral scan is performed. This identifies the position of the needle on a single breath-hold. If the position is correct, a sample can be obtained. This method is used in combination with an on-site cytology technician providing instant cytological analysis. **RESULTS:** This technique has an extremely good diagnostic yield of 85%, with a reduced number of passes (mean number 1.1). The pneumothorax rate was small (9%), with none requiring further intervention. **CONCLUSIONS:** This is an outpatient procedure and no patient required admission or was re-admitted with complications. This CT biopsy technique provides a safe effective method of obtaining a diagnostic sample from an intraparenchymal lesion.

### **Macroscopic assessment of pulmonary fine needle aspirate samples: correlation with cytological diagnostic yield**

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**PURPOSE:** To assess the degree of correlation between a macroscopic grading of fine needle aspiration biopsy (FNAB) samples made at the time of imaging guided lung biopsy by the radiologist performing the procedure and subsequent cytological diagnostic yield. **METHODS:** Biopsy procedures performed on 45 consecutive patients in whom pulmonary neoplastic disease was strongly suspected on clinical-radiological grounds were included in the study. Macroscopic sample appearances were graded on a 5-point scale from 1 (blood with no particulate material) to 5 (solid tissue pieces without haemorrhage). Grades 2-4 were used to denote intermediate amounts of haemorrhage. All grading was performed by a single operator. Samples were then sent for cytological reporting in the routine manner. **RESULTS:** A positive FNAB result was obtained in 38/43 (88.4%) patients included in the final analysis. A positive result by FNAB pass was obtained in 66/79 (83.5%) passes performed within the sample. The positivity rate increased with macroscopic grading, from 50% for samples graded 1 up to 100% for those samples graded 5. Grouping the predominantly haemorrhagic samples (grades 1 and 2) together and comparing them with the particulate samples (grades 3-5) demonstrates a statistically significant difference in diagnostic yield ( $p < 0.001$ ). **CONCLUSION:** This small study shows that simple macroscopic grading of pulmonary FNAB samples can provide a good indication of likely cytological diagnostic yield. This may provide a basis for decisions on the number of passes performed during a biopsy procedure when immediate time-of-biopsy cytological review of samples is not available.

### **Radiological imaging as the basis for simulation software to advance individualized inhalation therapies**

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**PURPOSE:** Inhalation therapies are increasingly used for airways and systemic diseases. New developments require a comprehensive model, including the anatomy, delivery process, inhalation deposition and uptake of inhaled drugs. The purpose of this study is to implement CT and MRI as the foundation of a compartmental lung model. Hyperpolarized helium-3 MR will be used for validation purposes. **METHODS:** Spiral CT data and segmentations using automatic region growing algorithms are implemented to provide detailed anatomic information of the tracheobronchial tree, pulmonary arteries and lung volumes. Paired inspiratory/expiratory high resolution CT scans, dynamic cine CT and cine MRI during continuous respiration demonstrate calibre changes of the trachea and central airways as well as density changes of the parenchyma during respiration. From these data, the changing 3D geometrical structure of elastic wall airways is modelled using surface meshes, and particle trajectory models within a computational fluid dynamics environment. The results are displayed with the volume rendering technique. **RESULTS:** From CT data, the tracheobronchial and pulmonary arterial tree were automatically segmented down to the 5th level. Calibre changes of the trachea at

dynamic CT and MRI studies were successfully used to model airflow using computational fluid dynamics. Lung volumes were automatically quantified. Density-based assessment of dynamic scans allowed for separation of pulmonary compartments exhibiting different functional characteristics. From dynamic CT, time constants were assigned to the different compartments. CONCLUSION: CT and MRI represent the basis for a simulation program, which can assist in the development of new inhaled therapies. Refinements of this lung model are ongoing. [Supported by European Commission (IST-1999-14004: "COPHIT") and the British Council.]

#### **Contrast enhanced ECG gated MRI in pulmonary sarcoidosis**

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**PURPOSE:** To assess the potential of contrast enhanced ECG gated MRI (CE-MRI) for the assessment of disease activity in pulmonary sarcoidosis. **METHOD:** A retrospective analysis was undertaken of 40 patients referred for CE-MRI for the assessment of cardiac sarcoid, of which 11 had a contemporaneous high resolution CT (HRCT). The HRCTs were scored for the degree and parenchymal pattern type (potentially reversible disease: consolidation, nodules or ground glass; inactive, irreversible disease: pattern of fibrosis and parenchymal distortion). The HRCT findings were correlated with the extent of CE-MRI parenchymal abnormality and late signal enhancement on transverse multislice spin echo gated MRI. **RESULTS:** 59 lobes were assessed. On HRCT 17 showed irreversible disease, 17 showed reversible disease, 15 showed mixed disease and 10 were normal. The sensitivity of CE-MRI was 49% and the specificity 100%. The addition of contrast only marginally increased the sensitivity of MRI. Enhancement after contrast occurred in 91% of lobes with mixed disease, in 80% of lobes with reversible disease and in 56% of lobes with irreversible disease. CE-MRI was not sensitive for lymph node involvement (sensitivity 46%, specificity 100%) and all lymph nodes enhanced. **CONCLUSION:** CE-MRI is less sensitive than HRCT for parenchymal changes in sarcoid, but is specific. Lobes containing mixed, irreversible and reversible disease on HRCT show different enhancement characteristics that may be due to differing contrast kinetics of active and inactive sarcoid.

#### **Distribution of pleural thickening in patients with malignant pleural effusions**

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**PURPOSE:** To describe the distribution of pleural thickening on contrast enhanced CT in patients with malignant pleural effusions. **METHODS:** 22 patients with cytologically proven malignant pleural effusions were investigated with contrast enhanced CT. The axial and craniocaudal distribution of pleural thickening were reported and consensus was agreed by two consultant radiologists. Axial distribution was reported as involvement of the anterior, posterior, lateral and mediastinal pleural surfaces. Craniocaudal distribution was described in relation to four zones: superior to the aortic arch; from the arch to the inferior pulmonary veins; from the inferior pulmonary veins to the dome of the diaphragm; and inferior to the dome. Maximum pleural thickness, appearance and pleural effusion size were also recorded. **RESULTS:** 62% of the effusions were large (>50% of hemithorax occupied). 12 (54.5%) patients had pleural thickening. In 91% (20 patients), maximum pleural thickening was below the inferior pulmonary veins, and in 73% (16 patients) it was below the dome of the diaphragm. Average maximum pleural thickening as 16 mm (range 3–55 mm), which affected the posterior pleural surface in 86% (19 patients). **CONCLUSION:** Pleural thickening detected by CT in patients with malignant pleural effusions occurs maximally posteriorly and caudally.

#### **Fibrosis or recurrence? MRI evaluation of mediastinal masses after treatment for lymphoma**

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**PURPOSE:** Residual mediastinal masses in patients treated for lymphoma present a diagnostic and management problem. It is important

to differentiate active disease from lymph node fibrosis as this influences the use of adjuvant therapy. We report a retrospective study of six consecutive patients in whom MRI proved valuable in distinguishing residual disease from fibrotic change. **METHODS:** Six consecutive patients (mean age 35.8 years) with mediastinal masses following treatment for lymphoma underwent CT and MRI examinations. The radiological findings were correlated with both clinical and pathological findings. **RESULTS:** Three patients were found to have mediastinal fibrosis. One has subsequently died from unrelated disease and two are well at follow-up. The three cases of mediastinal relapse detected on MRI were all confirmed on histological specimens. One patient demonstrated recurrence within a fibrotic mass. MRI also detected fatty infiltration secondary to steroid treatment. **CONCLUSION:** MRI is able to distinguish lymphomatous from fibrotic tissue. Tumour tissue contains an excess of free water, which prolongs the  $T_2$  relaxation time, resulting in high signal on  $T_2$  weighted imaging. The converse is true for fibrotic scar tissue, which results in low signal on  $T_2$  weighted imaging. In keeping with other series, we have found a good correlation between MRI findings and histological recurrence. MRI provides a non-invasive means to evaluate residual mediastinal masses in this difficult diagnostic group.

#### **High resolution CT in usual interstitial pneumonitis and non-specific interstitial pneumonitis: morphological differences and diagnostic accuracy**

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**PURPOSE:** To compare morphological appearances and diagnostic accuracy of high resolution CT (HRCT) in biopsy-proven usual interstitial pneumonitis (UIP) and non-specific interstitial pneumonitis (NSIP). **METHODS:** HRCT scans in patients with UIP ( $n=32$ , 22 males; mean age  $53.1 \pm 10.4$  years) and NSIP ( $n=21$ , 12 males; mean age  $54.3 \pm 9.7$  years) were reviewed. Four observers independently recorded the likely diagnosis (and confidence level) in each case. The overall pattern (predominant reticular, predominant ground-glass opacification (GGO) or mixed) and its distribution (subpleural, bronchocentric or random) were noted. The coarseness of predominant reticular pattern was graded. **RESULTS:** The overall sensitivity, specificity, accuracy and positive predictive value for a HRCT diagnosis of NSIP were 70%, 63%, 66% and 55%, respectively. The proportion of GGO (but no other HRCT pattern) was independently associated with the histopathological diagnosis of NSIP (odds ratio 1.04 for each 1% increase in the proportion of GGO, 95% CI 1.01–1.07,  $p<0.005$ ). Misdiagnoses of UIP on HRCT in patients with biopsy-proven NSIP were independently associated with the presence of a subpleural distribution ( $p=0.02$ ) and less GGO ( $p<0.0005$ ), whereas misdiagnoses of NSIP in biopsy-proven UIP were independently related to the lower likelihood of a subpleural distribution ( $p<0.0005$ ), finer fibrosis ( $p<0.005$ ) and more GGO ( $p<0.01$ ). **CONCLUSIONS:** There is an overlap in HRCT appearance between UIP and NSIP. However, the sensitivity, specificity and accuracy of a HRCT diagnosis of NSIP is higher than in previous reports.

#### **Contributing role of high resolution CT in diagnosing active pulmonary tuberculosis**

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**PURPOSE:** The purpose of this study is to show the role of high resolution CT (HRCT) in diagnosing active pulmonary tuberculosis (TB) as early and as accurately as possible. Previous studies show that centrilobular nodules and a "tree-in-bud" appearance on HRCT are more sensitive than chest radiography in detection of early endobronchial spread. In a study by Im et al, 97% of patients with active pulmonary TB had evidence of bronchogenic spread of the disease on HRCT. **METHOD:** 102 patients clinically suspected of having active pulmonary TB, with chest radiography appearances suggestive of the

disease, underwent HRCT examination. RESULTS: HRCT showed that 76 (74.5%) patients had active pulmonary TB, and further clinical work-up indicated that the final diagnosis of this disease was confirmed in 52 (51%) patients. According to the binomial test, the combination of the two main HRCT appearances, namely centrilobar nodules and a "tree-in-bud" appearance, accurately confirms TB diagnosis. The sensitivity of HRCT in diagnosing active pulmonary TB was 96% and the negative predictive value was 93%. CONCLUSION: We conclude that HRCT is a powerful and reliable diagnostic tool in TB diagnosis, and it can be used even before mycobacteriological results are available, when problematic situations arise.

## Scientific Session Oncology

### Dynamic contrast enhanced MRI is the imaging modality of choice for ovarian cancer

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INTRODUCTION: Diagnosis of ovarian malignancy usually relies on ultrasound and CT. Conventional static MRI has excellent sensitivity, but the specificity is more limited. We investigated the ability of dynamic contrast enhanced MRI (DCE-MRI) to improve the specificity of malignancy detection using pharmacokinetic modelling. MATERIALS AND METHODS: 86 patients with an abnormal ultrasound or CT examination underwent DCE-MRI. Patients were assessed on an IGE 1.5 T Signa Echosped MR system using  $T_1$  and  $T_2$  weighted FSE sequences as well as a dynamic  $T_1$  weighted FSPGR sequence with intravenous Gd-DTPA contrast medium. Data were transferred to a workstation and pharmacokinetic modelling was implemented using a linear two-compartment open model. Statistical analysis was with the Mann-Whitney test. RESULTS: 21/86 women did not have ovarian pathology on MRI. Of the 65 ovarian lesions, 46 were benign and 19 were malignant. Pharmacokinetic modelling showed the malignant tumours had significantly higher values for enhancement factor ( $p$  0.001), amplitude ( $p$  0.021) and exchange rate ( $p$  0.006) than benign tumours. Using the amplitude combined with morphology, the total accuracies obtained were sensitivity 74%, specificity 96%, PPV 88%, NPV 90% and overall accuracy 91%. DISCUSSION: These results highlighted a significant number of patients in whom the ultrasound or CT diagnosis was inaccurate. Pharmacokinetic modelling of data from DCE-MRI allows the differentiation of benign from malignant lesions, improving the specificity of diagnosis. DCE-MRI should be the tool of choice in the pre-operative assessment of an adnexal mass, allowing differentiation of non-ovarian disease and more accurate classification of the malignant potential of the ovarian tumour.

### CT of leukaemic patients with neutropaenic sepsis

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A cohort of patients treated for acute leukaemia in the Avon Haematology Unit between 1998 and 2000 were included in the study. Criteria for inclusion were neutropaenia, sepsis or suspected sepsis, and a lack of response to broad spectrum antibiotics. Patients were excluded if thoracic CT had not been carried out as part of the investigation of the septic episode. METHODS: The patients' CT examinations were reviewed and characteristic features of *Aspergillus fumigatus* infection were sought, including nodular opacities with a surrounding halo of ground glass attenuation, nodules with air crescent formation, and peripheral pleurally based areas of consolidation. RESULTS: Characteristic features were found in only 24% of patients. More commonly, features were non-specific consisting of small patchy areas of ill defined opacification or consolidation (44% of patients), which could have been due to any cause of pulmonary infection. Pleural effusion or thickening was present in 52% of patients. Significant lymph node enlargement was not a common feature being present in only 4% of patients, but small mediastinal nodes were more commonly seen (28% of patients). Microbiological confirmation of *Aspergillus* infection was rare. The majority of patients were treated empirically for fungal infection before CT was performed. CONCLUSION: In neutropaenic patients with presumed fungal infection, characteristic

features are rarely seen on CT. More commonly the features are non-specific and could be due to a number of causes. Antifungal therapy is usually given empirically without specific radiological or microbiological evidence of fungal infection. The role of CT in the management of these patients is discussed.

### Impact of selective CT bone window surveillance on the management of breast and prostate cancer

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PURPOSE: In the surveillance of patients with breast and prostate cancer, routine unselective CT bone window (CTBW) printing has not been shown to be clinically or cost effective. The impact of CTBW in the management of patients with either stable or no measurable soft tissue disease has not been studied. We evaluate the impact of CTBW review in a subgroup of patients who show either no measurable disease or stable soft tissue disease. METHODS: Consecutive body CT studies were performed on 26 metastatic breast and 22 prostate cancer patients over a 12-month period. All CTBW images on serial studies in 48 patients were reviewed. The patient treatment plan before and after CT scan was recorded and comparison was also made with any available radionuclide bone scan imaging. CT scans were assessed for changes in disease status. Cases demonstrating CTBW findings that altered patient therapy were recorded. RESULTS: For breast patients, CTBW altered the treatment plan, namely cessation or continuation of chemotherapy, in 23% of patients (19% showed progressive disease). One patient staged as progressive disease on radionuclide bone scan had stable disease status on review and follow-up of serial CTBW. For prostate patients, CTBW confirmed radionuclide bone scan findings of bony disease progression in 32% of patients, although it did not specifically alter therapy. CONCLUSION: In those with apparently stable disease, supplementary CTBW influences therapy of nearly one-quarter of breast cancer patients. There is, however, no current additional benefit in CTBW for prostate cancer investigation.

### Reducing waiting times in colorectal cancer: a new approach

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Survival rates for colorectal cancer in Britain are generally lower than the rest of Western Europe and the United States. It is postulated that a delay in diagnosis and treatment may be partly to blame. The government has pledged to reduce waiting times and has set a target of 2 weeks from referral by a general practitioner to first hospital appointment for all cases of suspected cancer. This does not take into account the often considerable waiting time for subsequent investigations. This study assesses whether fast tracking urgent referrals directly from the general practitioner to a radiologist, and hence bypassing the initial outpatient assessment, will reduce the time to first definitive treatment. It also assesses the impact of this service on outpatient waiting times for colorectal surgeons. A retrospective study is being performed of urgent referrals from general practitioners over the preceding 3 years, documenting waiting times at all stages from referral to definitive treatment. A prospective study over 6 months of all urgent referrals made directly to a radiologist, documenting waiting times from referral to definitive treatment, is also being performed. Surgical outpatient waiting list lengths, prior to and subsequent to the introduction of this fast track service, are being assessed. Preliminary results indicate that this service has led to a reduction in the time from first referral to first definitive treatment. It has also led to a reduction in waiting lists for colorectal surgeons and has led to financial savings due to increased efficiency.

### Extracolonic abnormalities identified during abdominopelvic CT for colorectal carcinoma in the frail elderly patient

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PURPOSE: Minimal preparation CT is an alternative strategy for evaluating the colon in frail, elderly or immobile patients. The relative disadvantages of missing small colonic tumours by this technique are

potentially balanced by the ability of CT to visualize abnormalities outside the colon. We present our experience of such "extracolonic" findings. **METHODS:** 1077 CT studies over a period of 4 years (1995–1999) undertaken on 1031 patients (median age 79.6 years) who warranted investigation for symptoms suspicious of a colonic neoplasm were reviewed. The CT technique involved helical acquisition (10–15 mm collimation, 1.5 pitch) following 2 days of preparation with oral contrast medium only. The medical, pathological and radiological records of patients in whom positive extracolonic findings were identified were reviewed to determine their validity and usefulness. **RESULTS:** 359 extracolonic lesions were identified in 271 (24.5%) patients. The most common were liver lesions (47 patients), pelvic masses (45 patients), aortic aneurysms (34 patients), renal tract lesions (28 patients), pancreatic/biliary lesions (20 patients) and abdominal/retroperitoneal masses (16 patients). The findings included disseminated malignancy (not necessarily related to colon carcinomas), previously unsuspected tumours (e.g. ovarian, renal, pancreatic, gall bladder, gastric), lymphoma, and abdominal and pelvic collections (e.g. pancreatic pseudocyst, pyonephrosis, psoas abscess). Unusual tumours included renal oncocytoma and retroperitoneal liposarcoma. These findings were considered to have contributed to management in 172 patients (16%). **CONCLUSIONS:** Extracolonic disease may account for the presenting symptoms and may contribute substantially to the management of patients with colonic symptoms. Representative cases demonstrating the valuable contribution of CT will be presented.

#### Work in Progress

##### Early multiphasic CT appearances of metastatic liver disease following radiofrequency ablation

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**PURPOSE:** To describe the early (2–10 days) spiral CT appearances of metastatic tumours following radiofrequency ablation (RFA). **METHODS:** 37 liver metastases (33 colorectal, 4 cholangiocarcinoma; size 15–60 mm) in 17 patients were treated for 10–36 min using a water-cooled system (Radionics, Burlington, MA). The RFA lesions underwent spiral CT at 2–10 days: 16/37 at 8 mm collimation in the portal venous phase (PVP) and 21/37 in three phases (unenhanced, late arterial phase (LAP) and PVP) at 5 mm collimation. Tumours were assessed pre-treatment for marginal enhancement (ME), and post-RFA for intratumoural thrombosis (ITT), ME and subtended hyperattenuation (SHA) at LAP and PVP CT. **RESULTS:** RFA lesions demonstrated ITT in 29/37 (78%). ME was noted pre-RFA in 15/37 (41%), at LAP CT in 11/21 (52%) and at PVP CT in 17/37 (46%). SHA was seen in 11/21 (52%) in the LAP and in 10/37 (27%) in the PVP. **CONCLUSION:** ITT and ME are common features of thermal injury lesions. SHA is a significant feature following RFA of liver metastases and possibly relates to arterioportal shunting. It appears to be less problematic, in terms of image interpretation, at PVP CT.

##### The relationship between oncologists and peripheral hospital radiologists in the northwest of England

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**PURPOSE:** To audit the relationship between cancer centre oncologists visiting peripheral hospitals by assessing: (i) oncologists' knowledge of radiological services available locally; (ii) oncologists' perceptions of radiological services; (iii) radiologists and oncologists' perceptions of each other; and (iv) barriers to communication. **METHODS:** A postal questionnaire was sent to all radiology departments visited by an oncologist, and to all medical and clinical oncologists from two regional oncology centres. **RESULTS:** The response rate was 100% (21 peripheral hospital radiology departments and all 35 oncologists). (i) Oncologists' knowledge of the imaging modalities available at peripheral hospitals was limited (especially MRI and intervention). (ii) 72% of oncologists rated the overall service provided by peripheral radiology departments as excellent or good, 46% rated the overall quality of reports as excellent to good. Deficiencies in oncological reports were identified. (iii) 44% of radiologists thought the oncologists did not relate well with the local radiology department. 50% of radiologists did not know the specialist oncology interest of the visiting oncologist. (iv) 69% of oncologists did not regularly attend clinicoradiological meetings in the peripheral hospital and a lack of

written and oral information was hampering the work of both specialities. **CONCLUSION:** Communication between oncologists and the local radiology department should include: (1) regular clinicoradiological meetings; (2) information on local radiology services for visiting oncologists; (3) improved clinical information for radiologists; and (4) standardized report content.

#### Scientific Session

##### Musculoskeletal (1)

##### An update on the use of ultrasound in management of osteomyelitis

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**PURPOSE:** This study of 200 patients is an update study of our previously published paper [Nath AK and Sethu AU. Use of ultrasound in osteomyelitis. *Br J Radiol* 1992;65:649–52], which had 25 patients. **MATERIALS AND METHODS:** Plain radiographs of the affected area and ultrasound of the affected and the opposite normal area were performed in 200 patients clinically suspected of having osteomyelitis. Ultrasound scans were obtained using a 7.5 MHz phased array linear transducer. Needle aspiration or surgery was performed to confirm the diagnosis. **RESULTS:** 120 of the 200 patients had osteomyelitis, ultrasonically revealing fluid in contact with the bone with no intervening soft tissue. The fluid proved to be pus. Of the 120 osteomyelitis patients, 50 had a positive radiograph and ultrasound and 70 had a normal radiograph initially but positive ultrasound. 50 of the other patients had the following findings: 30 patients had soft tissue abscesses, 10 patients had cellulitis and 10 were normal. Limitations of ultrasound in suspected osteomyelitis in the remaining 30 patients will be highlighted, as seen in sickle cell disease (10 patients), septic arthritis (10 patients), epiphyseal osteomyelitis (7 patients) and Brodie's abscess (3 patients). **CONCLUSIONS:** Ultrasound is useful in predicting osteomyelitis, in differentiating osteomyelitis from soft tissue abscesses and in localizing lesions. The limitation of ultrasound in the disorders mentioned above means that we must resort to more direct methods such as aspirations to make the diagnosis of osteomyelitis.

##### Application of digital X-ray radiogrammetry to the diagnosis of osteoporosis

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**PURPOSE:** Radiogrammetry and peripheral cortical assessment of bone mineral density (BMD) have been established techniques for many years in the diagnosis of osteoporosis. However, until recently these methods have been limited by poor precision due to technical aspects and operator subjectivity in manual measurements. A newly developed system (Pronosco X-posure System) overcomes these problems and provides a measure of the average BMD, striation and porosity of the 2nd, 3rd and 4th metacarpals, the distal radius and the ulna. **METHODS:** 215 patients attending for bone densitometry were recruited. There were 48 males and 167 females, aged 22–76 years (mean male 52.9 ± 13.6 years; mean female 54.4 ± 12.1 years). **RESULTS:** A systematic difference was found between BMD on duplitzed and mammographic film, duplitzed film giving consistently higher values (mean difference 0.017 g cm<sup>-2</sup>). Precision was good, with CV = 0.92% (n=20). Various correlations were found between digital X-ray radiogrammetry (DXR) BMD and DXA spine (r=0.58, p<0.01), femoral neck (r=0.594, p<0.01) and SXA distal forearm (r=0.918, p<0.01). **CONCLUSION:** DXR is quick and simple to use, with good precision and having potential for application in a variety of settings, as analysis can be made in a central unit, with radiographs being performed in other centres over a wide geographic area.

##### Role of radioisotope bone scanning in the diagnosis of occult pelvic fractures in the elderly

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**PURPOSE:** Bone isotope scans at a London teaching hospital between January 1999 and November 2000 were reviewed. The isotope scans

had been requested for patients whose previous plain radiographs had not revealed any pathology, but for whom a high index of clinical suspicion remained. **RESULTS:** Of the 2048 requests, 32 (1.56%) concerned trauma to the pelvis and femoral neck. 19 (59%) of these 32 isotope scans revealed occult pathology, 17 (89.5%) of which were identified as fractures. Of these 32 scans, only 6 had been reported by a radiologist (reported normal) and 2 of these 6 proceeded to have positive bone scans. There was an unequal age distribution in positive bone scans, with a higher incidence in the elderly (over 60 years), yielding 13 of 19 (68.4%) positive scans. The sex distribution was also unequal, with 9 (59.4%) of 32 requests being made for female patients and a higher incidence of fractures in this group (10 of 19 (52.6%)) identified. **CONCLUSIONS:** Radioisotope bone scanning should be second line investigation, supported by appropriate history and clinical examination, as well as being incorporated into management and care protocols, in patients presenting with hip or pelvic pain and in whom plain radiographs are negative. Radiographs should be reported by a radiologist. The under use and delay in the initiation of this investigation may have a negative impact on the mortality and morbidity of these patients.

#### **Assessment of suspected musculoskeletal infection using "LeukoScan"**

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**PURPOSE:** Infection of joint prostheses, or of other orthopaedic implants, can be a devastating complication. However, the imaging diagnosis of this condition may not be straight-forward because  $^{99m}\text{Tc}$  MDP bone scans have low specificity and labelled leukocyte scans involve blood handling with its associated risks to patient and technician. **METHOD:** Since February 1999 radiologists in our hospital have offered  $^{99m}\text{Tc}$  labelled antiglycocalyx Fab' antibody fragment (LeukoScan®) for such diagnostic dilemmas. During this time 30 LeukoScans® have been performed for suspected musculoskeletal infection in this context. For 24 of these examinations the standard three phase protocol was extended to include a fourth phase at 24 h. **RESULTS:** We found extending the protocol to include a fourth phase particularly helpful to confirm a negative result with confidence as at 24 h post injection the target to background ratio has improved through reduction of blood pool activity, and this reduces interference from vascular structures. We present a pictorial review of our experience and include examples of the LeukoScan® clarifying diagnosis of false positive and false negative bone scans. We also include the appearance on LeukoScan® of soft tissue inflammation as distinct from osteomyelitis. **CONCLUSION:** In our initial 18 months experience of LeukoScan® for suspected prosthetic infection, we have found its use valuable and reliable in the resolution of diagnostic dilemmas. Could we even say Fab'?

#### **Avascular necrosis of bone in the HIV population: a new diagnostic challenge for radiologists!**

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Avascular necrosis (AVN) of bone is an extremely rare complication in the HIV population. Only a handful of cases are reported worldwide. Proposed causative factors include (1) history of steroid usage, (2) systemic vasculitis including SLE and (3) biochemical abnormalities which include raised serum antiphospholipid or anticardiolipin antibodies. In addition, an anti-retroviral drug, called the protease inhibitor, has recently been implicated. In this report we present five cases of proven HIV infection with AVN that involves one shoulder and six hip joints. All cases have a past history of moderate to high dose steroid usage during their initial presentations. Only two of the patients were on protease inhibitor before development of AVN. None of our patients demonstrates any biochemical abnormality listed before or during the course of their illness. For three of the patients, early diagnosis of AVN was clinched by MRI. The sequences used include  $T_1$  and  $T_2$  weighted SE sequences, which demonstrate the precise distribution of the disease process, as well as a STIR sequence that shows marrow oedema. **CONCLUSION:** As HIV patients are surviving longer owing to powerful anti-retroviral treatment, new complications, including AVN of bone, are becoming more common. Being familiar

with these new complications is vital for radiologists to instigate the appropriate imaging investigation to establish the correct diagnosis.

#### **CT analysis of patellofemoral tracking abnormalities and their clinical correlations**

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**INTRODUCTION:** Patellofemoral misalignment is a major cause of anterior knee pain in the young active population. Despite recent improvements, clinical and imaging related assessment remains difficult. The importance of the first 20 degrees of flexion using CT has previously been confirmed. This study evaluates the usefulness of standardized CT methods in assessing clinical symptoms in both knees of patients with either unilateral or bilateral symptoms. **METHODS:** A retrospective study of 53 patients, clinically judged to have patellar misalignment, was performed by assessing axial CT scans of both knees. Measurement of femoral-trochlear angle, femoral-trochlear depth, patellar tilt and congruence angle were made according to previously described techniques. Using these measurements, each knee was assigned to one of four groups: subluxation without tilt; subluxation with tilt; tilt without subluxation; and normal. Patients were scored according to their clinical presentation using a patellofemoral rating score (maximum of 100, normal). **RESULTS:** 15 patients (28%) demonstrated unilateral patellofemoral misalignment that correlated with the affected knee ( $p < 0.01$ ). 29 patients (55%) demonstrated bilateral patellofemoral misalignment, but only 14 of these (48%) complained of bilateral symptoms. The most frequently found misalignment was subluxation without tilt in the unilateral group and subluxation with and without tilt in the bilaterally affected group. Patellar tilt in either the presence or absence of subluxation was less commonly seen. No significant correlation between the patellofemoral rating score and the degree of misalignment was achieved. Patellar tilt or subluxation could not be correlated with the more simplistic measurement of femoral-trochlear angle or depth. **DISCUSSION:** CT scanning of the knees using a standardized technique correlates well with the clinical presence of patellofemoral misalignment but is less useful in predicting the degree of severity. Assessment using femoral-trochlear depth and angle is less reliable. Inadequacies in the diagnosis and knowledge of patellofemoral biomechanics in anterior knee pain remains. Although fixed angle CT is a useful clinical adjunct, dynamic imaging may be more useful.

#### **MRI in the diagnosis of ulnar nerve entrapment at the elbow**

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**INTRODUCTION:** Ulnar nerve entrapment at the elbow (UNEE) is a common entrapment neuropathy. The clinical outcome following treatment for this disorder is often less than optimal. Diagnosis of this condition is usually made on clinical evaluation and electrodiagnostic studies (EDS). In this study, we proposed to evaluate the ability of MRI of nerve (MRIN) to improve the diagnosis of UNEE. **METHODS:** Patients were presumed to have UNEE if they met the clinical criteria using a reference standard. These patients then underwent MRIN of the ulnar nerve across the elbow, as well as an electrodiagnostic evaluation, prior to an initial 4-week trial of medical treatment. Patients who failed to improve were then considered for surgery and, if they met the current standard of care, underwent standard surgical treatment. Patients were then evaluated post-operatively, and the outcome was graded. **RESULTS:** 19 patients were male and 2 were female; mean age 51.6 years. All subjects were diagnosed with UNEE based on clinical criteria. EDS were positive in 15/21 (71%) patients. In 21/21 (100%) subjects, MRIN was diagnostic of UNEE. All subjects failed to improve with medical therapy and underwent operative treatment of their UNEE. In 21/21 (100%) subjects, intraoperative evidence of ulnar nerve compression was noted. Mean post-operative follow-up was 5.72 months. Improvement was noted in 17/21 (81%) patients and no improvement was noted on follow-up in 4/21 (19%) cases. Sensitivity of EDS was 0.647 (95% CI 0.44–0.86); sensitivity of MRIN was 1.000 (95% CI 0.80–1.00). **CONCLUSION:** Our pilot study indicates a high degree of sensitivity for MRIN in identifying pathology of the ulnar nerve at the elbow, which is superior to EDS.

**<sup>90</sup>Tc<sup>m</sup> sulesomab white cell scan and <sup>18</sup>F<sup>18</sup>FDG PET imaging in infection of hip prostheses**

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**AIM:** To assess the value of <sup>90</sup>Tc<sup>m</sup> sulesomab and <sup>18</sup>F<sup>18</sup>FDG PET imaging in the diagnosis of infection in painful hip prostheses prior to revision surgery. **METHOD:** A total of 8 patients (15 prosthetic hips) were imaged prior to revision hip surgery. The scans were independently reported by two consultant radiologists (AM, MB) with experience in the interpretation of nuclear medicine and PET studies. A 4-point scale with respect to the perceived likelihood of infection was used. Quantitative analysis of the PET data was attempted using the Patlak technique. The results were compared with the results of microbiological and pathological analysis of the removed prosthesis and surrounding tissues as a gold standard for the detection of infection. **RESULTS:** The white cell study correctly identified the two infected hips but produced a false positive result in three non-infected joints. The PET study appeared positive for all painful hips studied but was negative for the non-painful side in all cases. **CONCLUSIONS:** Neither technique appears promising as a sole diagnostic study for the detection of infection. <sup>18</sup>F<sup>18</sup>FDG PET may have a role in the early detection of loosening of hip prostheses.

## Scientific Session Gastrointestinal (1)

**Radiofrequency ablation: improved quality with CT monitoring**

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**PURPOSE:** Radiofrequency ablation of liver neoplasms is usually performed using ultrasound guidance. The purpose of this study was to prospectively evaluate the potential benefit of CT guided treatment. **PATIENTS AND METHODS:** 18 patients with metastatic tumours of the liver received a single treatment of both ultrasound guided and CT guided percutaneous radiofrequency ablation to 32 lesions (lesion size 1–4.5 cm; median 2.5 cm). For follow-up, contrast enhancement of liver metastases was measured with CT by digitally subtracting tumour data acquired during a non-enhanced phase from data acquired in a portal-dominant phase. **RESULTS:** 22/32 (69%) lesions were easier to identify and follow under CT guidance, and this was particularly true for lesions <2 cm. Ultrasound and CT were equivalent for lesion delineation. Sonographically, radiofrequency lesions appeared as hyperechoic areas with blurred margins during and shortly after treatment. With CT, however, the actual size of necrosis and the extent of induced coagulation could be determined at all stages. In addition, multislice spiral CT minimizes patient motion artefacts, which have hindered acceptance of digital subtraction CT in clinical practice. **CONCLUSION:** Radiofrequency procedures should be performed with CT rather than ultrasound monitoring as this improves detection of liver lesions, guidance of electrode placement and monitoring of energy delivered. The degree of contrast enhancement of a tumour correlates with its vascularity and thus might be used to determine its response to radiofrequency ablation.

**Use of radiofrequency ablation in the treatment of tumours**

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**PURPOSE:** To present our experience in the treatment of tumours using radiofrequency ablation (RFA). **MATERIALS AND METHODS:** Between 1996 and November 2000, 46 patients (mean age 55 years) were referred to our unit for RFA therapy. The majority of patients were treated for metastatic liver disease; of these, the majority had colorectal cancer. One patient had a renal cell carcinoma and another had a large secondary lesion in the pancreas. A young child with an osteoid osteoma in the femur is currently being considered for RFA. All examinations were carried out in the radiology department using CT or ultrasound guidance and sedo-analgesia. RFA was carried out using the Radionics cool-tip (triple or single) electrode. Mean RFA time was 12 min for each position, with the needle then often

re-directed. The mean end temperature achieved was 70 °C. **RESULTS:** There were no severe complications. Minor complications included: one pleural effusion, one pneumothorax (no treatment required), four patients with abdominal discomfort and pain (from capsule and abdominal wall irritation), one abscess and one haematoma. Tumour ablation reduction was obtained in all cases. **CONCLUSIONS:** Until recently, the alternatives to surgical treatment of malignancy have been limited to radiotherapy and chemotherapy. One of the most exciting techniques for percutaneous tumour destruction is RFA. Although largely used for hepatic disease, RFA may be beneficial for extrahepatic tumour treatment in patients who may not be surgical candidates owing to location, extent of involvement, concomitant debilitating medical conditions or a history of multiple previous surgeries.

**MRCP: how good are we?**

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**PURPOSE:** All the magnetic resonance cholangiopancreatograms (MRCPs) in a large teaching hospital have been reviewed since this technique was introduced 2 years ago, to assess the diagnostic accuracy and impact of this test. All the examinations were retrospectively analysed. In addition, comparison with ERCP or operative findings was assessed where available. **METHODS:** Over a 13-month period, 151 MRCPs were performed. Patient age ranged from 19–96 years; 49% of patients were male. A refusal rate of 3% was encountered. All examinations were performed on a 1 T Siemens Magnetom scanner, after 4 h fasting. **RESULTS:** A successful MRCP was performed in 12 patients in whom ERCP had been attempted but failed. 35 cases had both MRCP and ERCP/PTC. In 11 patients, ductal strictures were suggested by MRCP and all were confirmed at ERCP/PTC. Ductal calculi were suggested in 12 cases in which ERCP was subsequently performed. In eight cases, ductal calculi were demonstrated, the smallest 6 mm. In four, the ERCP was negative. However, there was ductal dilatation at the time of the MRCP, which had resolved at ERCP, and all calculi in this group had been <5 mm. Seven MRCPs demonstrated ductal dilatation but did not suggest calculi. At ERCP, one missed calculus was identified, one ampullary tumour and five examinations demonstrated dilatation but no calculi. **CONCLUSIONS:** MRCP offers an accurate method of identifying biliary disease. This technique is extremely accurate at demonstrating strictures within the system. It can accurately diagnose all CBD stones greater than 6 mm.

**Biliary imaging by MR cholangiopancreatography and spiral CT cholangiography: a comparative retrospective analysis**

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**PURPOSE:** To assess the technical efficacy and clinical value of magnetic resonance cholangiopancreatography (MRCP) and computed tomography cholangiography (CTC) in non-icteric patients with suspected pancreaticobiliary disease. **METHODS:** A review of 60 patients (22 male, 38 female; mean age 59 years, age range 20–87 years) who had undergone both MRCP and CTC was performed on separate occasions by two radiologists who were blinded to the underlying diagnosis. The ability of either modality to produce technically satisfactory images and to detect biliary dilatation, bile duct stones and biliary stenosis was assessed. Where there was disagreement in the radiological findings, correlation with results of other diagnostic procedures and clinical follow-up was made. **RESULTS:** 54/60 MRCP examinations compared with 59/60 CTC examinations produced technically satisfactory images. In a total of 13 cases of bile duct dilatation, 10 were detected by both modalities and 3 by CTC alone; gas in the biliary tract accounted for the inability to detect these on MRCP. Nine ductal stones were detected by both modalities, and CT detected a further two calculi not seen on MR but confirmed on ERCP. A further two were also suggested by MR, but these were not confirmed. Out of a total of four strictures imaged, three were confirmed cases of primary sclerosing cholangitis. All the strictures were detected by CTC but only one by MRCP. **CONCLUSION:** CTC is frequently overlooked because of recent developments in MRCP. However, in this selected group of patients, CTC was technically successful in more cases and detected significant pathology missed on MRCP.

**Magnetic resonance cholangiography in the assessment of bile duct strictures following hepatobiliary surgery**

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**PURPOSE:** To establish the accuracy of magnetic resonance cholangiography (MRC) in the assessment of bile duct strictures in patients following hepatobiliary surgery. **METHODS:** 37 patients with suspected biliary strictures following liver transplantation ( $n=29$ ), cholecystectomy ( $n=5$ ), hepatic resection ( $n=2$ ) and Whipple's procedure ( $n=1$ ) underwent MRC. Imaging was performed on a 1.5 T system and comprised single shot FSE (TR 4500 ms, TE 940 ms, ETL 240,  $360 \times 512$  matrix, 50 mm slice thickness, TA 5 s) in the coronal through to sagittal plane at 100 increments, and contiguous haste images (TR 1900 ms, TE 96 ms, ETL 128,  $218 \times 512$  matrix, 4 mm slice thickness) in the transverse and optimal coronal/oblique plane. The MRC images were reviewed independently by three blinded observers who recorded the diagnostic features and the presence of a biliary stricture based on a 5-point confidence scale. The results were correlated with ERC ( $n=25$ ), PTC ( $n=8$ ) or surgery ( $n=4$ ). The accuracy of MRC was measured by ROC analysis, and sensitivity, specificity, PPV and NPV were also calculated. **RESULTS:** All but one anastomosis was seen on MRC, and duct depiction was graded as good to excellent in most patients. 16/37 patients had strictures, which were diagnosed by MRC in all cases. In five patients with moderate duct dilation and calibre change at the level of the anastomosis, strictures were overcalled by MRC. The mean accuracy, sensitivity, specificity, PPV and NPV were, respectively, 0.92, 98%, 62%, 0.72 and 0.98. **CONCLUSION:** MRC was accurate for the detection of bile duct strictures following hepatobiliary surgery, although there was a tendency to overestimate the significance of minor duct dilation and calibre change.

**MRI in the staging of upper gastrointestinal malignancy: comparison with conventional imaging modalities**

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**AIM:** To assess the role of magnetic resonance (MR) in staging upper gastrointestinal (GI) malignancy, in particular to examine the role of MR in detecting metastatic liver disease in addition to staging local disease. The incidence of upper GI malignancy in the western world is increasing faster than any other malignancy. Until recently, the mainstay of treatment was surgery, although the role of down-staging of the disease with chemoradiation is increasing. This treatment requires accurate staging of the disease, and despite a multimodality imaging approach recurrence is often detected in either the liver or lungs. This prospective blinded pilot study is designed to assess the role of MRI in staging both the local extent of the tumour and in detecting early liver disease. **METHODS:** All patients are volunteers with either biopsy-proven squamous or adenocarcinoma of the oesophagus or gastro-oesophageal junction. All patients are staged conventionally with endoscopic ultrasound and CT. In addition, an MR scan is performed. Multiple sequences including iv gadolinium enhancement are used. These scans are interpreted by one of two consultant radiologists blinded to the results of all other imaging. Most patients in the unit then have a staging laparotomy at which the liver is examined, before definitive surgery is performed. The imaging findings are compared with the results of both the laparotomy and the actual operation. Ultimately, the imaging is compared with the pathological staging of the resected disease.

**How effective is a reduced dose of SPIO for MRI in the cirrhotic liver?**

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**INTRODUCTION:** The purpose of this study was to compare the effects of high dose (HD) and low dose (LD) ferumoxides on liver signal intensity in patients with end stage cirrhosis. **METHODS:** 13 cirrhotic liver transplant candidates underwent HD ferumoxide

enhanced imaging at a dose of 15 mmol kg<sup>-1</sup> b.w, and 17 candidates underwent LD ferumoxide enhanced imaging at a dose of 7.5 mmol kg<sup>-1</sup> b.w. A LD control group comprised 13 patients with colorectal metastases. Using a 1.5 T system, T<sub>2</sub> weighted FLASH (TR 159, TE 15.1, FA 30°) images were obtained before and after ferumoxides in all patients. ROIs were used to measure liver percentage signal intensity loss (PSIL) post ferumoxides. Lesion-to-liver contrast-to-noise ratio (CNR) was measured in patients with focal lesions. The Mann-Whitney test was used to test differences between the PSIL of the three groups. **RESULTS:** PSIL for the HD cirrhotic group (median 90.0, IQR 87.8–92.2) and the LD non-cirrhotic group (median 77.1, IQR 67.7–84.6) were significantly greater ( $p<0.005$ ) than the LD cirrhotic group (median 58.5, IQR 46.5–70.5). However, in the six LD cirrhotic patients with tumours, CNR values after LD infusions (median 20.4) were similar to those obtained in the non-cirrhotic control group (median 25.1). **CONCLUSION:** Whilst we found a substantial PSIL after LD ferumoxides in the majority of our cirrhotic patients, the range of PSIL values was considerably greater than in the other groups and we feel that further studies are needed before a reduced dose can be recommended in this patient population.

**Scientific Session  
Radiotherapy**

**Determination of the accuracy of manual outlining methods for radiotherapy planning**

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**PURPOSE:** In departments where CT scanning is not used for radiotherapy planning of head and neck tumours, an alternative method of outlining must be used. This study examined the relative accuracy of the most commonly used manual methods to determine whether they met the published criteria of  $\pm 2$  mm accuracy. **METHOD:** Five beam direction shells were outlined using a CT simulator, and these were taken as the gold standards. A team of four researchers then took two outlines of each shell using thin wire, thick wire and thermoplastic tubing. The resulting outlines were then compared with the gold standard. A further investigation was made to determine whether accuracy was improved by adding an additional reference point 5 cm posterior to the lateral laser marks. **RESULTS AND CONCLUSIONS:** None of the stated methods met the criteria of  $\pm 2$  mm variation from the gold standard. The greatest variation was found posterior to the lateral laser marks, where the average maximum variation was 4.5 cm, 3.4 cm and 5.4 cm, respectively. This has implications for clinical practice, as it may have an effect on the dose distribution of tumours that are posteriorly situated or have posterior oblique beams entering through this part of the outline. Addition of the extra reference point did not improve the outline enough to meet the accuracy criteria quoted above. However, it did bring about a marked reduction in variation from the gold standard in the region posterior to the laser reference point, the average maximum variation being 4.5 cm.

**MRI and MRS of radiation distributions using a polymer gel dosimeter**

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**PURPOSE:** MRI is useful in demonstrating radiation dose distributions in tissue-equivalent gels. A new polyacrylamide-based gel has been shown to combine sensitivity to radiation with stability. Radiation-induced polymerization increases relaxation rates and can be analysed with MR. This work describes the use of MRI and MRS for quantitative dose distributions at high resolution. **MATERIALS AND METHODS:** A polyacrylamide gel was irradiated from beneath by a 5 cm  $\times$  5 cm field delivering a dose of 5 Gy. MR studies were performed on a 1.5 T GE Signa, and imaging and spectroscopy were used to investigate areas of maximum and zero dose. T<sub>1</sub> and T<sub>2</sub> weighted sequences were acquired to assess imaging sensitivity. Spin echo images were acquired to measure T<sub>2</sub> (TE/TR = 11, 400 ms/4 s). Multiple fast spin echo images covering the entire flask were obtained for subsequent 3D post-processing (TE/TR = 100–400 ms/4 s, 2.5/0 mm). Single voxel spectroscopy was also acquired in the regions of interest (TE/TR = 40 ms/2 s). **RESULTS:** All images demonstrated

contrast between zero and maximum dose regions, with  $T_2$  weighting showing greatest sensitivity.  $T_2$  values of 833 ms and 476 ms for zero dose and 5 Gy regions were measured. Post-processing permitted realistic 3D visualization of the irradiated volume inside the flask. Spectra from the gel demonstrated the spin-spin coupling of monomer resonances, which were broader and less concentrated at 5 Gy. CONCLUSIONS: Results show the feasibility of 3D dose measurement using MR. Future work will involve confirming isodose lines from complicated radiotherapy treatment plans and increasing measured dose accuracy using a combination of MRI and MRS.

#### Graphical methodology for assessing consistency of high dose rate brachytherapy treatment plans

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PURPOSE: As part of our ongoing quality assurance of the Nucletron high dose rate (HDR) brachytherapy treatment planning used at the Cleveland Clinic, we have developed graphical models to allow rapid checking of simple treatment plans. METHOD AND RESULTS: Data acquired from more than 150 patients over the past several years have been used for analysis of intracavitary gynaecologic implants (vaginal cylinder, Fletcher Suit applicator, tandem/ring applicator) and intraluminal implants (oesophageal and endobronchial). First, representative examples of each type of these HDR cases were planned on a second system (ROCS) for comparison. Dosimetric equivalence (dose points and V100 (volume enclosed by the prescription dose, *i.e.* 100%, obtained from the dose volume histogram)) of double plans (Nucletron's Plato for HDR and ROCS) for these data was excellent (better than within 2%). Next, the whole data set for each implant type was reduced to a plot of time  $\times$  source activity/dose vs V100. For the oesophageal and endobronchial cases, the active length of the implant or the number of dwell positions could substitute for V100. CONCLUSION: These plots are very linear and thus provide an easy check of any new plans without the necessity of re-planning on a second, independent system.

#### Exit dose measurement using LiF TLD rods

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PURPOSE: The need for reliable techniques to measure exit dose has become important owing to the development of improved methods of estimating tumour dose from exit dose. METHODS: In this study LiF:Mg,Ti thermoluminescent dosimeters (TLDs) were used to measure the exit dose in a "solid-water" phantom, with and without backscatter material for radiotherapy photon beams. 1 mm  $\times$  1 mm  $\times$  6 mm Harshaw LiF:Mg,Ti TLD rods with reproducibility within  $\pm 3\%$  and sensitivity variation below 15% were selected. 6 MV and 10 MV photon beams from a linear accelerator formed the radiation source and a Harshaw 3500 was used as the TLD reader. The TLDs, positioned in specially designed slots in a 3 mm thick phantom, were fixed at the exit surface of the phantom. Measurements were taken for different thicknesses and field sizes at 100 cm SSD. RESULTS: The measured exit doses for phantom thicknesses of 4–24 cm, for 6 MV and 10 MV photon beams, were found to be lower by 12.2–17% and 10.4–16.9%, respectively, compared with the per cent depth dose plotted in water. Likewise, the exit dose for different field sizes is found to be within 1.2%. The exit dose for depth with backscatter material from 2 mm to 15 cm shows the expected increase, and the saturated values agreed to within 1.5% for both beams. CONCLUSION: From the results, it can be expected that LiF TLDs can be used to determine critical dose at the exit surface as well as to estimate tumour dose within accepted limits of uncertainty.

#### Intensity modulated radiotherapy with physical compensator: an evaluation of the Nucletron Plato software

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PURPOSE: Nucletron's IMRT planning software allows the use of either multileaf collimators or physical compensators for delivery of the IMRT beam. We have evaluated the use of this software in association with lead compensators. METHODS: IMRT requires beam

attenuation of up to 95%, and for such thicknesses of lead the effects of scatter and off axis beam softening need to be considered. The software permits the user to define correction factors to allow for the variation in effective attenuation factor with lead thickness, and for differences in off axis attenuation. The dose calculation has been tested using both an idealized stepped compensator and a compensator designed by the inverse planning software to treat a real tumour. The dose distributions from single fields were measured in a cuboidal phantom using diodes, film, thermoluminescent dosimeters (TLDs) and ionization chambers, and in anthropomorphic phantoms using TLDs and ionization chambers. RESULTS: The Plato dose calculation agreed with the measurements within the experimental error of  $\sim 3\%$ . CONCLUSION: Because of the inherent inhomogeneity of the dose distribution from a single field, positional accuracy is very critical and this is also likely to be a problem for patient treatments. Smoothing the IMRT beams should reduce the sensitivity of dose distribution to set up errors, and this possibility is currently being evaluated.

#### A comparison of prone pelvic treatments with and without the use of a thermoplastic shell

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PURPOSE: The objective of this study was to assess set-up reproducibility of radical pelvic treatments for obese patients in the prone position, with and without the use of an immobilization shell. METHOD AND MATERIALS: To ascertain the most suitable positioning and/or immobilization device(s) for The Plymouth Oncology Centre, initially two different patient positions have been compared for accuracy using portal imaging and evaluation of interfractional set-up deviations during treatment. The original aim was to randomize 20 patients into two groups: Group 1 were to be treated for the first 2 weeks of their treatment with no positioning device and then for the last 2 weeks of their treatment with a device; Group 2 commenced treatment in a shell and then reverted to no shell. Portal images in the posterior and lateral plane were to be acquired on Days 1–5, Day 7 and Day 9 of both Plans 1 and 2. RESULTS: Early results from this study highlighted large random errors in the superior/inferior plane when patients were positioned in the thermoplastic shell and therefore the study was abandoned at patient No. 4. CONCLUSION: This paper will discuss the design of the study, the results prior to study abandonment, the possible reasons for the large deviations and future suggestions.

#### Coming out of the bunker: the radiotherapist as a member of the multiprofessional cancer team

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The radiotherapy team of tomorrow will be very different to that which we have become accustomed to. This paper will show how the initiatives that have been implemented in the Derby Cancer Centre support the local team of radiotherapists (or therapy radiographers) in its development towards a competency and occupational standards-based workforce, both working and continuing to develop as a fully integrated component of the interdisciplinary cancer care team. Examples of initiatives include not only specialization between treatment and planning sections and role development at Superintendent Specialist grades (in areas such as breast mark-up, treatment review and portal image interpretation), but also the development of rotational posts in these key specialties and the creation of key Link Radiotherapist posts (*e.g.* oncology inpatients, palliative care, lung cancer/CHART, head and neck, gynaecological and colorectal cancers), to provide effective development of skills and succession planning at all grades. Another initiative that is key to the success of such a model has been the introduction of both clerical and clinical assistants, or helpers. The whole is underpinned by an ethos of multiprofessional working within Cancer Site teams (*i.e.* extending the MDTs) and the implementation of a structured novice-to-expert model for continuing professional development and postgraduate education of the radiotherapist workforce from Assistant grades through to Senior Specialists.

## Scientific Session Dose Optimization

### Image quality and patient dose in paediatric radiology using CR plates

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Following the introduction of a computed radiography (CR) system into the Radiology Department at Great Ormond Street Hospital, there has been a need to revisit the optimization of exposures to ensure adequate and consistent image quality for acceptable patient dose. Experience has shown that traditional film-screen techniques and exposure factors cannot simply be transferred to CR systems, and the suggestion that CR is inherently a low dose technique must be investigated more closely. A study has been undertaken of how changes in technique can affect image quality and dose. Image quality is hard to assess objectively, although there is guidance available through the EU quality criteria. In particular, it is important to note that the spectral response of a CR plate is significantly different to that of conventional film-screen and that it is necessary to adjust the kVp to match its characteristics. In doing so, this would reverse the move towards higher kV techniques for paediatric radiography and consequently highlight the need for caution when adopting national diagnostic reference levels for radiographic examinations.

### Pitfalls of optimization and harmonization of exposure protocols in a mixed film-screen/computed radiography department

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PURPOSE: A survey of patient doses has indicated an apparent non-harmonized practice within the radiology department. This is most apparent between rooms using film-screen as the detector and those using computed radiography (CR) photostimulable phosphor plates. The objectives of this study were to ascertain the causes of non-harmonized practice, to harmonize exposures and to identify the scope for optimization and implement it for chest X-ray examinations. METHODS: Exposure protocols in the outpatient rooms (which use film-screen detectors), the inpatient rooms (which use CR) and the dedicated chest room (which use film-screen and CR) were surveyed. The results were related to dose area product (DAP). Image quality was assessed using a TO16 Leeds CR Test Object. RESULTS: The majority of outpatient film-screen exposures appear to be harmonized. One room with very different available exposure settings gives a higher DAP than the others, for a poorer image quality. The inpatient CR rooms give higher DAPs per examination than the film-screen rooms. This is due to their use of a higher kilovoltage and the higher minimum mAs settings available to the X-ray machines. The dedicated chest room uses lower set kilovoltages and mAs for CR exposures compared with inpatient rooms. This is reflected in lower DAPs and relatively poorer image quality in this room. CONCLUSION: This study has identified two cases of non-harmonized practice within our department. Radiology departments that make use of both film-screen and CR as imaging media need to optimize their exposure protocols for each medium separately.

### Doses to radiologists' legs: are they a cause for concern?

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PURPOSE: Radiologists performing interventional procedures need to stand close to the X-ray couch. Their legs, which are not protected by a lead apron, are exposed to radiation scattered from the bottom of the couch. The aim of this study is to determine the magnitude of the doses received. METHODS: Thermoluminescent dosimeters have been attached to the legs and feet of interventional radiologists in a number of large hospitals. Doses have been measured for sessions and for

individual procedures. RESULTS: Where no purpose-built shielding is used, the doses received may be 1–2 mSv per session, and could reach the skin dose limit required for classification. The doses received by the legs can be similar to or greater than those to the hands of the radiologist, depending on the type of procedure. For leg angiograms and arteriograms, doses to the radiologist's legs are double those to the hands, whereas for biliary drainage and biliary stents, which involve manipulations closer to the X-ray beam, doses to the hands and legs are similar. Protection for the legs and feet can readily be provided by lead rubber drapes either attached to the table or mounted on a free-standing support. Where such screens are in use, the doses measured have been between 0.05–0.3 mSv per session. CONCLUSION: Doses to the legs of interventional radiologists can be significant where shielding is not used. Drapes attached to the X-ray couch provide the most effective method of reducing doses.

### CT reference dose levels in Onassis Cardiac Surgery Center

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PURPOSE: The purpose of the study was to apply European Commission (EC) reference dose levels (RDLs) in CT examinations at Onassis Cardiac Surgery Center (OCSC). These RDLs are weighted CT dose index (CTDI<sub>w</sub>) for a single slice and dose-length product (DLP) for a complete examination. METHODS: Lumbar spine, cervical spine and neck examinations were chosen because there are no specific values as yet available from the EC. CTDI measurements were performed and CTDI<sub>w</sub> and DLP were calculated. RESULTS: Third quartile values of CTDI<sub>w</sub> were chosen to be 47 mGy for cervical spine, 40 mGy for lumbar spine and 64 mGy for neck examination. Third quartile values of DLP were chosen to be 226 mGy cm for cervical spine, 348 mGy cm for lumbar spine and 900 mGy cm for neck examination. CONCLUSIONS: The above values of CTDI<sub>w</sub> and DLP were set as initial examination specific RDLs for OCSC. The suitability of the proposed RDLs should be checked and reviewed regularly to promote continuous improvement over time.

### X-ray dose reduction during percutaneous closure of the persistent ductus arteriosus

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INTRODUCTION: In a recent audit, we established that all information on duct size, morphology and device implantation strategy is provided by aortography in the lateral projection for 20/20 (100%) cases of percutaneous closure of the persistent ductus arteriosus (PCPDA). Using a biplane angiography system and adopting the strategy of combining fluoroscopy available in either plane with lateral projection fluorography only, we have estimated the potential reduction in effective dose (ED) and associated risk. METHOD: Using transmission ionization chambers attached to each X-ray tube, detailed dosimetry has been made for each stage of each procedure for 50 children aged  $4.0 \pm 3.4$  years (mean  $\pm$  SD) undergoing PCPDA. Using recently published conversion factors, the total ED was estimated together with age-dependent associated risk. The relative contribution for all fluorography other than the lateral projection was subtracted from the total ED. RESULTS: The relative contributions to ED for fluoroscopy and fluorography were 58% and 42%, respectively. The total ED was  $3.6 \pm 2.7$  mSv. (median  $\pm$  SD), with a median associated risk of 0.058%. After removing the contribution to ED for all non-lateral projection fluorography, the relative contributions to ED for fluoroscopy and fluorography were 65% and 35%, respectively. The ED and risk were reduced to  $3.1 \pm 2.7$  mSv and 0.05%, respectively. CONCLUSION: For PCPDA procedures, fluoroscopy available in two planes, combined with single plane lateral projection aortography, results in a reduction of ED and associated risk of 13.9% and 13.3%, respectively, without compromising procedure outcome.

**Big Brother comes to radiology...**

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The current patient administration system (PAS) for Bart's and the London NHS Trust allows input of dosimetry data for diagnostic X-ray examinations, including dose-area product (DAP), screening time, examination type and number of films, with patient age and sex also available. This is transferred monthly to the physics dosimetry database. Reports can then be produced over any period for a given examination, which include mean DAP, screening time and number of examinations carried out. With the implementation of IRR99 and IRMER, collection and collation of this data for all diagnostic examinations was deemed a requirement and, in collaboration with IM&T and radiology departments, we are updating the PAS to our needs. Request information, practitioner, operator, rejected and repeated radiographs, and cancelled requests are all now included, and the patient will be categorized as small, medium or large. These data will be fed nightly to a new SQL Server database, which will also hold the diagnostic reference level values and calibration data. We shall use an Access front end to gain access to the data. The new system should be functional by April 2001 and will allow compliance with IRMER and will also provide a source of up-to-date information from the radiology activity for our own analysis, with a huge potential for more. This presentation will outline the structure of our database, the practical problems encountered and samples of the information we can expect to provide once the system is live.

**Work in Progress****Cancer and chronic exposure to high levels of natural radiation: facts vs fear**

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Life evolved in a higher radiation environment than exists today, and background radiation levels today are lower than at any time in the history of life on Earth. Today, natural background radiation levels on Earth vary by at least two orders of magnitude, so people and other organisms are subject to a wide range of background radiation levels. One of the arguments used in support of increasingly strict radiation dose limits is that every incremental reduction in radiation exposure carries with it a net benefit to the public health. This hypothesis is also frequently cited by those with a seemingly irrational fear of radiation. People in some areas of Ramsar, a city in northern Iran, receive an annual radiation dose from background radiation that is more than five times higher than the 20 mSv year<sup>-1</sup> that is permitted for radiation workers. Inhabitants of Ramsar have lived for many generations in these high background areas. If an annual radiation dose of a few hundred mSv is detrimental to health, causing genetic abnormalities or an increased risk of cancer, it should be evident in these people. Our cytogenetic studies show no significant differences between people in the high background radiation areas (HBRAs) compared with people in normal background radiation areas (NBRAs). To test for adaptive response, an *in vitro* challenge dose of 1.5 Gy of  $\gamma$ -rays was administered to lymphocytes, which showed significantly reduced radiation sensitivity for chromosome aberrations for people living in HBRAs compared with those in NBRAs. Specifically, inhabitants of HBRAs had approximately 56% the average number of induced chromosomal abnormalities compared with NBRAs inhabitants following this exposure. These findings suggest that an adaptive response can be induced by chronic exposure to radiation at levels lower than have been used in the laboratory. There were no differences in laboratory tests of the immune systems, and no noted differences in haematological alterations or induction of repair proteins between these two groups of people. Although there is currently no solid epidemiological information, most local physicians in Ramsar report anecdotally that there is no increase in the incidence rates of cancer or leukaemia in their area. There are no data to indicate a significant increase in cancer incidence in other HBRAs. Several studies show a significant decrease of cancer death rates in areas with high backgrounds. Given the apparent lack of ill effects to the populations of these high dose rate areas, these data further suggest that current dose limits are overly conservative. However, the available data do

not yet seem sufficient to cause national or international advisory bodies to change their current conservative radiation protection recommendations. For this to happen, more definitive data are needed.

**College of Radiographers****William Stripp Memorial Lecture****Eponymous Lecture****The bare bones of the matter**

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This lecture is an attempt to provide an insight into the investigation, diagnosis and treatment of osteoporosis with cross-reference into the world of orthopaedics. It is an attempt to bridge the perceived chasm between the two specialties and to show that they are inextricably linked, in terms of patient care, economy and professionalism. There should be, and I hope in the future will be, an interaction between the orthopaedic and osteoporosis services, which could mean a reduction in the workload of the busy orthopaedic trauma department. Any atraumatic or low trauma Colles' fracture in the pre- or peri-menopausal female should be treated with suspicion and should trigger an investigation. The result could be a dramatic reduction in later life of inappropriate neck of femur fractures, 80% of which, at today's estimate, are due to osteoporosis and potentially avoidable. The investigations to predict osteoporosis are reliant mainly on measurement of bone mineral density and the multifarious ways and means of such has never been greater. Examples of some will be illustrated. Morphometry of the spine and classification of fractures is another area where DXA scanning can supplement radiographic techniques. Lateral spine scans of the thoracic and lumbar vertebra are superior in detail compared with radiographs and can be achieved with a considerable reduction in radiation dose to the patient.

**Workshop****Imaging the Liver: therapeutic applications****Invited Review****Anatomy and surgical planning**

J Karani

King's Healthcare NHS Trust, Denmark Hill, London SE5 9RS,  
 UK

**Invited Review****Biliary stenting—anything new?**

A F Watkinson

c/o X-ray Department, Royal Free Hospital, Pond Street,  
 Hampstead, London NW2 2QG, UK

**Invited Review****Thermal ablation of liver metastases**

A Gillams

Department of Medical Imaging, Middlesex Hospital, Mortimer  
 Street, London W1N 8AA, UK

**Workshop****Plain Film Reporting for Radiographers****Invited Review****Plain film reporting for radiographers**

Q Field-Bowen

X-ray Department, Wansbeck General Hospital, Woodhorn  
 Lane, Ashington, Northumberland NE63 9JJ, UK

**Institute of Physics & Engineering in Medicine****Douglas Lea Lecture****Eponymous Lecture****Imaging with light**

D Delpy

University College London, 1st Floor Shropshire House, 11–  
 20 Capper Street, London WC1E 6JA, UK

## Scientific Session

### Gastrointestinal (2)

#### Self-expandable metal stents for benign and malignant colonic obstruction

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**PURPOSE:** Colonic stenting has recently been advocated for treatment of malignant large bowel obstruction, and may also have a role in benign disease. We describe our experience in 24 patients. **METHODS:** We performed a mixed retrospective and prospective case-note review of 24 consecutive, unselected cases of large bowel obstruction in which colonic stenting was attempted between May 1997 and June 2000 using a combined endoscopic and radiologic technique. Clinical indication, site of obstruction, technique used, procedure time, post procedure patency and complications, if any, were determined. **RESULTS:** 23 patients had left sided strictures, with 1 transverse colon lesion. 22 strictures were malignant and 2 were benign (one anastomotic and one Crohn's). Obstruction was complete in 6 patients and partial in 18. 23 stents were placed in 20 (83%) patients and successful colonic decompression was achieved in all. In the remaining four patients, the stricture could not be crossed with the guidewire or stent. Of the 20 patients in whom stent insertion was successful, 10 remain alive (2 benign strictures; 8 malignant). 2 patients had surgery. Median stent patency is 150 days (range 1–633 days). Early complications occurred with 7 of 23 (30%) stents (4 stent migration, 1 perforation, 1 rectal bleed, 1 focal ulceration). Repeat stenting was successfully performed in two patients who re-obstructed several months following initial insertion. **CONCLUSION:** Colonic stenting successfully treats malignant obstruction and selected cases of benign disease. A combined radiological/endoscopic approach afforded a high technical success rate for stent deployment, even in difficult cases.

#### The influence of the radiologist on patient dose in barium enemas

R H Corbett

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Since the publication of ICRP60, there has been a considerable amount of work carried out to reduce the dose received by patients during common fluoroscopy procedures. This has included equipment improvements, optimization of equipment, use of fast film–screen combinations, etc. Papers have been published showing that large dose savings can be made by attention to equipment, but also a number of papers have been published that have commented that dose can vary considerably depending on the clinical technique. These comments do not appear to have been noticed by the radiological community at large, but there are exceptions. Many suggest that dose can be reduced by careful clinical radiological technique. In addition, the introduction of reference dose levels (RDLs) has had a significant effect, and UK figures from the NRPB ably show this. But reference doses are not fully understood by all. Their *raison d'être* is to act as a simple test for identifying situations where patient doses are becoming unusually high and action is urgently required. The techniques used in obtaining and checking RDLs can be used to help in assessing dose reduction in any department. Changes in a radiologist's technique, especially utilizing digital technology, can lead to substantial dose savings in barium enema examinations. I have introduced new/different views into my routine examination, but with the use of video-grab techniques I have been able to reduce the overall dose by about 20%. This has been achieved with a relatively old digital unit. Greater savings may be possible with more modern equipment.

#### Trans-sphincteric fistulae: MRI findings

L Hattingh and J A Spencer

*Clinical Radiology, St James' University Hospital, Leeds LS9 7TF, UK*

**PURPOSE:** Relapse of perianal sepsis results from failure to eradicate initial sepsis or from the presence of complexity, trans-sphincteric fistulation being the commonest type. We describe the MRI patterns of trans-sphincteric fistulation and correlate these with outcome. **METHODS:** A retrospective study of 31 patients (aged 22–83 years; 22 men, 9 women) with trans-sphincteric fistulae was carried out. Two

radiologists in consensus reviewed features in coronal and axial T<sub>2</sub> weighted and gadolinium enhanced T<sub>1</sub> weighted sequences. Fistulae, secondary tracks and abscesses were marked on anatomic proforma in the axial and coronal planes. **RESULTS:** Of 32 fistulae in 31 patients, all were posterior except one. Cutaneous openings were posterior or lateral in 31 tracks, with only one track opening anteriorly in the midline. Only 3 (9.4%) obeyed Goodsall's rule with midline posterior anal entry (Group 1). The remainder (90.6%) entered laterally or posterolaterally (Group 2), associated with ischioanal fossa fibrosis and inflammatory change in 84%. The middle third was the commonest coronal plane entry level in 17/32 (53%). Secondary track or abscesses were seen in 17 and 14 patients, respectively. 10 (32.3%) patients required second MR studies. **CONCLUSION:** Trans-sphincteric fistulation is frequently associated with complex disease and displays two principal patterns. The majority do not obey Goodsall's rule and have unexpected secondary tracks and/or abscesses. Familiarity with these patterns will allow radiologists to correctly classify fistulae, providing guidance to the surgeon prior to operative probing and in the post-operative follow-up.

#### Accuracy of the barium enema examination in the detection of colorectal cancer

I Hassan

*Department of Radiology, Royal Bolton Hospital, Bolton BL4 0JR, UK*

**PURPOSE:** To determine the accuracy of the barium enema examination in the detection of colorectal cancer. **METHODS:** All histologically proven cases of colorectal cancer seen at the Royal Bolton Hospital between 1997 and 1999 were reviewed. Of these, all cases that had a barium enema examination up to 12 months previously were selected. The case notes, barium enema films and reports were reviewed retrospectively. **RESULTS:** Of 383 cases of colorectal cancer identified between 1997 and 1999, 88 had a barium enema up to 12 months previously. 78 (89%) tumours were detected and 10 (11%) were overlooked. Of the latter, five were due to perceptible errors, but the tumour was not visible in the other five cases, even retrospectively; Four of these latter five were small rectal tumours. **CONCLUSION:** The detection rate of 89% was within the limits of 80% and 95% reported in the literature and confirms that most colorectal cancers are detected by the barium enema examination under standard working conditions. Perception errors could be reduced by double-reading. However, failure to detect some small rectal cancers emphasizes the need for prior sigmoidoscopy.

#### Predictive value of impaired proctographic evacuation for diagnosis of anismus

<sup>1</sup>M M Marshall, <sup>1</sup>S Halligan, <sup>1</sup>C I Bartram, <sup>2</sup>A Malouf, <sup>1</sup>N Hollings and <sup>2</sup>M A Kamm

*Departments of <sup>1</sup>Radiology and <sup>2</sup>Anal Physiology, St Marks Hospital, Harrow HA1 3UJ, UK*

**PURPOSE:** To determine the positive predictive value of impaired evacuation during evacuation proctography for the subsequent diagnosis of anismus. **METHODS:** 31 adults with features of impaired evacuation during evacuation proctography, defined as inability to evacuate two-thirds of a 120 ml contrast enema within 30 s, underwent subsequent anorectal physiology testing to search for anismus. A physiological diagnosis of anismus was based on a typical clinical history in combination with impaired rectal balloon expulsion and/or abnormal surface electromyography. **RESULTS:** 28 (90%) of 31 patients with impaired proctographic evacuation were found to have anismus on subsequent physiological testing. This included all 10 patients who evacuated no contrast and all 11 with inadequate pelvic floor descent, giving evacuation proctography a positive predictive value of 90% for the diagnosis of anismus. A prominent puborectal impression was seen in only three subjects during proctography, one of whom subsequently showed no physiological sign of anismus. **CONCLUSION:** Impaired evacuation during evacuation proctography is highly predictive for diagnosis of anismus.

#### Were we justified in abandoning the erect abdominal radiograph?

U M Hughes, K E Thomas, B Shuckett, A Daneman and D Stephens

*The Hospital for Sick Children, Toronto, Canada*

**INTRODUCTION:** The radiological assessment of potential bowel obstruction differs on either side of the Atlantic. In North America,

routine practice entails a two-view abdominal series (supine and horizontal beam). In much of Europe, the additional film (horizontal beam) has been abandoned. However, there are no published data on its diagnostic efficacy in children. **PURPOSE.** To determine whether the additional film improves diagnostic accuracy in paediatric bowel obstruction. **METHODS.** The abdominal radiographs of 72 paediatric patients were retrospectively evaluated for the presence of bowel obstruction by 22 independent observers (radiologists, surgeons and emergency staff) of varying experience. Evaluation involved initial assessment of the supine radiograph alone, followed by re-assessment with the addition of an erect or decubitus radiograph. **RESULTS.** When observers evaluated the supine radiograph alone, their sensitivity was 66%, specificity 72% and accuracy 70%. With the addition of the horizontal beam film, sensitivity was 78%, specificity 75% and accuracy 76%. The mean change in accuracy was 6%, with no statistically significant difference between radiologists, surgeons or emergency staff. **CONCLUSION.** The value of the horizontal beam radiograph in the accuracy of diagnosis of paediatric bowel obstruction is limited and its use should be restricted to selected cases in which diagnostic uncertainty persists.

## Workshop

### Creating PowerPoint Presentations: intermediate/advanced

**How to create PowerPoint presentations: intermediate/advanced**

M Tatlow

*Division of Professions Allied to Medicine, Faculty of Health Sciences, South Bank University, London SE1 0AA, UK*

## Workshop

### Plain Film Reporting for Radiographers

**Invited Review**

**Plain film reporting for radiographers**

Q Field-Bowen

*X-ray Department, Wansbeck General Hospital, Woodhorn Lane, Ashington, Northumberland NE63 9JJ, UK*

## Debate

### Workload in Radiology Departments

**Invited Review**

**Priorities in staffing and workload—a radiologist's view**

A K Dixon

*Addenbrooke's Hospital NHS Trust, Hills Road, Cambridge CB2 2QQ, UK*

**Invited Review**

**Priorities in staffing and workload—a radiographer's view**

A Thomas

*Department of Radiology, University Hospital of Wales, Cardiff CF14 4XN, UK*

**Invited Review**

**The USA perspective**

E Zerhouni

*Johns Hopkins Medical Centre, 601 N Caroline Street, Room 4210, Baltimore, MD 21287-0842, USA*

## Controversy

### Colorectal Cancer Screening

**Invited Review**

**Colorectal cancer—why bother screening?**

D G Morton

*University of Department of Surgery, Queen Elizabeth Hospital, University of Birmingham, Birmingham B15 2TH, UK*

**Invited Review**

**If you're going to screen, use colonoscopy**

B Saunders

*Department of Radiology, St Mark's Hospital, Watford Road, Harrow HA1 3UJ, UK*

**Invited Review**

**If you're going to screen, use barium enema**

A H Chapman

*Radiology Department, St James' University Hospital Trust, Leeds LS9 7TF, UK*

## Advances

### Genes and Imaging

**Invited Review**

**Introduction to genes in cancer**

M Steel

*Department of Medical Sciences, University of St Andrews, Bute Medical Building, South Street, St Andrews, Fife K16 9TS, UK*

**Invited Review**

**Current and future clinical applications**

R Eeles

*Royal Marsden NHS Trust, Cancer Genetics, Downs Road, Sutton SM2 5PT, UK*

**Invited Review**

**Implications for diagnostic imaging**

R Ott

*Department of Physics, Royal Marsden NHS Trust, Downs Road, Sutton, Surrey SM2 5PT, UK*

**Invited Review**

**Implications for therapy**

D Kerr

*CRC Institute for Cancer Studies, Queen Elizabeth Hospital, Birmingham University, Edgbaston, Birmingham B15 2TH, UK*

## Advances

### Musculoskeletal Imaging

**Invited Review**

**Interventional and biopsy techniques**

D Wilson

*Nuffield Orthopaedic Centre, Windmill Road, Headington, Oxford OX3 7LD, UK*

**Invited Review**

**Interventional musculoskeletal imaging**

J Laredo

*Hopital Lariboisiere, 2 Rue Ambrois-Pare, Paris 75475, France*

## Scientific Session

### Vascular

**Colour duplex surveillance of aortoiliac stents**

R Uberoi, J Coleman, B Sarkar, A Mudawi and H Ashour

*X-ray Department, Queen Elizabeth Hospital, Gateshead, Tyne & Wear NE9 6SX, UK*

**PURPOSE:** To assess the effects of stent placement on waveforms/velocities following aortoiliac stent placement for atherosclerotic disease, and to determine whether duplex scanning can detect stenosis and complications. **METHODS:** Patients were scanned prior to and within 48 h of stent placement, then at 3-month intervals for 1 year. Angiography was performed at 1 year, or sooner if problems arose. 100 stents were placed in 67 patients (40 males, 27 females; mean age 63 years, range 39–91 years). 41 limbs were treated for occlusions and 53 for stenosis. 3 aortic stents were placed in 3 patients and 97 aortoiliac stents in 64 patients. Mean velocity in non-stented

common iliac arteries was  $150 \text{ cm s}^{-1}$  (range  $106\text{--}185 \text{ cm s}^{-1}$ ) and in the external iliac arteries mean velocity was  $181 \text{ cm s}^{-1}$  (range  $140\text{--}223 \text{ cm s}^{-1}$ ). With stents, mean velocities were  $157 \text{ cm s}^{-1}$  (range  $69\text{--}274 \text{ cm s}^{-1}$ ) in the common iliac arteries and  $180 \text{ cm s}^{-1}$  (range  $95\text{--}325 \text{ cm s}^{-1}$ ) in the external iliac arteries. Waveforms remained monophasic in 41%, biphasic in 35% and triphasic in 24%. Nine in-stent stenoses, one in-stent and distal vessel stenosis and 10 stenoses proximal or distal to the stent were found on duplex scanning and confirmed at angiography. One aneurysm developed in the external iliac artery following stent placement. There were two disagreements between duplex scanning and angiography. **CONCLUSION:** This preliminary study confirms that colour duplex scanning is feasible in the majority of patients and can detect both in-stent and native vessel stenosis post aortoiliac stenting.

#### **Ultrasound follow-up after endovascular abdominal aortic aneurysm repair**

R G McWilliams, J Martin, D White, D A Gould, P C Rowlands, J Brennan, G L Gilling-Smith and P L Harris  
*Departments of Radiology and Vascular Surgery, Royal Liverpool University Hospital, Prescot Street, Liverpool L7 8XP, UK*

**PURPOSE:** To compare unenhanced and enhanced ultrasound with biphasic CT in the detection of endoleak after endovascular abdominal aortic aneurysm (AAA) repair. **METHODS:** 53 patients were examined during 96 follow-up episodes after endovascular AAA repair. All patients had colour Doppler ultrasound and power Doppler ultrasound studies performed before and after the administration of an ultrasound contrast agent. Biphasic—arterial and delayed phase—CT was performed on the same day and the ultrasound and CT studies were independently scored to record the presence or absence of endoleak and the level of confidence in the observation. This study was supported by grants from the Royal College of Radiologists and Mersey and Cheshire Research support fund. **RESULTS:** The sensitivity of the ultrasound techniques in the detection of endoleak improved with the use of ultrasound contrast medium. The sensitivity was 12% with unenhanced colour Doppler ultrasound and 50% with enhanced power Doppler ultrasound. Enhanced power Doppler ultrasound failed to detect evidence of type 2 endoleak in nine patients where there was CT evidence of lumbar endoleak. Enhanced power Doppler ultrasound had an 86% negative predictive value for endoleak. There were only two graft-related endoleaks in the study. One of these was diagnosed at ultrasound and the other had an undiagnostic series of ultrasounds owing to of poor views. **CONCLUSION:** CT scanning remains our surveillance modality of choice.

#### **Aortic stent-graft assessment: CT vs ultrasound with and without Levovist given as contrast bolus and infusion**

R Jones, B Sarkar and R Uberoi  
*Radiology Department, Queen Elizabeth Hospital, Gateshead NE9 6SX, UK*

**PURPOSE:** This study compares the role of dual phase contrast enhanced CT with transabdominal ultrasound in the evaluation of endovascular aortic stent-grafts, and assesses the advantages of using Levovist ultrasound contrast agent (Schering, Germany) administered in both infusion and bolus form. **METHODS:** 17 patients have undergone endovascular aortic aneurysm repair at Queen Elizabeth Hospital. In addition to regular CT evaluation, all patients have undergone colour Doppler ultrasound examination performed by an operator blinded to the CT findings. In eight ultrasound assessments, Levovist was administered as a bolus and also as infusion 20 min apart. Image quality was assessed with respect to ease of identifying flow in the stent body and limbs, bloom artefact and confidence in endoleak detection. The ultrasound findings were compared with CT results, which are currently considered to be the gold standard. **RESULTS:** In the group of 17 patients, ultrasound failed to detect one endoleak demonstrated by dual phase CT. Levovist contrast was not administered during this ultrasound examination. One Type 2 endoleak, confirmed with contrast CT, was demonstrated in the group of eight patients who received Levovist. This endoleak was more easily visualized after Levovist infusion, partly reflecting a marked reduction in bloom artefact seen immediately after bolus injection of Levovist. In seven of the eight patients, flow in the stent body and limbs was more clearly identified with Levovist infusion, increasing the confidence of endoleak

exclusion. Although early results are encouraging, the merits of Levovist infusion need further evaluation with a larger study, which is currently being undertaken.

#### **"Kissing stent": safe and durable procedure and effect on the non-diseased limb**

R Uberoi, F Mohamed, H Ashour and A Mudawi  
*X-ray Department, Queen Elizabeth Hospital, Gateshead, Tyne & Wear NE9 6SX, UK*

**PURPOSE:** A recent study suggested that "kissing stents" have high complication rates and poor patency. We assessed the outcome of "kissing stents" in our unit over 3 years, in particular the effect on the non-diseased limb. **METHODS:** We carried out a prospective study to look at the outcome of kissing aortoiliac stents with 3-monthly clinical follow-up, including ABPI and duplex ultrasound. Outcomes of unilateral iliac stents and kissing stents were compared as well as the effect on the non-diseased limb where there was unilateral disease. **RESULTS:** Kissing stents were placed in 20 patients (9 male, 11 female; mean age 66 years, range 48–87 years). 12 were in patients with unilateral disease. Six patients were Fontaine II(a), eight were Fontaine II(b), three were Fontaine III and three were Fontaine IV. Mean ABPI pre stent was 0.59 (0.15–1). Small haematomas occurred in four patients and aortic dissection in one. There were six re-interventions in five patients. One had re-occlusions at 2 weeks and 3 months requiring thrombolysis, one had an aortobifemoral graft, one required a fem–fem crossover graft, one required re-stenting and one required angioplasty. Two of these cases had poorly positioned stents. Two of these re-interventions were to salvage a previously non-diseased limb. In comparison with unilateral stent placements, outcomes were marginally worse. **CONCLUSION:** Outcome in kissing stents is worse than in unilateral iliac stents. Serious consideration should be given when placing stents across a previously unaffected common iliac artery.

#### **Follow-up of stent placement for obstructive aortic atherosclerotic disease**

J J Wood, K P Murphy and M R Rees  
*Department of Radiology, Bristol Royal Infirmary, Bristol BS2 8HW, UK*

**AIMS:** To investigate the outcome of patients who have undergone angioplasty and stenting of the aorta for obstructive atherosclerotic disease. **METHODS:** 9 patients (3 female, 6 male; age range 50–83 years) underwent percutaneous angioplasty and stenting of occlusive or stenotic atherosclerotic disease of the abdominal aorta under local anaesthesia. Patients were followed up clinically and by non-invasive imaging using ultrasound. Stent patency and complications of the procedure were monitored. Stents were dilated to between 12–16 mm at placement. **RESULTS:** The mean time of active follow-up was 15 months (range 7–51 months). Mean time since the procedure was 41.2 months (range 18–58 months). In that time, three patients died of other causes. 2/9 patients developed stent restenosis. (at 7 months and 51 months). In both cases of stent restenosis, the stents were redilated successfully. The remaining stents showed primary patency at death or on final follow-up. Complications of the procedure occurred in four cases. Two patients had complications from femoral cannulation, one patient suffered partial renal impairment and one patient a distal embolus. **CONCLUSION:** This is a procedure performed in patients with very severe atherosclerotic disease. The overall patency rate of these stents is high but there is also a significant complication rate. The late restenosis of one patient indicates the need for prolonged follow-up.

#### **Changing diameter of aneurysm neck after endovascular repair of abdominal aortic aneurysm**

D A Gould, M F Badran, O Brown and P C Rowlands  
*Department of Radiology, Royal Liverpool University Hospital, Liverpool L16 7QH, UK*

**PURPOSE:** To determine the extent of change of aneurysm neck diameter after endovascular repair (EVR) of abdominal aortic aneurysm (AAA) and to relate any such change to stent-graft diameter. **METHODS:** 76 patients with AAA were assessed pre-operatively by contrast enhanced spiral CT and managed by EVR. 74 patients were discharged and followed up with spiral CT. Aneurysm neck diameter was assessed at the time of CT reporting and was recorded in a database. Baseline and follow-up mid neck diameters were reviewed and compared. Manufacturers' values for unconstrained stent-graft

diameter were related to baseline and follow-up neck diameters. RESULTS: Pre-operatively, the mean stent-graft oversize (stent-graft diameter – neck diameter) was  $3.7 \pm 2$  mm. Stent-graft diameter exceeded neck diameter in 71 (95.9%) cases. Baseline mean aneurysm neck diameter was  $22.3 \pm 2.5$  mm, increasing to  $24 \pm 3$  mm at most recent follow-up (mean  $19.3 \pm 13.4$  months). The mean neck diameter changed over the follow-up period by  $+1.8 \pm 2.7$  mm (range  $-2$  mm to  $+9$  mm), with neck diameter increasing in 48 (64.9%) cases. Stent-graft oversize reduced on follow-up to  $1.8 \pm 2.9$  mm (range  $-4$  mm to  $+10$  mm), with follow-up diameter exceeding stent-graft diameter in 18 (24.3%) cases by a mean of  $1.9 \pm 1$  mm (range  $1-4$  mm). CONCLUSION: Aneurysm neck diameter increased in the majority of cases following EVR, with the follow-up neck diameter exceeding stent-graft diameter in nearly a quarter of cases. There are implications for long-term security of the upper endograft attachment site.

#### Arteriography in the management of failing arteriovenous renal dialysis fistulae

<sup>1</sup>T Bryant, <sup>2</sup>L Wales, <sup>3</sup>S Redla, <sup>3</sup>A Frankel, <sup>2</sup>E M Gordon and <sup>1</sup>A Mitchell

Departments of <sup>1</sup>Imaging, <sup>2</sup>Vascular Surgery and <sup>3</sup>Renal Medicine, Hammersmith Hospitals NHS Trust, Charing Cross Hospital, London, UK

PURPOSE: Maintaining vascular access in haemodialysis patients can be challenging, with failure causing significant morbidity. Arteriography can improve diagnostic imaging of failing arteriovenous fistulae and can assist in planning and performing intervention. This study was performed to evaluate the role of fistula arteriography in the management of failing arteriovenous fistulae. METHODS: Diagnostic arteriograms were performed when fistula flow rates were insufficient to support haemodialysis. Diagnosis, complications, treatment and outcome were investigated. RESULTS: We reviewed 33 fistula arteriograms performed in 30 patients over a 4-year period. Diagnoses included cephalic vein stenosis (14), anastomotic stenosis (9), cephalic vein occlusion (7), radial artery in-flow stenosis (4) and radial artery occlusion (2). There were no complications associated with arteriography. 10 stenoses were suitable for angioplasty, 13 patients were referred for further surgical revision and 5 fistulae were not salvageable. In five patients with  $<50\%$  stenoses, no intervention was performed. Seven angioplasties were undertaken (six cephalic vein and one radial artery). Technical success was achieved in all seven, with functional patency in six; median follow-up 10 months (range 4–23 months). 10 patients had proximal surgical revision, with 6 achieving functional patency and 4 failing due to poor run-off. All five fistulae with  $<50\%$  stenosis achieved function. CONCLUSIONS: Imaging of haemodialysis fistulae is important in the evaluation of failing fistulae and is essential before undertaking angioplasty or surgical revision. Significant lesions may be demonstrated that would be missed using a fistula venogram. Angioplasty is an effective procedure for fistula salvage.

#### Debate

##### Perspectives on Palliative Care

###### Invited Review

###### A medical perspective on palliative care

A Marks

Dellwood Hospital, Duchess of Kent House, Leibenrood Road, Reading, Berks RG30 2DX, UK

###### Invited Review

###### Palliative care: a social work perspective

N McMurray

Social Work Manager, Wisdom Hospice, St William's Way, Gillingham, Kent, UK

#### Advances

##### Recent Developments in CT Technology

###### Invited Review

###### Recent developments in CT technology: part I

S Edyvean

IMPACT Medical Physics Department, St George's Healthcare NHS Trust, Blackshaw Road, London SW17 0QT, UK

###### Invited Review

###### Recent developments in CT technology: part II

N Keat

IMPACT Medical Physics Department, St George's Healthcare NHS Trust, London SW17 0QT, UK

#### Workshop

##### Plain Film Reporting for Radiographers

###### Invited Review

###### Plain film reporting for radiographers

Q Field-Bowen

X-ray Department, Wansbeck General Hospital, Woodhorn Lane, Ashington, Northumberland NE63 9JJ, UK

#### State of the Art Symposium

##### PET in Oncology: evolving role in GI malignancy

###### Invited Review

###### Clinical view

N Maisey

Department of Diagnostic Radiology, Royal Marsden Hospital, Royal Marsden NHS Trust, Sutton SM2 5PT, UK

###### Invited Review

###### Staging oesophageal cancer

S C Rankin

Radiology Department, Guy's & St Thomas' NHS Trust, St Thomas' Street, London SE1 9RT, UK

###### Invited Review

###### Colorectal cancer—detection of recurrence

G J Cook

Department of Nuclear Medicine, Guy's & St Thomas' NHS Trust, St Thomas' Street, London SE1 9RT, UK

#### Refresher Course

##### How Do I Do It? Imaging the colon

###### Invited Review

###### The perfect barium enema

C I Bartram

Department of Radiology, St Mark's Hospital, Watford Road, Harrow HA1 3UJ, UK

###### Invited Review

###### CT pneumocolon

Z Amin

Radiology Department, Chelsea & Westminster Hospital, 369 Fulham Road, London SW10 9NH, UK

###### Invited Review

###### Virtual colonoscopy

H Fenlon

Department of Radiology, Mater Hospital, Eccles Street, Dublin 7, Ireland

#### Refresher Course

##### Colorectal Cancer: the role of imaging

###### Invited Review

###### Staging

G Brown

Radiology Department, Royal Marsden NHS Trust, Downs Road, Sutton SM2 5PT, UK

###### Invited Review

###### Detection of recurrence

J A Spencer

Department of Radiology, St James' University Hospital Trust, Leeds LS9 7TF, UK

## Refresher Course Musculoskeletal Ultrasound

### Invited Review Ultrasound of joints

E McNally

Department of Radiology, Nuffield Orthopaedic Centre,  
Headington, Oxford OX3 7LD, UK

### Invited Review

#### Shoulder

I Beggs

Department of Clinical Radiology, Edinburgh Royal Infirmary,  
Lauriston Place, Edinburgh EH3 9YW, UK

### Invited Review

#### Tendons and muscles

W Gibbon

Department of Radiology, Leeds General Infirmary, Great  
George Street, Leeds LS1 3EX, UK

## Scientific Session Advancing Practice

### Work in Progress

#### Ultrasound of the optic nerve for the detection of raised intracranial pressure

A H Hamilton

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Newtownabbey, County Antrim BT37 0QB, UK

**AIM:** Early diagnosis of acute intracranial pressure associated with shunt malfunction is essential in children with hydrocephalus to facilitate quick, optimal treatment. The optic nerve sheath diameter (ONSD) is surrounded by layers representing a continuum of the intracranial meninges and is increased in raised intracranial pressure. This prospective study aimed to establish the range of abnormal values for ONSD in children up to 15 years, quantified with regard to requirement for surgical shunt revision. Advantages of the technique would include its non-invasiveness, the absence of radiation, wide availability and low cost. **PATIENTS AND METHODS:** 27 children with suspected shunt malfunction were included in the study. Three measurements of ONSD were recorded bilaterally, 3 mm behind the optic nerve head using a 15 MHz linear probe. **RESULTS:** The range of ONSDs was 2.1–6.4 mm. There was no significant difference between ONSDs of the right and left eyes ( $p=0.206$ ). Sensitivity and specificity of ultrasound of the optic nerve as an indicator of shunt revision were 80% and 64%, respectively. The positive and negative predictive values were 24% and 96%, respectively. ONSDs of 4.5 mm or greater were not a significant indicator of shunt revision ( $p=0.189$ ); values greater or equal to 4.9 mm were more significant ( $p=0.027$ ). **CONCLUSION:** Results suggest that an ONSD greater than 4.9 mm should be regarded as abnormal, and ONSDs less than 4.9 mm as within normal limits. Ultrasound of the optic nerve should be performed in all children with suspected shunt malfunction and serial monitoring should have potential future diagnostic capabilities.

### Work in Progress

#### Variation in A&E musculoskeletal appendicular radiographic reports and the development of a report template

C M Ryan, K J Piper and A M Paterson

Canterbury Christ Church University College, Canterbury  
CT1 1QU, UK

**PURPOSE:** The purpose of this project is to develop a computer-based report template, which through its development will elucidate aspects of the phenomenon of variation, including those descriptive and structural variations that may be independent of interpretative error. **METHODS:** The methods used incorporate both exploratory and developmental design. Phase I focuses on inductively exploring variations from: (1) a bank of musculoskeletal reports ( $n=230$ ) that have been reported by multiple reporters; and (2) a sample of reports of radiographic examinations from reporters in the SE region. This phase will endeavour to: (1) create precise definitions of variations; (2) categorize variations; and (3) quantify variations. Phase II includes the

development of the template tool by: (1) using the quantitative data from Phase I; (2) reviewing literature to identify existing standards for reporting; and (3) using qualitative methods in the form of a focus group of experienced reporters. The template(s) developed will be subsequently piloted and refined as necessary. Phase III will test the utility of the template to investigate variations. Phase IV will test the ability of the computer-based report template to effect change in musculoskeletal A&E appendicular radiographic examinations as reported in current clinical practice. **RESULTS:** The nature of descriptive and structural variations will be explored and data will be presented from Phase I. These data will provide an initial database of possible variations in descriptive and structural components of free-text radiographic reports and inform the development of a report template.

### Work in Progress

#### Accuracy of radiographer reporting of MRI for suspected acoustic neuroma

K Gillmore, J Byrne, K Piper, M Jeffrey and J Millar

Thanet MRI, Lodestone Patient Care, QEOM, Margate, Kent  
CT9 4AN, University Department of Radiology, University of  
Oxford, Radcliffe Infirmary, Oxford OX2 6HE and Department  
of Radiography, Christ Church University College, Canterbury,  
Kent CT1 1QU, UK

**PURPOSE:** To assess the accuracy of radiographer reporting of MRI of the internal auditory meati (IAM) in patients with suspected acoustic neuroma, prior to and following a period of structured education and training. **METHOD:** 100 MRI examinations of the IAM, undertaken for suspected acoustic neuroma, were reported by three consultant neuroradiologist. A proforma was used requiring each observer to grade the examinations using the following system: A, normal; B, acoustic neuroma present; C1, unable to diagnose, need second opinion; C2, unable to diagnose, possible acoustic neuroma, require gadolinium to confirm; C3, unable to diagnose, poor quality images, needs repeating and/or second opinion; C4, unable to diagnose, other pathology present, need second opinion. Where there was complete agreement among the three neuroradiologists, the examinations were included in a test bank to be assessed by a subject radiographer. The test bank was graded by the radiographer using the same system as well as using a 5-point scale to indicate confidence in each decision. The subject radiographer then attended a structured education and training programme devised in collaboration with a higher education institution experienced in postgraduate radiographer reporting. On completion of the programme, the test bank was re-ordered and re-presented to the subject radiographer. **RESULTS AND CONCLUSIONS:** Data on the pre- and post-training findings will be presented, in comparison with the consensus radiological report, for accuracy, sensitivity and specificity. This study was partly funded by a Special Interest Group in Radiographic Reporting bursary award.

### Work in Progress

#### The PA chest radiograph: challenging our methods

E M Unett and B J Carver

University of Wales, Bangor, School of Radiography,  
Wrexham LL13 7YP, UK

**PURPOSE:** The posteroanterior (PA) chest projection still forms a large proportion of the imaging workload, contributing 7% of UK patient dose levels. UK methods for centring/angling vary, with those abroad questioning this variation. Students and radiographers often become confused about accepted PA chest technique. Technique should be standardized, with a logical alternative. Questions that arise include the following. (1) What techniques are employed? (2) What is a logical centring point? (3) How valid is the use of caudal angulation? **METHODS:** To date: (1) 40 radiographers have been interviewed and have been observed undertaking chest radiographs to establish centring points/angles being used. (2) 92 PA chest images have been studied and the mode value of vertebral body level of the lung field midpoint has been assessed. Each image fulfils criteria regarding acceptable technique/patient condition. (3) Lateral chest images will be studied to assess whether caudal angulation is likely to improve visualization of lung tissue, although theory suggests that this is unlikely. **RESULTS:** Work to date suggests that: (1) radiographers actually use the T8 level for centring, although most state T6 at interview; (2) (approx.) 65% of lung midpoint levels are at T8, 16% at the T7/8 intervertebral space, 11% at T7, 2.2% each at T6/7, T8/9 and T9, and 1.1% at T6. **CONCLUSIONS:** Results so far suggest that: (1) radiographers do not

use T6 centring or angulation to the extent they say they do; (2) the centring method used should be level with the body of T8 (the spinous process of T7), with (3) possibly no use of caudal angulation. This challenges the traditional centring point of T6 ( $\pm$  angulation) mostly used in the UK and textually stated. Some USA texts suggest T7, but whether this indicates the spinous process or the body is unclear.

#### Work in Progress

##### Evaluation of the diagnostic efficacy and dose reducing efficiency of erbium filtration for diagnostic X-ray investigations

L Rainford, J Stack and P C Brennan  
*School of Diagnostic Imaging, University College Dublin, St Anthony's, Herbert Avenue, Dublin 4, Ireland*

**PURPOSE:** This study investigated the diagnostic efficacy of erbium filtration of the X-ray beam for commonly performed radiographic examinations. **METHODS:** An anthropomorphic phantom study and a systematic patient survey were undertaken. An X-ray beam with 2.6 mm Al total filtration was employed for the control cohort of patients. Two experimental groups of patients followed: the first group was imaged with the addition of a 0.1 mm erbium filter to the X-ray beam (5.9 mm Al total filtration equivalent); a second experimental group was examined following addition of aluminium to the X-ray beam equal to 5.9 mm Al total filtration. **RESULTS:** Statistically significant reductions in effective dose of 34–50% were demonstrated following employment of the erbium filter compared with the control group. No significant differences between the experimental groups were shown. The highest image evaluation scores were achieved for six out of the eight radiographic examinations investigated following employment of the erbium filter. Consistently lower image quality scores were recorded when additional aluminium was employed compared with the control group. **CONCLUSION:** The authors recommend employment of 0.1 mm erbium filtration for a number of common diagnostic examinations and encourage further research to establish more widespread use of this filter.

## Scientific Session Genitourinary (2)

#### Work in Progress

##### An audit of the use of emergency ultrasound in the diagnosis of acute testicular pain

R Gupta, S Houghton and C M Parks  
*Radiology Department, The Middlesex Hospital, UCLH, London W1N 8AA, UK*

The purpose of this study is to determine the value of colour Doppler ultrasound in the diagnosis of the acute scrotum and to correlate this with clinical outcome. Scrotal ultrasound scanning is now the primary imaging investigation in the initial evaluation of the symptomatic testis. Many papers have been written about the use of colour Doppler ultrasound in the diagnosis of testicular torsion, and sensitivity rates of over 90% have been quoted. However, testicular ultrasound is rarely performed out of hours and further management is based on clinical presentation and examination. In our institution, for the last 2 years all patients with recent onset of testicular pain have a clinical examination and scrotal ultrasound at presentation. This sometimes necessitates a radiologist being called out of hours, leading to delays in treatment. Suspected torsions are then taken to theatre based on these results. This retrospective study analyses the results of testicular ultrasound (performed for acute scrotal pain) at a large teaching hospital over a period of 2 years, and correlates the findings with the clinical outcome to assess whether providing an on-call ultrasound service actually alters further clinical management of the patient.

#### Work in Progress

##### The role of ultrasound guided cytology of groin lymph nodes in the management of squamous cell carcinoma of the vulva

T B Hall, E C Moskvic, J Shepherd, P Trott and D Barton  
*Departments of Radiology, Gynaecology and Pathology, Royal Marsden Hospital, Sutton, Surrey SM2 5PT, UK*

**PURPOSE:** To assess the accuracy of ultrasound combined with fine needle aspiration (FNA) cytology in detection of inguinal lymph node involvement in patients with squamous cell carcinoma of the vulva.

**METHODS:** The groin nodes of 81 sequential patients with squamous cell carcinoma of the vulva were assessed with ultrasound and FNA cytology. The results were compared with histology from subsequent groin dissection. 29 patients underwent bilateral groin dissections and 15 unilateral, providing comparable data for 73 groins. 37 further patients underwent no surgery, and their ultrasound and cytology results were correlated with subsequent clinical follow-up. **RESULTS:** Histology demonstrated metastatic disease in 28 groins and no metastatic disease in 45. Ultrasound agreed with the histology in 67 of the 73 (92%) groins, with two false positives, four false negatives and two indeterminate scans. Cytology agreed with the histology in 65 of 72 (90%) FNA samples obtained, with 6 false negatives and 1 indeterminate result. No false positive cytology results were seen. Ultrasound and FNA together failed to detect metastatic disease in four groins, one with an indeterminate ultrasound appearance, another with indeterminate cytology, the other two each having a single positive inguinal node despite negative ultrasound and FNA. **CONCLUSION:** The combination of ultrasound and aspiration cytology provides a sensitive and specific tool for pre-operative assessment, and may prevent unnecessary groin dissection and its attendant morbidity in some patients with vulval cancer.

#### Work in Progress

##### Early experience in the percutaneous radiofrequency ablation of small renal cell carcinoma

D J Breen, S Minhas, S Puri, J Easterbrook, G Cooksey, D Almond and J Hetherington

*Department of Radiology, Hull Royal Infirmary, Hull HU3 2JZ, UK*

**PURPOSE:** The use of diagnostic imaging has resulted in increased detection of incidental small renal cell carcinoma (RCC). These patients are often elderly with significant co-morbidity and are generally unfit for major surgery. This study aims to determine the safety and efficacy of percutaneous radiofrequency ablation (RFA) in the treatment of high risk patients. **METHODS:** Seven patients (mean age 74 years, range 60–88 years) underwent RFA of 10 tumours under ultrasound/CT guidance between November 1999 and February 2001. Tumours ranged in size from 30–55 mm. 12 treatment sessions were carried out under sedo-analgesia to 20 tumours using a water-cooled system (Radionics, Burlington, MA). Treatment sessions lasted between 6 min and 14 min. All the patients were followed up by immediate (<7 days) followed by approximately 6-monthly CT surveillance. **RESULTS:** All patients were discharged within 24 h of the procedure with no complications. No local or distant tumour recurrence has been detected on CT surveillance (follow-up 1–15 months). One patient has since died of an unrelated medical condition. **CONCLUSION:** RFA appears to be a safe and minimally invasive treatment modality for RCC and is well tolerated. In the era of nephron-sparing surgery, RFA may have a role in the management of small RCC in problematic patients.

#### Work in Progress

##### MR guided laser thermal ablation of renal tumours

E A Dick, R Joarder, J Vale and W M W Gedroyc  
*Department of Interventional MRI, St Mary's Hospital, London W2 1NY, UK*

**INTRODUCTION:** In patients with malignant renal tumours who are not suitable for surgery, minimally invasive therapy with selective tumour destruction would be useful. **METHODS:** Seven patients (age range 56–81 years) with malignant renal tumours underwent percutaneous laser thermal ablation (LTA) under MR guidance in a 0.5 T open magnet. Six patients were unsuitable for surgery because of a solitary kidney ( $n=2$ ) or poor general health ( $n=4$ ). LTA was performed prior to surgery in one patient. Real-time colour thermal mapping was used to monitor tumour ablation, and follow-up was with gadolinium enhanced MRI at 6 weeks and (where appropriate) 6 months post procedure. **RESULTS:** Follow-up ranged from 3–22 months. There were no major post-procedure complications. All patients were discharged home the day after the procedure. The patients were divided into two groups: (i) a cure could reasonably be expected; and (ii) the procedure was palliative. In three potentially curable patients, no recurrence of tumour was demonstrated after LTA (average tumour size 3.3 cm; follow-up 15–22 months, average 17.3 months). Thermal mapping demonstrated excellent tumour ablation of at least 90%. Of four patients in whom the procedure was palliative, none have shown local recurrence (follow-up 3–24 months, average 11.5 months). Two have died;

of liver metastases ( $n=1$ ) and chronic renal failure ( $n=1$ ).  
CONCLUSIONS: In potentially curable patients, LTA ablated at least 90% of tumour with no recurrence at follow-up of 17.3 months. LTA also provided good palliation in four patients: although metastases developed further, the size of the primary tumours was controlled.

## Refresher Course

### Brachytherapy

#### Invited Review

##### Gynaecology

M Wilkins

*Department of Radiotherapy, Royal Marsden NHS Trust,  
Fulham Road, London SW3 6JJ, UK*

#### Invited Review

##### Prostate

J Solano

*Myerstein Institute of Oncology, Middlesex Hospital, Mortimer  
Street, London W1N 8AA, UK*

#### Invited Review

##### Head and neck brachytherapy

C Coyle

*Department of Clinical Oncology, Cookridge Hospital, Leeds  
LS16 6QB, UK*

## State of the Art Symposium

### Quantitative MR and Image Texture

#### Invited Review

##### Introduction to quantitative MRI and texture

R A Lerski

*Medical Physics, Ninewells Hospital, Dundee DD1 9SY, UK*

#### Invited Review

##### Texture analysis and methodologies

A Materka

*Institute of Electronics, Technical University of Lodz, ul  
Stefanowskiego, Lodz 90-924, Poland*

#### Invited Review

##### Problems in texture analysis with MR

L Schad and I Zuna

*German Cancer Research Centre, Heidelberg D-69120,  
Germany*

#### Invited Review

##### Clinical results in osteoporosis

Y Rolland

*Department d'Imagerie et de Radiologie, Hopital Sud, 16  
Boulevard de Bulgarie, Rennes 35056, France*

Wednesday 23 May

## Workshop

### Musculoskeletal Ultrasound

#### Invited Review

##### Musculoskeletal ultrasound

D Chapman-Jones

Canterbury Christ Church University College, Canterbury  
CT1 1QU, UK

## Refresher Course

### Information Technology: its impact on radiology

#### Invited Review

##### Teleradiology—opportunities as threats

N H Strickland

Hammersmith Hospital NHS Trust, Du Cane Road, London  
W12 0HS, UK

#### Invited Review

##### PACS—does it improve patient care?

R Fowler

Radiology Teaching Department, Leeds General Infirmary,  
Great George Street, Leeds LS1 3EX, UK

#### Invited Review

##### Do you need data?

E P H Torrie

Royal Berkshire Hospital, Reading RG1 5AN, UK

## Refresher Course

### Pancreas

#### Invited Review

##### Pancreatic cancer—what the surgeon needs to know

R C G Russell

Middlesex Hospital, c/o 149 Harley Street, London W1N 2DE,  
UK

#### Invited Review

##### Pre-operative staging of pancreatic cancer

M B Sheridan

Department of Clinical Radiology, St James's University  
Hospital Trust, Beckett Street, Leeds LS9 7TP, UK

#### Invited Review

##### Pancreatitis—imaging and intervention

Z Amin

Radiology Department, Chelsea & Westminster Hospital, 369  
Fulham Road, London SW10 9NH, UK

## Refresher Course

### Brain Imaging: problems and solutions

#### Invited Review

##### The role of the radiologist in acute neurovascular disease

R Sellar

Department of Clinical Neurology, Western General Hospital  
NHST, Crewe Road, Edinburgh EH4 2XU, UK

#### Invited Review

##### MR

P D Griffiths

Section of Academic Radiology, Royal Hallamshire Hospital,  
University of Sheffield, Sheffield S10 2JF, UK

## Refresher Course

### MRI of the Lower Limb

#### Invited Review

##### Hip

P M Hughes

Department of Radiology, Derriford Hospital NHS Trust,  
Plymouth PL6 8DH, UK

#### Invited Review

##### Knee

P M Cavanagh

X-ray Department, Taunton & Somerset NHS Trust, Musgrove  
Park, Taunton TA1 5DA, UK

#### Invited Review

##### Ankle

C W Heron

Radiology Department, St George's Healthcare NHS Trust,  
Blackshaw Road, Tooting, London SW17 0QT, UK

## Refresher Course

### Optimizing Image Quality in Paediatric Plain Film Imaging

#### Invited Review

##### The differences between paediatric and adult injuries

K Parkes

Department of Paediatric Radiology, Birmingham Children's  
Hospital, Ladywood Middleway, Ladywood, Birmingham  
B16 8ET, UK

#### Invited Review

##### Mobile neonatal imaging

M Scriven

Paediatric Radiology Department, Southampton University  
Hospital NHST, Tremona Road, Southampton SO16 6YD, UK

#### Invited Review

##### "Ban the babygram": radiography of non-accidental injury

J McKinstry

X-ray Department, Royal Belfast Hospital, Falls Road, Belfast  
BT12 6BE, UK

## Scientific Session

### Breast (1)

#### Can MRI predict invasion in ductal carcinoma *in situ* of the breast?

<sup>1</sup>S J Vinnicombe, <sup>1</sup>L Bartella, <sup>2</sup>C A Wells and <sup>3</sup>R Carpenter  
Departments of <sup>1</sup>Radiology, <sup>2</sup>Histopathology and <sup>3</sup>Surgery,  
St Bartholomew's Hospital, London EC1A 7BE, UK

**PURPOSE:** Ductal carcinoma *in situ* (DCIS) accounts for about 20% of all screen-detected breast cancers. Histological examination of the surgical specimen often demonstrates invasive disease, unsuspected pre-operatively even with core biopsy. This may necessitate re-operation for definitive surgical treatment. A non-invasive technique that could predict the presence of invasion could potentially reduce re-operation rates. The aim of this study is to assess whether breast MRI could fulfil this role. **METHODS:** A prospective study of 17 patients with a pre-operative diagnosis of DCIS on mammography, confirmed with FNAC or core biopsy, was performed. All patients underwent pre-operative breast MRI with dynamic enhanced 3D fast gradient echo sequences. Scans were reported by one breast radiologist experienced in MRI, with access to mammograms, prior to surgery. The distribution, morphology and degree of enhancement were noted. The presence of nodular enhancement greater than 3 mm was

taken to indicate invasion. Comparison was made with the definitive histology. In cases of discrepancy, the histology and MR scans were reviewed. RESULTS: Enhancement was present in all cases. MRI correctly predicted invasion in 9/10 cases and lack of invasion in 3/7 cases (sensitivity 90%, specificity 43%). There were four false positive examinations and one false negative examination (overall accuracy 70.6%). In one false positive case, clinical findings and conventional imaging also suggested invasive disease. CONCLUSION: Preliminary results suggest that MRI has a high sensitivity for invasive foci in cases of DCIS. However, in this small sample the presence of nodular enhancement is insufficiently specific.

**Magnetic resonance mammography of radial scars: potential for reduction in benign biopsy rates**

D J Manton and L W Turnbull

YCR centre for MR Investigations, Hull Royal Infirmary, Hull HU3 2JZ, UK

PURPOSE: An unwanted consequence of breast screening is the high proportion of biopsies carried out on benign lesions, one cause being radial scars/complex sclerosing lesions (CSL) that can have a mammographic appearance mimicking small spiculated carcinoma. Therefore, a study was undertaken to determine whether contrast enhanced magnetic resonance mammography (MRM) can reduce the benign biopsy rate in this patient sub-group. METHODS: 27 women were recruited, 8 (30%) with cancer (proven by open biopsy). MRM was carried out using a 1.5 T Signa whole body scanner and a bilateral phased-array breast coil. Dynamic contrast enhanced imaging (DCE-MRI) was carried out using a 2D multislice, fast RF spoiled gradient echo (FSPGR) sequence including bolus injection of Gd-DTPA (0.1 mmol kg<sup>-1</sup> body weight). High resolution 3D FSPGR images were also acquired with fat suppression. DCE-MRI data was analysed using a three compartment pharmacokinetic (PK) model. RESULTS: Diagnosis by expert radiologist demonstrated 100% sensitivity (hence 100% negative predictive value, NPV) with a specificity of 58% and a positive predictive value (PPV) of 50%. The most efficacious PK parameter was microvessel transfer constant (K<sub>trans</sub>) with a specificity of 89% and a PPV of 80% (whilst maintaining 100% sensitivity and NPV). CONCLUSIONS: Results suggest that MRM may be able to determine a high proportion (89%) of benign cases accurately (100% NPV) whilst maintaining the very high sensitivity (100%) required in breast screening. This could potentially reduce the benign open biopsy rate in this patient sub-group by limiting this invasive procedure to those women whose lesions demonstrate sufficiently high K<sub>trans</sub> (i.e. rapid contrast enhancement) to warrant further investigation.

**Assessment of soyabean oil breast implants by MRI**

<sup>1</sup>J M Hawnaur, <sup>2</sup>M Wilson, <sup>2</sup>E Elangovan and <sup>2</sup>N Brundred

<sup>1</sup>Diagnostic Radiology, University of Manchester and <sup>2</sup>Breastcare Unit, Nightingale Centre, South Manchester University Hospitals Trust, Manchester, UK

PURPOSE: 5000 women in the UK have received soyabean oil filled breast implants, recently withdrawn from use because of safety concerns. This study used MRI to evaluate soyabean oil implants in a group of mainly asymptomatic women. METHODS: MRI was performed in 73 women with a total of 109 soyabean oil implants. Transaxial, coronal and sagittal T<sub>1</sub> weighted spin echo sequences were obtained in the breast coil. Transaxial fat suppressed dual echo fast spin echo sequences were also obtained. RESULTS: 57 (52%) implants were normal on MRI. The signal intensity of soyabean oil was identical to breast fat on all sequences. An identification transponder produced a large susceptibility artefact posteriorly, and a sealing device caused a small anterior signal void. Minor abnormalities were seen in 36% of implants, most frequently (33/39) as small amounts of serous fluid between folds in the implant envelope or adjacent to the chest wall. Major abnormalities were identified in 13 implants. Symptoms included implant deflation, hardening, lumpiness and pain; four women (five implants) were asymptomatic. Reduced T<sub>1</sub> signal intensity and/or incomplete fat suppression was observed in eight implants, with layering of different signal intensity fluids in five. These observations suggest increased non-lipid fluid within the implant. A large intracapsular fluid collection was present in 12 cases, with signal intensities compatible with serous fluid in five, mixed serous/lipid fluid ± layering in six and lipid in two. All implants with major abnormalities showed marked infolding or irregularity of the envelope, but discontinuity or other morphological signs of rupture were seen in

only 8 (62%). CONCLUSION: MRI can identify signs of soyabean oil degeneration and peri-implant fluid collections that may precede symptomatic implant rupture.

**Magnetic resonance mammography following equivocal cytology: potential for obviating additional biopsies**

D J Manton, A-M Coady and L W Turnbull

YCR Centre for MR Investigations, Hull Royal Infirmary, Hull HU3 2JZ, UK

PURPOSE: Investigation of potential breast cancer routinely utilizes cytology following fine needle aspiration. Methodological limitations lead to an equivocal diagnosis in up to 20% of cases, thus necessitating an additional biopsy. Magnetic resonance mammography (MRM) has the advantage of imaging the whole lesion and a retrospective study was undertaken to establish the benefit of adding MRM to the clinical management of this patient sub-group. RESULTS: 39 women were identified, 15 with cancer (proven by open biopsy). MRM was carried out using a 1.5 T Signa whole body scanner and a bilateral linear breast coil. Dynamic contrast enhanced imaging (DCE-MRI) was carried out using a 2D multislice, fast spoiled gradient echo (FSPGR) sequence including bolus injection of Gd-DTPA (0.1 mmol kg<sup>-1</sup> body weight). High resolution 3D FSPGR images were also acquired with fat suppression. DCE-MRI was analysed using a three compartment pharmacokinetic (PK) model. Logistic regression analysis (LRA) was used to develop diagnostic models. RESULTS: Cytology demonstrated sensitivity of 80% and specificity of 88%. Diagnosis by MRM (expert radiologist) demonstrated sensitivity of 87% and specificity of 83% and permitted accurate, unequivocal diagnosis (AUD) in 15% of cases. The best PK parameter was exchange rate with sensitivity of 93%, specificity of 83% and AUD of 49%. The best LRA model comprised cytology and the PK permeability with sensitivity of 93%, specificity of 96% and AUD of 49%. CONCLUSION: Results have shown that PK analysis has comparable accuracy to expert diagnosis and can also provide AUD in a substantial proportion of cases (49%) thus obviating additional biopsies and the associated increase in patients' morbidity and psychological distress.

**Screening mammography in patients aged 70 years and over: workload implications and positivity rates**

N T F Ridley, S J Taylor, J Cook, J Scolding and J Webb

Breast Care Unit, Princess Margaret Hospital, Swindon SN1 4JU, UK

PURPOSE: The upper limit of screening age for breast mammography has recently been increased to 70 years. However, all women over 65 years have been eligible for a mammogram on demand and many women have taken up this offer. Demand for mammography in the over 70s age group may rise in the future. METHOD: We have reviewed previous screening mammograms in the over 70s age group. RESULTS: All screening mammograms in ladies aged 70 years and older between 1997 and 2000. The age range was 70-75 years. 428 mammograms were performed. 29 patients were recalled for assessment. Eight cancers found. Two were symptomatic. CONCLUSION: The cancer detection rate was high, as expected in this age group. These mammograms and assessments represent a small percentage of our present workload. However, this should be reviewed in the future as it may increase substantially.

**Breast examination in the Breast Screening Assessment Clinic: can a nurse perform as well as a doctor?**

N T F Ridley, L Lark, S J Taylor, J Cook and M Galea

Breast Care Unit, Princess Margaret Hospital, Okus Road, Swindon SN1 4JU, UK

PURPOSE: The majority of patients attending screening assessment clinics require clinical breast examination. This has traditionally been performed by surgeons or radiologists. In our department, a specially trained nurse undertakes the breast examination. A snap audit of 12 recent cancers (excluding DCIS) was performed. THE STANDARD: The nurse examiner should be able to palpate 100% of surgically palpable cancers. RESULTS: 9 of 12 cancers were palpable by the surgeons. The nurse palpated 11 of 12 cancers. 1 of 12 cancers was not palpable by either. CONCLUSION: The nurse examiner performed well in this audit. A more detailed audit is indicated to confirm these findings.

### The relevance of symptoms in a breast screening programme

R S Williams, D Brook, K Gower-Thomas and I J Monypenny

*Breast Test Wales, Cardiff CF1 9LJ, UK*

**PURPOSE:** The aim of breast screening is a reduction in breast cancer mortality of asymptomatic women aged 50–64 years. Inevitably, some patients attending screening report breast symptoms and at our centre a system is in place for the identification of women with important symptoms. Radiologists are provided with this information when reading films and can recall patients on the basis of symptoms alone. **METHOD:** Women with symptoms were identified over a five-year period. Cases were classified according to radiological opinion as either suspicious (any mammographic abnormality) or benign. **RESULTS:** Of 285 793 women screened in Wales between 1991 and 1996, 1394 had reported significant symptoms at their initial appointment and 756 (54%) of these were assessed. 125 (9%) of 1394 women were found to have breast cancer at subsequent assessment. This gives a cancer detection rate of 90 per 1000 for patients with symptoms. However, 94% of those with cancer had abnormal mammograms and would have been recalled on that basis. For those with normal mammograms and symptoms, 494 were assessed and only 7 cancers detected (6.2 per 1000). All of the 7 patients with cancer had described a breast lump. Finally, the interval cancer rate was investigated. 12 patients, of whom 6 had been assessed, developed cancer within 3 years of screening. **CONCLUSIONS:** It appears that recording symptoms in the screening programme is useful given the high rate of cancer shown. However, when mammography is benign, only those with significant symptoms should be recalled and a selective system of recall is needed.

### Symptomatic breast services in the UK: a survey

S J N Daniell

*Department of Diagnostic Imaging, Bromley Hospitals NHS Trust, Bromley BR6 8ND, UK*

**PURPOSE:** Whilst much is known about the provision for the NHS National Breast Screening Programme, there is little information on imaging services for symptomatic breast patients. **METHOD:** Using the NHS Confederation's data, all 459 NHS Trusts in the UK were surveyed, and those providing breast imaging services to symptomatic patients were sent a questionnaire in March 2000. **RESULTS:** Completed questionnaires were received from 181 of 238 (76%) Trusts serving a total population of approximately 54.1 million. The clinics reported seeing approximately 280 000 new patients each year and diagnosing approximately 26 000 new breast cancers. **DISCUSSION:** Information will be presented on the type of service delivered, the radiologist and radiographer workforce, funding and vacancies, morale and litigation, equipment numbers and age, GP mammography access, audit, multidisciplinary working, workload (mammography including double reading, ultrasound, cyst aspiration, FNA, core biopsy and localization) and service provision. The overall picture shows that three out of four breast cancers diagnosed in the UK are seen by the symptomatic service, with standards that compare favourably with the NHS breast screening service. The symptomatic service is striving to provide a high quality of care but often lacks the necessary staff, funding and equipment to meet patient needs and expectations.

### An automated breast segmentation technique for the evaluation of hormone replacement therapy

A Knowles, C E Kearney, P Gibbs, D W Purdie and L W Turnbull

*Centre for MR Investigations, Hull Royal Infirmary, Anlaby Road, Hull HU3 2JZ, UK*

**PURPOSE:** MRI is a safe and non-invasive method of accurately quantifying breast parenchymal volume. However, difficulties arise owing to variations in signal intensity secondary to B1 inhomogeneity. This study aims to demonstrate that a combination of artificial neural networks and image processing techniques can correct B1 inhomogeneity and allow automated segmentation. The technique developed has been used to determine serial changes in parenchymal volume secondary to hormone replacement therapy as well as a selective oestrogen receptor modulator (SERM). **METHODS:** Breast MRI was performed pre treatment and at 1 month, 3 months and 6 months post treatment on 34 osteopenic post-menopausal patients randomized to

receive Premique, Premique Cycle, Raloxifene and Tibolone. A 3D T<sub>1</sub> weighted volume was acquired using a 1.5 T Signa Advantage (General Electric Medical Systems, Milwaukee) with a dedicated breast coil. **RESULTS:** Training and correcting for B1 inhomogeneity took 40 s. The resultant correction enabled visualization of anatomy adjacent to and distant from the surface coil using the same contrast settings. Automated segmentation of the data set took a further 20 s. Patients receiving Raloxifene and Tibolone showed no significant change in parenchymal volume, whilst those receiving Premique or Premique Cycle showed an increase of 16–20%. **DISCUSSION:** This is a retrospective technique for automated B1 correction and segmentation, which minimizes human intervention compared with more traditional methods that are time consuming and prone to operator error. Implementation of this technique has demonstrated no significant change with Tibolone or the SERM Raloxifene.

## Refresher Course

### Aspects of Patient Care

#### Invited Review

#### Models of care in diagnostic radiographic practice

P J Reeves

*School of Radiography, University of Wales Bangor, Archimedes Centre, Wrexham Technology Park, Wrexham LL13 7YP, UK*

#### Invited Review

#### Enhancing the radiographer's role in patient assessment—the golden opportunity

R Carlton

*Radiological Sciences, Box 910, Arkansas State University, Chickasaw Hall, 106 N Carraway Road, Arkansas, AR 72467, USA*

## Refresher Course

### Quality Control for Equipment

#### Invited Review

#### How do I start? Requirements, organizations and examples

W Hoban and J Elford

*X-ray Department, Royal Free Hospital, London NW3 2QG, UK*

#### Invited Review

#### What do I do—key test and examples

A P Hufton

*North Western Medical Physics, Christie Hospital NHS Trust, Wilmslow Road, Manchester M20 4BX, UK*

#### Invited Review

#### Diagnostic reference levels: how low/high is acceptable?

I A J Fife

*Medical Physics Department, Royal Free Hospital, Pond Street, London NW3 2QG, UK*

#### Invited Review

#### What about digital—quality assurance in digital imaging

A Workman

*Department of Medical Physics, Forster Green Hospital, Belfast BT8 4HD, UK*

#### Invited Review

#### A clinical perspective

R F Bury

*Department of Nuclear Medicine, Leeds General Infirmary, Great George Street, Leeds LS1 3EX, UK*

## Workshop

### Creating PowerPoint Presentations: beginner

How to create PowerPoint presentations: beginner  
M Tatlow

Division of Professions Allied to Medicine, Faculty of Health Sciences, South Bank University, London SE1 0AA, UK

## Workshop

### Musculoskeletal Ultrasound

Invited Review  
Musculoskeletal ultrasound  
D Chapman-Jones

Canterbury Christ Church University College, Canterbury CT1 1QU, UK

## Workshop

### MR of the Breast

Invited Review  
Obtaining the best imaging

S J Vinnicombe  
Department of Imaging, St Bartholomew's Hospital, West Smithfield, London EC1A 7BE, UK

Invited Review  
MRI of benign disease  
S C Rankin

Radiology Department, Guy's & St Thomas NHS Trust, St Thomas' Street, London SE1 9RT, UK

Invited Review  
MRI of breast tumours  
M A Hall-Craggs

MR Unit, Department of Imaging, Middlesex Hospital, UCLHT, Mortimer Street, London W1N 8AA, UK

## Scientific Session

### MR and Nuclear Medicine

Interactive real-time MRI of the abdomen  
D J Lomas, M J Graves and M Makki

Department of Radiology, University of Cambridge and Addenbrooke's Hospital, Hills Road, Cambridge CB2 2QQ, UK

**PURPOSE:** To develop a real-time interactive MRI capability for abdominal imaging that provides resistance to artefacts and control of contrast, including  $T_2$  weighting. **MATERIALS AND METHODS:** A proprietary single shot half-Fourier rapid acquisition with relaxation enhancement (RARE) sequence was adapted to operate with an interactive interface (i-Drive) on a commercial 1.5 T MR system (CVi, GE Medical Systems). The sequence was modified to incorporate "on the fly" switching of phase encode order and fat saturation. The "inner volume" concept was included to allow faster frame rates, using reduced fields of view, without aliasing. The resulting sequence was tested in human volunteers. **RESULTS:** Imaging at 0.9–2.3 frames per s was achieved, with the ability to switch contrast between predominantly proton weighted and fat suppressed long effective TE  $T_2$  weighted imaging. This allowed, for example, projection MRCP images to be obtained interactively and in real-time during normal respiration. **CONCLUSIONS:** Unlike the majority of gradient echo methods, modified interactive single shot RARE imaging can provide robust real-time MRI of the abdomen with contrast control. This may prove valuable for reducing examination times and obtaining dynamic information about both normal and abnormal physiology.

**High definition whole body imaging at 3 T**  
S Roberts, A Freeman, P Murphy, R Gauss and M Burl  
Marconi Medical Systems UK Ltd, Farnham, Surrey GU9 9PA, UK  
**PURPOSE:** For whole body MRI, the potential signal advantage at high field (3 T) strength could be utilized to interrogate fine structures or to apply acquisitions of increased functionality. High field

imaging of the body presents a number of challenges in terms of image quality and scanning safety. With increasing field strength, the average SAR increases whilst issues such as RF penetration and field homogeneity become more problematic. We demonstrate that it is possible to acquire very high quality body images at 3 T within current regulatory safety limits. **MATERIALS AND METHOD:** All images were acquired with a Marconi Medical Systems 3.0 T Infinion System using a body RF coil (coil diameter 59 cm, length 61 cm). Scanning protocols were chosen to obtain representative images from abdomen/thorax and spine. Breath-hold abdominal images were obtained in the coronal (FOV 36 cm, matrix size 160 × 256) and axial (FOV 40 cm, matrix size 180 × 256) plane using the RF-FAST sequence. Sagittal spine images were obtained using a FSE sequence (FOV 30 cm, matrix size 384 × 512). **RESULTS:** Images offered high signal-to-noise and a high degree of contrast. B<sub>0</sub> and B<sub>1</sub> homogeneity were sufficient to allow imaging with a large FOV. Images were obtained using the body coil with sequences as detailed above without exceeding current SAR regulatory limits. **DISCUSSION:** Examination of fine structure using resolution not currently practical at 1.5 T could be further improved with smaller coils for specific regions of anatomy, e.g. spine, breast and prostate. High field (3 T) full body imaging can be performed in addition to the relatively established neurological applications. This enhances the value of operating a 3 T system in the broader research and clinical setting.

### An acceptable audit? Experiences with MRI acceptance testing

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**PURPOSE:** An audit has been carried out on the effectiveness of MRI acceptance tests carried out on 15 systems between 1994 and 2000. Specific questions asked were: Which parameters are failing most often? What action is taken following the report of a failure? Is there any evidence that scanner installations are getting better? What are the main safety issues regarding installation? Are we measuring the right things? **METHODS:** Systems from three manufacturers with field strengths in the range 0.5–1.5 T were included. Image quality tests were performed using bespoke test objects, protocols and two tier generic acceptance criteria. Additionally, nine of the systems were subject to a safety audit consisting of 100 questions. **RESULTS:** Signal-to-noise ratio (SNR) was the most frequently non-compliant parameter (eight incidences of parameter non-compliance), followed by uniformity, geometric distortion/linearity and ghosting (six each). Non-compliance was evenly split between "hard failures" and "soft failures". About 75% of SNR failures resulted in known favourable outcomes in terms of recalibration, re-testing or replacement. Known favourable outcome rates were lower for the other parameters. Failure rates did not vary significantly over the time period. The failure rate from the safety survey of 100 questions was 5%, with a range between 2 and 9. No installation achieved 0% non-compliance on the safety questionnaire. Most related to aspects of suite design. **CONCLUSION:** The audit demonstrates the usefulness of MRI acceptance tests, particularly with regard to SNR, geometry and safety.

### Diagnostic utility of perfusion weighted imaging of the prostate

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**PURPOSE:** Over the past few years MR imaging of the human prostate has become increasingly prevalent. However, owing to the similarity in signal intensity between prostatic carcinoma (PCa) and benign prostatic hyperplasia (BPH) the usefulness of conventional MRI is debatable. Perfusion weighted imaging and subsequent quantification has been shown to be useful when studying brain disease. This work attempts to employ a singular value decomposition (SVD) routine to quantify and diagnostically assess perfusion weighted imaging of the prostate. **METHODS:** All imaging was performed using a GE 1.5 T scanner and a commercial pelvic phased array coil. A total of 77 patients aged 43–83 years (mean 67 years) were imaged using a gradient-echo echo planar imaging sequence. 80 images were acquired at four slice locations with a temporal resolution of 2 s. Following the tenth image, 0.1 mmol kg<sup>-1</sup> body weight of Gd-DTPA was injected as a bolus. After acquisition, regions of interest were drawn in areas of peripheral zone, central gland, PCa, and BPH. An appropriate arterial

input function was also selected. Statistical comparisons were made after processing with the SVD routine. RESULTS: Significant differences were found between peripheral zone and PCa for the mean transit time ( $p < 0.021$ ) and blood flow ( $p < 0.016$ ). A significant difference was also noted between peripheral zone and BPH for the mean transit time ( $p < 0.004$ ). Unfortunately no significant differences were found between tumour and BPH ( $p > 0.170$ ). CONCLUSIONS: This work has shown that perfusion weighted imaging of the prostate gland is feasible and offers some diagnostic utility. Future improvements including absolute quantification may improve diagnostic accuracy further.

### **$T_2$ MRI of the abdomen in a breath-hold using SENSE**

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PURPOSE: To develop and test methods of  $T_2$  weighted imaging of the abdomen based on SENSE, with acquisition times suitable for breath-hold scanning. MATERIALS AND METHODS: SENSE achieves a reduction in scan time by replacing some of the usual gradient encoding with spatial information from the component coils in a receiver array. Reference data are acquired with the patient *in situ* to determine coil sensitivity profiles. This was achieved in 100 s with the subject free breathing and multiple averages used to suppress motion artefacts. Target and reference data consisted of  $T_2$  weighted 16 echo fast spin echo (FSE) sequences run on a 0.5 T Marconi Medical Systems Apollo scanner using a standard 4-channel wrap around receiver coil. Comparisons were made between a standard protocol with a square FOV,  $192 \times 256$  resolution and phase encode LR taking 33 s, a strip sampled version with only 128 phase steps and phase encode AP taking 22 s and a strip sampled version combined with SENSE requiring only 64 phase steps taking 11 s and acquired during a breath-hold. The method was tested in four normal volunteers. RESULTS: The 3-s and 22-s scans each suffered from motion-induced ghosting and blurring. The 11-s scan was achieved in a breath-hold and was free from respiratory blurring and artefacts. SNR was reduced as expected with SENSE, but contrast was unchanged. CONCLUSION: SENSE brings  $T_2$  weighted FSE sequences within the realm of a short breath-hold that patients are likely to be able to achieve.

### **Work in Progress**

#### **Assessment and management of developmental dysplasia of the hip using dynamic interventional MRI**

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Early diagnosis and appropriate management of developmental dysplasia of the hip is essential to improve the results of treatment, to reduce the risk of complications and to alter favourably the natural history of the condition. Interventional MRI (iMRI) opens up the possibility of a safe, non-invasive and radiation-free examination of the hip in the anaesthetized child. The vertical configuration, open MR scanner provides a 56 cm gap for surgical access to the patient in the most homogeneous part of the static magnetic field. A flexible coil (both a transmitter and a receiver) is placed around the part of the anatomy to be examined. MR-compatible equipment permits anaesthesia and monitoring of the child. Static, coronal and axial  $T_1$  weighted spin echo images are initially obtained to assess joint anatomy. Near real-time imaging using a fast gradient echo technique permits further evaluation of the hip as the examiner moves the femur. For the past 3 years, iMRI has been employed as an alternative to arthrography for developmental dysplasia of the hip in 19 patients. We have successfully used this approach to assess the stability of the dysplastic hip under stress and to verify accurate reduction. Hip spicas have been applied, and adductor tenotomies have been performed without removing the patient from the scanner. "Dynamic" appraisal of stability has facilitated planning of subsequent femoral osteotomies. The near real-time imaging and multiplanar capabilities of the iMRI scanner, coupled with the anatomical detail offered, means that much more can be achieved compared with arthrography or ultrasound.

#### **Intra-individual comparison of two contrast agents—Gd-DTPA and Gd-BOPTA—for multiphasic abdominal MR angiography**

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PURPOSE: To compare two different MR contrast agents in terms of their vascular enhancement characteristics for time resolved MR angiography of the abdomen. METHODS: An intraindividual, double blinded, randomized crossover comparison was performed in five healthy volunteers. Two contrast agents were used at a dose of  $0.15 \text{ mmol kg}^{-1}$  body weight, administered at a rate of  $3 \text{ ml s}^{-1}$ ; Gd-DTPA 0.5 M (Magnevist, Schering) and Gd-BOPTA 0.5 M (MultiHance, Bracco). A minimum time period of 48 h was maintained between exams. All studies were performed on a 1.5T clinical MR imager using a modified fast 3D gradient echo sequence with asymmetric k-space readout (TR 3.2, TE 1.1, a  $40^\circ$ , acquisition time 6.4 s) enabling five sequential image sets within a single breath-hold. Assessment was performed by blinded reader analysis. Quantitative data were obtained by placing regions of interest, and qualitative data were acquired by means of a continuous scale from +5 (excellent) to -5 (unacceptable). RESULTS: Quantitative assessment revealed significant ( $p = 0.03$ , Kruskal-Wallis) differences between the two contrast agents. Median arterial peak enhancement ( $S_{\text{max}} - S_0$ ) in the aorta was significantly ( $p < 0.05$ ) higher for Gd-BOPTA (551) than for Gd-DTPA (356). Venous peak enhancement in the cava was 295 for Gd-BOPTA and 233 for Gd-DTPA. The qualitative assessment found the overall image quality score for Gd-BOPTA (4.8) to be significantly ( $p < 0.01$ ) better than that for Gd-DTPA (3.6). Visualization scores for the portovenous system were 3.9 for Gd-BOPTA and 2.6 for Gd-DTPA. CONCLUSION: This intraindividual comparison confirmed significant enhancement differences between the two agents. This implies that optimal MRA procedures need to consider the specific characteristics of different agents. Gd-chelates with weak protein interaction (Gd-BOPTA) present higher intravascular arterial and venous signal at the same dose.

#### **Combined optical and functional MR spectroscopy in graded hypercapnia at 3 T in rat brain**

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Combined optical and functional MR spectroscopy can provide high temporal resolution measures of oxyhaemoglobin (HbO) and deoxyhaemoglobin (Hbr) together with the associated BOLD/CBV signal changes. METHODS: We have used an InnerVision research console interfaced to a 3 T magnet to acquire MR spectra at a rate of up to 10 per s to investigate the haemodynamic response and "early deoxy dip" in the functional response of rat brain to a range of external stimuli. Optical spectra over the visual range were acquired using a fibre optic illumination and collection system interfaced to a slit spectrograph and CCD camera. Analysis of the overlapping absorption peaks owing to HbO and Hbr between 500 nm and 600 nm produces an estimate of absolute concentration of these species as well as total haemoglobin. Animals were anaesthetized using urethane, maintained in a stable physiological state and sacrificed before recovery in accordance with ASPA 1986. In particular, we have investigated the effects of hypercapnia and 100% oxygenation for periods of 30 s, which elicits a large signal response and has allowed us to perform a detailed comparison of optical and MR methodologies. RESULTS: Good correlation was observed between the time course of the optical measurements and the BOLD response in graded hypercapnia and with 100% oxygen. CONCLUSION: These data are providing input for a new theoretical model of functional MR based on a modification of the Buxton-Frank balloon model.

#### **1½ years' clinical experience with MCD/AC gamma camera PET: an affordable option?**

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PURPOSE: Although dedicated PET systems have been available for several years, their use for routine clinical cases has been limited to

research and large teaching institutions. The availability of commercial gamma camera PET/SPECT systems, together with the use of fluorodeoxyglucose (FDG) labelled with the longer half-life  $^{18}\text{F}$ , has made this facility an affordable option. **METHOD:** We purchased such a system to provide a routine and emergency nuclear medicine service and to start a 1–2 day per week FDG-PET service. This system included attenuation correction and volume acquisition for better image quality, to enable localization and quantification of tumour uptake. Clinicians were encouraged to refer five categories of patients with cancer, for which the HCFA in the USA has agreed reimbursement. A database was set up and so far 175 patients have been studied. **RESULTS:** From May 1999 to July 2000, 142 patients were studied: 46 Hodgkin's lymphoma; 15 non-Hodgkin's lymphoma; 42 lung cancer; 12 malignant melanoma; 10 colorectal cancer; 5 breast cancer; and 12 patients with other conditions. With attenuation correction, excellent images have been obtained and a robust quantitative method for tumour uptake has been developed. **CONCLUSION:** Gamma-camera FDG-PET provides a flexible, cost effective alternative to dedicated PET. With attenuation correction, this imaging system is an affordable, clinically applicable option for the management of patients with cancer. Clinical examples will be presented.

**Validation of a target-to-background ratio method in measuring tumour uptake of  $^{18}\text{F}$ -FDG using phantom studies**

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**PURPOSE:** Quantitation of the uptake of  $^{18}\text{F}$ -FDG is a desirable feature in PET imaging in oncology. Target-to-background ratio (TBR) is a simple parameter for assessing the uptake of FDG in tumours applicable to  $^{18}\text{F}$ -FDG PET performed with a gamma camera PET system. The method involves measuring the ratio of counts in the lesion to counts in a background region, which relies on a robust procedure for outlining the lesion and the background region. The aim of this work was to evaluate the method of measuring TBR using phantom studies. The study was designed to assess: (i) a ROI method used to outline lesions; (ii) the effect on TBR with and without attenuation correction (AC); and (iii) the accuracy of TBR values measured. **MATERIALS AND METHOD:** The phantom used consisted of a cylindrical phantom with five small tubular inserts of equal diameter and with lengths ranging from 1–5 cm. A series of PET acquisitions was performed with  $^{18}\text{F}$  activities in the phantom (background) and the various tubular inserts (lesions) in the ratios: 1:2, 1:3, 1:4, 1:5 and 1:6. **RESULTS:** Each phantom study was reconstructed using OSEM algorithm, with and without AC. The results show a reasonable degree of reproducibility of TBR for inserts of larger size and higher background to insert activities. **CONCLUSION:** We have validated this method of quantitation of lesion uptake of FDG. TBR values obtained with AC were closer to the actual values than without AC. This method is routinely applied to clinical studies performed in our department.

**Optimum functional blood flow images by PET camera: part II**

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**METHODS:** In this study, functional cerebral blood flow (CBF) images were generated using positron emission tomography (PET) with two different protocols. In the first protocol,  $^{14}\text{CO}_2$  was inhaled by the patient for 1.0 min (activity 10 MBq ml $^{-1}$ ). In the second protocol,  $\text{H}_2^{15}\text{O}$  was infused to the patient (4000 GBq ml $^{-1}$ ). For each of these protocols, the optimum integral time for CBF imaging was evaluated. Thereafter, comparison between the two different protocols was made on the basis of relative error in CBF. Dynamic and integral analysis based on the Kety model was applied to a dynamic sequences of PET scans collected during and following the administration of tracer. Dynamic analysis was used to correct continuously monitored arterial whole-blood activity for delay and dispersion relative to tissue scans. An integral analysis, including correction for delay and dispersion, was then used to calculate CBF on a pixel-by-pixel basis. Three computer programs (TRACERS, MODELS and TURBCBF) were used to calculate CBF and to generate functional CBF images. **RESULTS:** From these different dynamic studies, the calculations predict that the statistical errors in CBF, delay and dispersion in the case of the second

protocol were small compared with the first protocol. Also, the effect of varying scanning time on relative error of CBF was investigated for the two different protocols.

**Keynote Lecture  
Imaging of Inflammatory Bowel Disease**

**Invited Review  
Imaging inflammatory bowel disease**

S Halligan  
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**Keynote Lecture  
Acute Head Injury: how and when to refer**

**Invited Review  
Acute head injury—how and when to refer**

D Hadley  
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**Keynote Lecture  
Hyaline Cartilage**

**Invited Review  
Hyaline cartilage**

I Watt  
*Department of Radiology, Bristol Royal Infirmary, Marlborough Road, Bristol BS2 8HW, UK*

**Keynote Lecture  
Child Psychology and its Implications for Paediatric Imaging**

**Invited Review  
Child psychology—its implications for paediatric imaging**

J Hardwick  
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**Scientific Session  
Breast (2)**

**Work in Progress  
The effect of hormone replacement therapy on mammographic breast arterial calcification**

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**PURPOSE:** Arterial calcification in the female breast is a common finding on breast cancer screening mammograms. An increased incidence of breast arterial calcification (BAC) is associated with manifestations of accelerated vascular disease, including diabetes mellitus, systemic hypertension, MI, TIA and stroke. Hormone replacement therapy (HRT) has been shown by a large body of epidemiological evidence to reduce the incidence of cardiovascular disease in post-menopausal women by up to 50%. The purpose of this study was to test the hypothesis that the prevalence of arterial calcification in the breast could be correlated with HRT consumption in the screening age population. **METHODS:** Mammograms from 4400 female breast screening patients (age 49–66 years) were prospectively reviewed by a single radiologist (WS). The following information was recorded: patient's age; whether or not the patient had been recorded as taking HRT at the time of screening or has been in the past; and the presence of BAC. Patients with a treated breast cancer (and therefore likely to be taking anti-oestrogenic preparations) were excluded from this series. **RESULTS:** BAC was present on the screening mammogram of 530 (12%) women. The prevalence of BAC in patients recorded as taking HRT was significantly lower than in patients recorded as not using HRT ( $\chi^2$  35.0;  $p < 0.001$ ). BAC increases as a function of patient age in both groups. Confirmation of this pattern is provided by logistical regression analysis. **CONCLUSION:** The results of this prospective

study of 4400 women of screening age show significant differences in the levels of BAC related to HRT, and suggest that HRT alters the natural history of the development of BAC.

#### Work in Progress

##### **Breast MRI as an adjunct to triple assessment: early experience**

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INTRODUCTION: MRI of the breast provides detailed anatomical and pathological information. However, the value of this investigation following standard triple assessment (clinical examination, mammography/ultrasound, biopsy) remains to be established. We describe our early experience. METHODS: We have examined 207 patients. The decision to carry out MRI was made at our multi-disciplinary meeting. The MRI scans were performed to a set protocol using a Philips 1.5 T magnet. RESULTS: Two main indications for MRI emerged. The first was discordance regarding extent of a lesion. 57 women with newly diagnosed breast cancer who were given the treatment options of wide local excision or mastectomy were scanned. In 28 women, additional disease was demonstrated. Undiagnosed contralateral tumours were demonstrated in three patients and additional foci were demonstrated in seven. In 16 patients the tumour was correctly shown to be considerably more extensive than initially believed. The second indication related to the nature of a lesion when there was non-concordance between the clinical findings and the findings on conventional imaging ( $n=95$ ). Of this group, 43 were new patients and 52 were being investigated after wide local excision. MRI performed well in both groups (sensitivity 88%, specificity 92%). In 15 cases, tumour initially diagnosed at MRI was successfully biopsied by "MRI directed" ultrasound or mammography guided biopsy. CONCLUSION: MRI is a valuable additional investigation, particularly when there is non-concordance at triple assessment regarding the presence or the extent of breast cancer.

#### Work in Progress

##### **Performance of individual screen readers working within the NHS Breast Screening Programme**

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Screen readers are encouraged to regularly participate in PERFORMS. This is primarily intended as an educational exercise, but also enables screen readers to compare their sensitivity and specificity with that of their peers. It is acknowledged, however, that performance in PERFORMS does not necessarily reflect performance in real life. At this unit, >90% of films are double read, with third reader arbitration if the first and second readers disagree. This results not only in increased sensitivity for cancer detection but also provides prompt feedback of missed cases to the first reader. If the cases had been single read, the reader would remain unaware of his/her error until the woman presented symptomatically with an interval cancer or when the cancer was detected at her next routine screen. A manual record is kept of cancers detected following arbitration. The number of cases read by each individual when acting as the first reader and their recall rate was obtained from the BSP computer system (co-writer report). Between 1 April 1995 and 31 March 2000, 121 456 women were screened and 688 cancers were detected. 46 (6.7%) cancers were detected following arbitration. A wide variation both in recall to assessment rate (3.7–6.2%) and in the number of cases incorrectly returned to routine recall by the first reader (0.14/1000–1.2/1000 cases read) was found. Monitoring performance will be particularly important if extension of the national programme to include women aged 50–70 years is accomplished in the rapid time scale anticipated by the NHS Cancer Plan. This method could be adopted nationally.

##### **Imaging palpable breast cancer: contribution of mammography and ultrasound**

M A Al-Attar and A Crozier  
*Radiology Department, Glenfield General Hospital, Leicester LE3 9QP, UK*  
PURPOSE: To determine the accuracy of mammography in demonstrating an abnormality in symptomatic women presenting with a lump in the breast proved to be a cancer, and to assess the additional benefit

of targeted ultrasound examination. METHODS: This was a retrospective study of patients presenting to Leicestershire breast care centre with a lump in the breast proven to be cancer. 100 patients with 103 cancers were reviewed. The imaging appearances of breast abnormalities were classified as 1 to 5 according to the degree of suspicion of malignancy. Any abnormality in the symptomatic area was regarded as positive. The background pattern of the breast tissue was classified as dense, mixed or fatty. Ultrasound was performed at the same time and by the same radiologist. RESULTS: 97 patients (with 100 cancers) underwent mammography. Eight cancers were mammographically occult, giving a sensitivity of 92% for the entire study group (age range 26–90 years). 7/8 missed cancers were in a dense or mixed density breast. One cancer was not shown in a fatty breast. 60 patients underwent both mammography and ultrasound. The combination of the two tests gave a higher sensitivity of 98%, increasing to 100% in women under the age of 50 years. Ultrasound upgraded the level of suspicion of malignancy in 13/60 cases. CONCLUSIONS: The combination of targeted ultrasound of the breast with mammography gives a higher sensitivity in the detection of palpable breast cancer. Ultrasound should be used more frequently, especially in younger patients, as mammography is more likely to be false negative.

##### **Film reading practice by radiographers in breast screening**

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PURPOSE: A number of initiatives aimed at enhancing and extending the radiographers' role in film reading (FR) in mammography and breast screening are currently taking place. In the context of these developments, a review of current and potential future FR practice by radiographers was undertaken. METHODS: A survey of radiographers-in-charge of all breast screening units in the UK was undertaken. A self-administered questionnaire was devised, which focused on two main themes: (i) features of and opinions on current FR practice; and (ii) issues surrounding the further development of FR. RESULTS: Of the units surveyed, 36% used radiographers in some type of FR role. Most of the units used radiographers as part of existing protocols, although 68% of respondents undertook FR specifically for their professional development. Positive outcomes of the introduction of FR included reported improvement in detection rates, improved timeliness of reporting and enhancement in the personal skills of those undertaking FR. Problems did occur in arranging cover for radiographers carrying out FR and in obtaining adequate support for developing the role further. When considering the future, 11% of respondents saw no formalized role for radiographers in FR, whilst 61% of respondents concluded that radiographer FR would probably be taking place in selected units only. CONCLUSIONS: Progress towards developing the role of breast screening radiographers in film reading continues. Key issues surrounding the identified logistical/operational problems associated with radiographer FR, however, need to be accounted for in shaping future radiographer FR practice.

#### Keynote Lecture **Radiographers and Evidence-based Medical Imaging**

Invited Review  
**Radiographers and evidence-based medical imaging**  
T Smith

*Faculty of Medicine and Health Sciences, The University of Newcastle, Newcastle, New South Wales, Australia*

#### Keynote Lecture **THz Imaging**

Invited Review  
**Terahertz frequency imaging**  
T Fitzgerald

*CoMIR, Medical Physics Department, Wellcome Wing, Leeds General Infirmary, University of Leeds, Leeds, UK*

## Workshop

### Musculoskeletal Ultrasound

#### Invited Review

#### Musculoskeletal ultrasound

D Chapman-Jones

Canterbury Christ Church University College, Canterbury  
CT1 1QU, UK

## Scientific Session

### Gastrointestinal (3)

#### The angiographic diagnosis of small intestinal tumours in patients with gastrointestinal bleeding referred for visceral arteriography

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**PURPOSE:** The aim of this study was to identify the incidence and the angiographic features of small intestinal tumours in a large group of patients with gastrointestinal bleeding referred for visceral arteriography. **METHODS:** Between 1991 and 1999, 783 patients were referred for visceral arteriography to determine the cause of their gastrointestinal bleeding. The arteriogram reports were reviewed and those that demonstrated a small bowel tumour were sought for further review. **RESULTS:** There were 21 patients (18 male, 3 female; age range 25–81 years) in whom a small bowel tumour was identified. Histology reports were available in all patients. There were nine leiomyomas, two leiomyosarcomas, two hamartomatous polyps, four carcinoid tumours, one adenocarcinoma, one malignant nerve sheath tumour and two metastases from known primaries. All of the leiomyomatous tumours, two of the carcinoid tumours and the adenocarcinoma were correctly diagnosed on the basis of their angiographic appearance. **CONCLUSION:** Small bowel tumours that were detected angiographically comprised 3% of the total number of cases referred for visceral arteriography to investigate gastrointestinal bleeding. The angiographic features of the more common small bowel tumours allowed a correct pre-operative diagnosis in most cases.

#### White cell scanning for inflammatory bowel disease: are biochemical markers useful referral criteria?

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**PURPOSE:** The aim of the study was to determine whether biochemical markers for inflammation could prove effective in identifying patients with suspected inflammatory bowel disease (IBD) most appropriate for white cell scanning. **METHOD:** A total of 125 patients were investigated. The values of C-reactive protein (CRP), antichymotrypsin (ACT) and acid glycoprotein (AGP) were measured in 72 patients; AGP and CRP in 8; and CRP in 45. Sensitivity, specificity and accuracy of each test were calculated using the scan result as the gold standard. **RESULTS:** ACT had the highest specificity (1.0) but the lowest sensitivity (0.27) of the three markers. CRP had the lowest specificity (0.67) and the highest sensitivity (0.79). The corresponding values for AGP were 0.87 and 0.5. The accuracy of each test was in the range 0.71–0.74. **DISCUSSION:** The low sensitivity of both ACT and AGP preclude them from being useful referral criteria. CRP is the most sensitive marker for inflammation, but the value of 0.79 is still not high enough. However, if the threshold is reduced from the normally accepted value of 8 mg l<sup>-1</sup> to 5 mg l<sup>-1</sup>, the sensitivity of the test increases to 0.98. Using this criterion to select the patients, 16 (13%) patients would not have been scanned and only 1 patient out of the 48 with IBD would have been missed. Where there is high demand for white cell scans, this may provide a useful strategy for rationalizing requests with negligible consequences.

#### How uncomfortable is virtual colonoscopy compared with fibre optic colonoscopy?

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**PURPOSE:** Virtual colonoscopy (VC) is a new CT technique for large bowel polyp and cancer detection. For VC to become established as a

diagnostic test it must be well tolerated and accepted by patients. **METHODS:** Patients with symptoms of colonic cancer underwent VC prior to fibre optic colonoscopy (FC). To perform VC, colonic air insufflation is performed via a rectal tube after intravenous Buscopan. A spiral CT of the abdomen and pelvis is then performed. From the patients point of view, the examination generally takes less than 15 min. FC was performed following VC using standard intravenous sedatives and muscle relaxants. Before and after both tests, patients completed a questionnaire regarding discomfort/pain, abdominal bloating, anxiety and overall preference between the techniques. The patients were asked to score each variable on a 100-point line scale. Two control groups (undergoing FC and barium enema) are asked the same questions. **RESULTS:** To date, 95 patients have been evaluated. Regarding discomfort and pain, 33% of patients experienced no difference between techniques, whereas 50% found FC more comfortable than VC, with only 17% tolerating VC better than FC. Regarding patient preference scores, 20% of patients had no preference between techniques, only 19% preferred FC whereas 61% would prefer a VC in the future. **CONCLUSIONS:** Preliminary results from this study have shown that patients experience more discomfort/pain with VC than FC. However, patients prefer VC when asked to choose between these two colonic imaging techniques.

#### Accuracy of computed tomographic colography compared with fibre optic colonoscopy in detecting colonic polyps

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**PURPOSE:** We are conducting a clinical trial (funded by the North West R&D NHS scheme) to determine the sensitivity and specificity of computed tomographic colography (CTC) compared with fibre optic colonoscopy (FC) in detecting colonic polyps and cancer. **METHODS:** Patients undergo CTC prior to FC, after standard bowel cleansing and preparation. Following intravenous Buscopan and colonic air insufflation, two CT scans are performed, with the patient supine and prone, using a single spiral CT. CT datasets are analysed on a 3D workstation. The findings of CTC are correlated with the findings of FC in each patient. **RESULTS:** To date, 112 patients have been compared. The FC patient diagnoses were as follows: normal/incomplete or diverticular disease, 72 patients; IBD, 3 patients; polyps <1 cm, 14 patients; polyps >1 cm, 11 patients; polyps (mixed size), 3 patients; colorectal cancers, 7 patients; and colorectal cancer + polyps, 2 patients. FC was completed to the caecum in only 79% of patients, whereas CTC was completed in all patients. A total of 65 polyps were identified at FC. CTC detected 91% of polyps >1 cm but only 51% of polyps <1 cm in diameter. In addition, five false positives were identified on CT. 9 cancers seen at FC were all detected by CTC. Additionally, CTC detected two further cancers in the right side of the colon not reached at FC, as well as a renal cell carcinoma in a patient presenting with pain and change in bowel habit. **DISCUSSION:** Initial results show that CTC is a sensitive method of detecting colorectal cancers and the majority of polyps >1 cm. Up to date figures from this study will be presented.

#### Ultrasound cholangiography: a bedside test useful in the diagnosis of acute acalculous cholecystitis

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Acute acalculous cholecystitis (AAC) is a rare but serious condition. It is often difficult to diagnose, yet prompt gall bladder drainage is the best treatment option. **PURPOSE:** In the intensive care setting, AAC, once suspected, may be treated prospectively with indiscriminate gall bladder drainage. We propose a bedside test that may help to stratify patients into those with cystic duct obstruction, and therefore likely to benefit from gall bladder drainage, from those in whom the cystic duct is patent and in whom the intervention would pose a risk without expected clinical benefit. **METHODS:** Eight patients with suspected AAC were evaluated with percutaneous injections of ultrasound contrast medium into the gall bladder to assess cystic duct patency. In six patients, the accuracy of ultrasound cholangiography was determined using departmental fluoroscopic cholangiography as the benchmark. Ultrasound cholangiography returned a 100% positive predictive value

in this small sample. **CONCLUSION:** Preliminary results suggest that this test may be a useful method of identifying, at the bedside, critical care patients who would benefit from cholecystostomy tube placement.

**A novel technique for measuring splanchnic transit time using Levovist-enhanced power Doppler ultrasound**

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**PURPOSE:** Doppler ultrasound of the splanchnic circulation in inflammatory bowel disease is technically demanding and there is disagreement regarding the most valuable Doppler index, possibly reflecting measurement error. These difficulties have precluded widespread adoption of the technique. However, a need for accurate and reliable assessment of disease activity remains clinically important. In an attempt to eliminate variability, we have developed a novel technique using intravenous ultrasound contrast agent that aims to afford a more robust, simple and reproducible ultrasound index of splanchnic bed resistance. **SUBJECTS AND METHODS:** 10 healthy volunteers were examined following an overnight fast, both before and after a standardized meal. The superior mesenteric vessels (SMA and SMV) were simultaneously interrogated using power Doppler ultrasound following an intravenous bolus injection of Levovist (2.5 g), and arrival of contrast medium in the SMA and subsequently the SMV were recorded using a PC ethernet link. Offline analysis of time-intensity curves allowed calculation of transit time across the splanchnic bed. Conventional spectral Doppler measurements were recorded for comparison. **RESULTS:** Median fasting splanchnic transit time was 11 s and median post-prandial transit time was 6 s ( $p:0.01$ ). Median fasting and post-prandial volume flow was 284 ml min<sup>-1</sup> and 432 ml min<sup>-1</sup>, respectively ( $p:0.05$ ). **CONCLUSION:** Levovist-enhanced power Doppler ultrasound provides a simple non-invasive method of measuring splanchnic transit time. Since this index reflects the normal physiological post-prandial decrease in splanchnic bed resistance, it may provide a more robust indicator of intestinal inflammation in assessment of inflammatory bowel disease.

**Imaging intraarterial hepatic port catheter systems by power Doppler ultrasound using contrast media**

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**PURPOSE:** This study was designed to determine whether intraarterial hepatic port catheter systems can be adequately detected by contrast enhanced power Doppler ultrasound. **METHODS:** 15 patients with a liver port system were investigated prior to chemotherapy. Examinations were performed with short bolus injections of the contrast media Levovist®, in addition to angiographic imaging. **RESULTS:** Liver port systems were easily detected by contrast enhanced power Doppler ultrasound. In 11 of 15 patients, correct flow of contrast medium via the port system was seen with both modalities. One partially occluded hepatic artery was not identified by power Doppler ultrasound despite correct flow of contrast medium. In one of three patients showing an incorrect flow of contrast medium, the blood circulated primarily through the splenic artery owing to dislocation of the catheter tip. Circulation through both the hepatic and the splenic arteries was shown in a second patient, and an occluded right hepatic artery was demonstrated in a third. All these findings were observed with both modalities. **CONCLUSION:** Power Doppler ultrasound provides reliable images of the port catheter system. This method can be used as a follow-up procedure to determine the state of the arterial hepatic circulation during chemotherapy.

## Scientific Session

### Neuroimaging

**Can dynamic contrast enhanced MRI predict those meningiomas in need of pre-operative embolisation?**

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**PURPOSE:** Meningiomas are generally benign tumours that are relatively easy to remove surgically. However, some display markedly

increased vascularity that can lead to high blood loss during surgery. Bleeding can be greatly reduced by embolisation of the major arteries feeding the tumour and a quantitative method of predicting which meningiomas may benefit from this procedure would be a valuable clinical management tool. Intracranial tumour vascularity can be investigated *in vivo* by dynamic T<sub>1</sub> weighted contrast enhanced MRI (DCE-MRI). A retrospective study was therefore undertaken to investigate correlation between DCE-MRI characteristics and microvessel density (MVD), as evidence for this would support the hypothesis that DCE-MRI could indicate highly vascular meningiomas. **METHODS:** Archival tissue was obtained for 20 lesions previously examined by DCE-MRI. Representative sections were stained with CD34 (highly specific for endothelial membranes) and mean microvessel density (MVD) was calculated. DCE-MRI had been carried out at 1.5 T using a 2D multislice, fast spoiled gradient echo sequence including bolus injection of Gd-DTPA (0.1 mmol kg<sup>-1</sup> body weight). A simple two compartment pharmacokinetic (PK) model was used to quantify the initial slope of the contrast enhancement time curve and the maximum percentage enhancement (MPE). **RESULTS AND CONCLUSIONS:** A statistically significant correlation was not observed between MVD and either initial slope ( $p=0.339$ ) or MPE ( $p=0.241$ ), which suggests the absence of correlation between DCE-MRI characteristics and MVD. However, the efficacy of sophisticated PK modelling, which provides physiologically relevant parameters, is to be investigated, as the possibility of using DCE-MRI to determine vascular meningiomas non-invasively remains a clinically relevant goal.

**Volumetric sinus scanning with multislice CT: the alternative to direct coronal imaging**

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**AIM:** Direct coronal CT of the paranasal sinuses is routinely required prior to functional endoscopic sinus surgery (FESS). The inherent disadvantages of the direct coronal scanning technique include patient discomfort, poor reproducibility, streak artefact from dental amalgam and limited information from a single imaging plane. This study aims to demonstrate the advantages of volumetric multislice CT imaging of the paranasal sinuses with primary axial scanning and reconstruction into any desired plane. **METHOD:** 70 patients with clinical rhinosinusitis were scanned on a Marconi MX 8000 multislice CT scanner in the supine position (as for a standard brain scan). Scans were taken from the bottom of the maxillary antra to the top of the frontal sinuses, thus avoiding dental amalgam. Technical factors were: 1.0 mm nominal slice width, 120 kV, 75 mAs, and standard reconstruction algorithm with 0.6 mm reconstruction increment. Scans were retrospectively viewed on a workstation in three orthogonal planes, with oblique reconstructions as required to visualise specific anatomy. In addition, a prospective trial was performed on six more patients who gave informed consent for both direct coronal and reconstructed coronal scanning technique. **RESULTS:** Typical acquisition time was 25 s. All scans were of high quality with no patient movement or dental artefact encountered. Sagittal reconstructions identified landmarks of the lateral nasal wall encountered during FESS. Anatomy relating to the frontal recess was particularly well shown and clinical implications of this will be discussed. Axial scans were available to show the relations of the optic nerves and carotid arteries. Irrespective of the reconstructed plane, no significant "stair step" artefact was seen. The volumetric data set can be used for creating virtual endoscopic CT images, examples of which will be shown. A comparison of direct coronal and reconstructed coronal images will be presented. **CONCLUSION:** Volumetric multislice CT scanning of sinuses is simple, quick, patient friendly and reproducible. Computer reconstructions, with excellent image quality, can be performed not only coronally but also in any given plane. Sagittal reconstructions provide useful anatomical information and in particular show detailed imaging of the frontal recess.

**An audit of lumbar puncture procedures following a normal CT scan in patients suspected of having subarachnoid haemorrhage**

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**PURPOSE:** The established guidelines for the early diagnosis of subarachnoid haemorrhage (SAH) state that, following a normal CT scan

a lumbar puncture (LP) should be performed before the diagnosis of SAH can be excluded. This audit examined compliance to these guidelines within our own hospital. **METHOD.** In the period between February 2000 and September 2000, 58 patients suspected of having SAH, as indicated on the request form by the on-call medical team, had a normal CT scan. These patients were identified prospectively by the three consultant neuroradiologists reporting the scans. They were then followed up by a combination of methods to see if they underwent LP. The audit standard was 100% compliance with the above mentioned guidelines. **RESULTS.** In 29 of these 58 patients (50%), LP was performed. However, in the other 50% LP had not been carried out. This group is currently under review. **CONCLUSION:** This audit demonstrated that half of the patients had been managed outside of these guidelines. Our centre, in a teaching hospital, is a tertiary referral centre with both radiological and surgical skills and facilities to treat SAH, yet does not comply with the guidelines. The significance of these findings and their remedy will be discussed.

#### **Spiral CT scanning in the detection and evaluation of vascular lesions of the brain**

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**PURPOSE:** To evaluate the use of spiral CT with three-dimensional (3D) and maximum intensity projection (MIP) reconstructions in studying vascular lesions of the brain, mainly aneurysms and arteriovenous malformations (AVMs). **MATERIALS AND METHODS:** 50 cases (age range 50–70 years) presenting clinically with headache and positive plain CT for subarachnoid bleed were studied for the presence of intracranial aneurysms and AVMs using AV Expander Plus Phillips CT scan equipment. The protocol used was iv injection of 120 ml of iopromide 300 using a power injector at 3 ml s<sup>-1</sup> flow rate and a scan delay of 14 s. The scan acquisition protocol was 3 mm slice thickness, 2 mm table feed and 1 mm reconstructions. 3D and MIP reconstructions were used and the images were rotated through various programs in real-time and studied. **RESULTS:** Of the 50 cases, 30 cases were positive for intracranial aneurysms and 9 cases for AVMs. Of the 11 negative cases, 3 cases were positive for intracranial aneurysms on digital subtraction angiography (DSA). In the remaining eight cases, both spiral CT and DSA were negative for any vascular lesions. A comparison between spiral CT and DSA will be presented. All 33 positive cases of intracranial aneurysms were confirmed at surgery. Of the nine cases of AVM, three underwent surgery, three radiosurgery and three embolisation. **CONCLUSIONS:** MIP and 3D reconstructions were very promising in evaluation and real-time orientation of intracranial vascular lesions, including very small aneurysms of 2 mm in size.

#### **Cerebral metastasis and other cerebral events in women with ovarian cancer**

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**PURPOSE:** There have been several recent reports of unusual late metastatic manifestations of ovarian cancer, with suggestions that cerebral metastasis has also become more common. We determined the incidence, imaging findings and prognostic significance of cerebral metastasis and other cerebral events in women with ovarian cancer. **METHOD:** A 5-year retrospective review of patients under review in two major gynaecological oncology centres was undertaken. Imaging findings and case records of all women who underwent cranial CT and/or MRI were reviewed. **RESULTS:** Of 1221 women under review, 77 underwent cranial imaging and 12 (1%) had cerebral metastasis. CT was diagnostic of parenchymal metastasis in 10 and MRI showed leptomeningeal disease in 2. The women were aged 23–71 years and all had stage III or IV disease at presentation. There was no dominant pathological subtype of ovarian cancer associated with cerebral metastasis. Cerebral metastasis occurred at 6–60 months from initial diagnosis, with death occurring predominantly within 12 months but with 4 survivors at 4–45 months. Of the remaining 65 women, 11 had cerebrovascular events and 3 had unrelated pathologies, including astrocytoma, white matter disease and developmental anomalies. **CONCLUSION:** Cerebral metastasis remains a rare event in women

with ovarian cancer but may be an isolated late event associated with survival beyond a year after neurosurgery and chemoradiotherapy. CT remains a useful first line investigation since as many women with cerebral symptoms will have cerebrovascular accidents as metastases.

#### **Neurosurgical guidance provided by motor functional MRI**

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**INTRODUCTION:** An important aspect of intracerebral tumour resection is post-surgical quality of life. Preservation of motor function is important. Functional MRI (fMRI) may provide a means of identifying eloquent areas of cerebral activation that can be used to guide surgeons in their quest to maximize tumour resection whilst minimizing motor function damage. The aim of this work was to develop and provide an initial assessment of such a technique. **MATERIALS AND METHODS:** 15 patients with frontal/parietal lobe mass lesions underwent fMRI at 1.5 T (Eclipse, Marconi Medical Systems). A single shot echo planar technique (TEff 40 ms, TR 3 s) acquired two functional datasets, one examining right hand and the other left hand movement. The time course of each voxel was correlated with a smoothed square wave representing a model haemodynamic response. Data were used in conjunction with an intra-operative navigation system (BrainLAB) in seven cases. **RESULTS:** Statistically significant "activation" was attributed to primary motor, primary somatosensory or supplementary motor cortex in 13/15 subjects, being adjacent to the tumour margin in 10/13 cases. No permanent changes in motor deficit were detected post surgery (two patients had transient neurodeficit). **DISCUSSION:** The added information provided by fMRI, particularly when these data were incorporated into a neuronavigation-guided craniotomy, was deemed highly valuable to the neurosurgeon, as it enabled safe resection of tumour in anatomical locations previously deemed to be too high risk for safe resection using a conventional (non-fMRI-guided) technique. This observation is reinforced by the fact that no patients suffered permanent neurological deficit after radical tumour debulking (surgical estimates >90% tumour resection).

#### **MRI appearances of dementia**

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**PURPOSE:** Several studies have described the usefulness of high signal changes on MRI in the diagnosis of vascular dementia. These studies have compared the appearances against normal controls. This study compares the appearance of vascular dementia against other common forms of dementia, namely Alzheimer's disease and frontotemporal dementia. **METHODS:** Patients with vascular dementia (VD) (n=31), Alzheimer's disease (AD) (n=49) and frontotemporal dementia (FD) (n=22) were studied. All patients underwent MRI scanning with a Philips 1.5 T magnet. The T<sub>2</sub> axial cuts were assessed using an established scale and compared with age-matched controls (n=9). **RESULTS:** The VD, AD and FD groups had more periventricular hyperintensities and dilated Virchow-Robin spaces compared with the controls (p<0.01). Pairwise comparisons showed a higher incidence and severity of white matter lesions, lacunes and pontine hyperintensities in VD compared with AD (p<0.001); this difference was not significant between the VD and FD groups. Although hyperintensities are most severe in VD, only lacunes are specific for VD (sensitivity 0.32). White matter lesions are most pronounced in VD, but these differences are not absolute. **CONCLUSION:** High signal changes on MRI should be interpreted with caution in dementias. Although helpful, they are not in themselves diagnostic of VD.

#### **Work in Progress**

##### **Clinical utility of nerve root injections**

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**INTRODUCTION:** Therapeutic injection of steroid and local anaesthetic in cervical or lumbar nerve roots has been utilized for a number

of years, with variable clinical success. We have introduced therapeutic and diagnostic nerve root injections at our unit and present our retrospective analysis of the clinical efficacy and diagnostic utility of nerve root sleeve injections. **PATIENTS AND METHODS:** All patients referred for either diagnostic or therapeutic nerve root injections were included. Analysis of technique, location, clinical benefit and impact on clinical decision-making was performed by review of the case notes and radiography. 26 patients with 37 procedures (1–3 per patient) were included, for which there was full clinical follow-up available. Age range was 23–77 years (median age 47.4 years). Injections were performed at C4 (1 patient), C6 (2), C8 (1), L3 (2), L4 (7), L5 (15) and S1 (9). Clinical indications were radiculopathy with: multilevel disease or conflicting MRI findings (12 patients); post-operative recurrence with no surgical lesion on MRI (8); appropriate MRI findings where a non-operative course was preferred (5); and a single case of non-operable painful neurofibroma. **RESULTS:** Where there was therapeutic intent, significant relief occurred in 12/13 (92%). Cervical injections were less efficacious, probably on account of the lower accuracy of needle placement. The result influenced management in all cases when it was used for diagnosis. However, there was some inconsistency as to how the results were interpreted by different clinicians. **CONCLUSIONS:** Nerve root injection is a good therapeutic procedure, but longer follow-up is required. It may help to select the operative level, but differences in interpretation require close scrutiny of post-operative results to ensure appropriate patients and levels are selected for surgery.

## Scientific Session Musculoskeletal (2)

### CT guided injection of sinus tarsi in patients with sinus tarsi syndrome

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**Purpose:** To describe a new technique using CT guided injection in patients with sinus tarsi syndrome, with short- and long-term follow-up. **METHODS:** 25 patients with a clinical diagnosis of sinus tarsi syndrome were referred for CT guided injection, after failed conservative management. Limited coronal 3 mm sections with a 1.5 pitch, using a reverse gantry tilt, were performed through the sinus tarsi with skin markers in place. A 22 G needle was introduced into the apex of the sinus tarsi under CT control. 10 ml 0.5% bupivacaine (Marcaine, Astra) and 10 mg triacinelone (Lederspan, Lederle) were injected into the sinus tarsi. Immediate response and long-term follow-up were recorded. **RESULTS:** 27 feet in 25 patients were treated (9 males, 16 females). The mean age was 43 years (range 19–83 years). There were no complications as a result of treatment. After the initial injection all the patients were asymptomatic thus confirming the diagnosis. Long-term follow-up is available on 11 patients. 18.2% of patients were asymptomatic at 10–27 months. 54.5% of patients were significantly improved at 5–18 months. There was no change in 27.3% of patients at 4–16 months. No patients deteriorated following treatment. **CONCLUSIONS:** CT guided injection of sinus tarsi is a simple, safe and effective treatment for sinus tarsi syndrome.

### Percutaneous CT guided drilling of osteochondral lesions under local anaesthesia

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**PURPOSE:** To describe a new technique of CT guided percutaneous drilling of osteochondral lesions, an alternative to arthroscopic drilling in symptomatic patients with intact overlying cartilage, thus avoiding insult to the hyaline cartilage. **METHODS:** 12 patients with osteochondral lesions, intact overlying cartilage and surrounding bone marrow oedema were identified on MRI (11 male, 1 female; mean age 31.6 years, range 18–55 years). Three patients had arthroscopic confirmation. All patients remained symptomatic despite conservative management. 3 mm sections with a 1.5 pitch were performed from the joint surface to beyond the osteochondral lesion, with skin markers in place. Local anaesthetic was infiltrated into the skin and periosteum. Drilling was performed through the area of bone marrow oedema using a 4.5 mm Temno bone biopsy needle (Bauer) or a 4.5 mm Steinmann pin. Patients were observed for 1 h before mobilization. Pain and function were initially followed-up for 6 months. **RESULTS:** The procedure was tolerated well by all 12 patients. Lesions were sited in the

femoral condyles (4/12), patella (3/12), tibial plateau (1/12), talar dome (3/12) and tibial plafond (1/12). Follow-up was available for 8 out of 12 patients. Pain at 6 months showed improvement in all eight patients, five being asymptomatic. Function scores improved in seven out of eight patients (one unchanged) and four had no disability at 6 months. No patients deteriorated after this treatment. The only complication was fracture of a Temno needle, which was easily recovered. **CONCLUSION:** Percutaneous CT guided drilling of osteochondral lesions is a safe and simple day case procedure with excellent results, offering a viable alternative to arthroscopic drilling.

### Is a lateral view sufficient for patients attending A&E with low back pain?

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**BACKGROUND:** Lumbar spine radiographs are not routinely indicated for acute low back pain (LBP) but are frequently requested by relatively inexperienced junior doctors faced with demanding patients. In most A&E departments the standard lumbar spine series consists of an anteroposterior (AP) and a lateral view. **PURPOSE:** To determine whether the AP view provides additional diagnostic information in patients attending casualty with LBP. **METHODS:** A consultant rheumatologist and a consultant radiologist reviewed the lumbar spine radiographs of 142 patients attending A&E complaining of LBP. Radiographs of patients under 16 years, or in whom there was a suspicion of malignancy, infection or significant trauma, were excluded. The lateral view was assessed first and radiological findings recorded. The AP view was then reviewed and the radiological findings recorded and any additional clinically meaningful diagnostic information was noted. **RESULTS:** Mean age of the patients was 51.5 years (range 16–95 years). 76 (54%) patients were female. 67 (47%) patients had atraumatic acute LBP. 61 (43%) patients had LBP associated with minor trauma and 14 (10%) patients were complaining of chronic LBP. In 141 patients the AP view added no clinically meaningful diagnostic information. In one (0.7%) patient a fractured L4 transverse process was noted on the AP view but did not alter clinical management. There was no disagreement between the reviewers regarding additional diagnostic information. **CONCLUSIONS:** The AP view adds no significant diagnostic information in patients attending A&E with LBP. Using a single lateral view could result in reduced patient irradiation and costs.

### A multicentre randomized comparison of two imaging policies in the management of low back pain

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**PURPOSE:** The aim of The Scottish Back Trial is to determine whether early use of MRI or CT influences clinical management and outcome in patients with low back pain (LBP) and whether it is cost effective. **METHODS:** Patients were recruited from 15 hospitals during the period November 1996–June 1999. Eligible patients were those with symptomatic lumbar spine disorders without “red flags” who had been newly referred to orthopaedic surgeons or neurosurgeons. After obtaining informed consent, patients were randomized to “imaging” (imaging as soon as possible) or “no imaging” (imaging only if an imperative clinical indication developed). Principal outcome measures are the SF-36 general health status questionnaire and the Aberdeen LBP score. Patients complete questionnaires at trial entry and after 8 months and 24 months. Information on health care resource use is collected from hospital case notes. **RESULTS:** Of the 2692 patients assessed, 782 (29%) were recruited and randomized. In the first 8 months of the study, there was no significant difference between the groups in terms of clinical management, with the exception of outpatient appointments. An improvement in health status, as measured by the Aberdeen LBP score, was noted particularly for patients in the “imaging” group. **CONCLUSION:** The intermediate assessment suggests that early use of imaging for LBP patients, for whom there is no clear clinical indication, does not significantly affect their clinical management. The 24-month follow-up will determine whether the marginal improvement in health status for patients in the “imaging” group is sustained over a longer time period. [The Scottish Back Trial is funded by the NHS Research & Development Health Technology Assessment

Programme. The Health Services Research Unit is funded by the Chief Scientist Office of the Scottish Executive Health Department. However, the views expressed are those of The Scottish Back Trial Group.]

#### Scapular fractures in polytrauma—association with spinal injury

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**PURPOSE:** The scapula is rarely injured in trauma, accounting for only 1% of all fractures. Injury is therefore associated with high impact forces and subsequently is commonly linked with injury to other sites, including the skull, chest and brachial plexus. Previous reports have suggested an increased risk of vertebral fractures. The prognosis depends upon the outcome of these associated injuries. **METHODS:** We performed a retrospective study of all patients admitted with scapula fractures between 1990 and 1996 via the Helicopter Emergency Medical Services. **RESULTS:** 51 patients suffered scapular fractures (44 male, 7 female; average age 45 years). Mean ISS was 30 and UKPS 65%. 21 (41.2%) of these 51 patients also had spinal fractures. The majority of these fractures occurred in the thoracic spine but a large proportion affected the cervical and lumbar spine. Of 329 patients sustaining spinal injuries during the same time span, 21 (6.4%) had scapular fractures. **CONCLUSIONS:** There is a marked association between scapular fractures and spinal injuries. When recognized on initial CXR, a scapular fracture warrants plain radiographs of the whole spine followed by further imaging of any abnormal site.

#### Dynamic ultrasound in the evaluation of muscular trauma

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**PURPOSE:** To determine the role of dynamic ultrasound in muscular trauma. **METHODS AND MATERIALS:** 50 male football players (age range 20–30 years) presenting with clinical muscular trauma in the thigh and calf region were evaluated. Dynamic ultrasound of both the affected and the contralateral normal region, using a 7.5 MHz phased array linear transducer in the sagittal, coronal and angulated axes, was performed both without and with contraction of the muscles. Needle aspiration of suspected haematomas was performed for diagnosis and treatment. All muscle tears and haematomas were studied and followed up after 72 h until complete healing. **RESULTS:** 46 of the 50 patients had muscle tears and/or haematomas in the thigh and calf region; 4 patients had no abnormality. 32 patients had clear cut muscle tears appearing as echogenic retracted portions surrounded by haematomas, ranging from a highly reflective mass to complete echo poor areas observed on follow-up. The remaining 14 patients had partial muscle tears. Healed tears appeared as highly reflective scar tissue. **CONCLUSIONS:** Ultrasound is very useful in the diagnosis, management and follow-up of muscle tears and haematomas. Dynamic ultrasound is essential for diagnosis of partial tears.

#### MRI in the diagnosis of osteoid osteoma: strengths and weaknesses

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**PURPOSE:** To study the attributes and limitations of MRI in diagnosing osteoid osteomas. **METHODS:** 49 MRI investigations, performed on 43 patients with osteoid osteomas referred to two orthopaedic centres over an 8-year period, were reviewed retrospectively by two radiologists. Other imaging modalities (plain films, CT) were available and served as a guide in the MRI review. **RESULTS:** 43 osteoid osteomas were identified. There was a wide spectrum of MR appearances of the lesion. The tumour was identified on 70% of sequences performed in the axial plane, 40% in the sagittal plane and 30% in the coronal plane. The osteoid osteoma was identified on 75% of proton density sequences and 50% of  $T_1$  and  $T_2$  weighted sequences. The nidus was present on one slice of the optimal sequence in 32 patients, two slices in 8 patients and three slices in 3 patients. Reactive bone changes were present in 38 patients and soft tissue changes in 43

patients. **CONCLUSIONS:** Reliance on MRI alone may lead to misdiagnosis. The osteoid osteoma may be difficult to identify. Axial images are the most useful, but the abnormality may be limited to a single slice and may have variable signal characteristics. Reactive changes in bone and soft tissue are usually the dominant features and suggest other erroneous diagnoses.

#### Developments in QCT and comparisons with DXA

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**PURPOSE:** To compare 2D and 3D QCT of the spine with the gold standard of bone densitometry, dual energy X-ray absorptiometry (DXA). **METHOD AND MATERIALS:** QCT scans of the spine were obtained in adults (mean age  $\pm$  SD  $61 \pm 12$  years, range 26–84 years) attending the Metabolic Bone Clinic using a Philips SR4000 CT Scanner in conjunction with QCT-Pro 3D QCT software (Mindways Software Inc., San Francisco, CA). All patients had spine DXA (L1–4) using either a pencil beam (Lunar DPX-L) or a fan beam (Hologic 4500 Acclaim) system. A comparison was made between the precision (CV%) of the DXA and QCT measurements. The ability of QCT to identify patients with osteoporosis (DXA lumbar spine  $T$  score  $< 2.5$  (WHO)) was determined. Vertebral fracture discrimination by QCT vs DXA was also assessed. **RESULTS:** The precision of 2D QCT (1.31%) in the lumbar spine is comparable with DXA (1.09% fan beam; 1.57% pencil beam). 3D QCT precision (0.5%, normal; 0.9%, osteoporotic) was superior to DXA. Comparison of  $T$  scores for diagnosis of osteopenic and osteoporotic individuals indicated that the WHO threshold of  $T$  score (2.5) is inappropriate for QCT lumbar spine. A QCT  $T$  score of  $-3.8$  identified the same number of individuals with spinal osteoporosis as defined by DXA. ROC curve analysis showed QCT was the better predictor of vertebral fracture. **CONCLUSIONS:** QCT has greater discrimination for vertebral fractures than DXA, and precision in the spine is similar (2D) or better (3D) than that of DXA.

#### Scientific Session

##### IR(ME)R: the paediatric angle

##### Putting the kids through IRMER

P J Marsden and J Hardwick

*Radiology Department, Great Ormond Street Hospital for Children NHS Trust, London WC1N 3JH, UK*

On October 12th 2000, Great Ormond Street Hospital for Children was subjected to a proactive inspection by the Department of Health IRMER Inspectorate to test for compliance with the Ionising Radiation (Medical Exposure) Regulations 2000. The purpose of this paper is to describe the experience and to illustrate how compliance was demonstrated in some key areas relating to diagnostic X-ray and nuclear medicine procedures in a specialist paediatric hospital. In particular, the presentation will address entitlement to act as practitioner, the authorisation of exposures by operators, the setting of diagnostic reference levels and the development of standard operating protocols. The outcome of the inspection was successful and our aim is to share the successes with interested Trusts. We will also make reference to our perceived weaknesses.

##### IR(ME)R—radiographer practitioner—consent/LMP issues where the patient is under 16 years

D Dewitt, L A Stanney and A R Child

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POPUMET stated that the responsibilities involved in the irradiation of the abdominal region of girls under 16 years of age lay with person “clinically directing”, the referrer and the radiographer. The radiographer would ascertain the likelihood of pregnancy and negotiate with the referrer about whether to proceed, often accepting the medical management of the patient gave the referrer the ultimate authority to decide whether or not to proceed. IR(ME)R makes this course of action unsustainable. IRMER places the responsibility unambiguously on the practitioner, who must decide whether or not the examination is “justified”. If the radiographer is acting as practitioner for an examination, it could be seen as their responsibility to determine the

pregnancy status of a patient before proceeding. This will not normally be a problem, but dealing with "children" who fall into this category can be problematic. What weight should be given to parents' "rights" to be involved in the protection and support of their children, and what should be given to the potentially sexually active "child" who could be entitled to handle this matter and consent on their own. This paper addresses some of the issues, e.g. establishment of "Gillick competence", and how they are handled at this hospital.

#### **How dare you? Establishing pregnancy in children**

P J Marsden, J Hardwick and K Lozhkin

*Radiology Department, Great Ormond Street Hospital for Children, and Medical Physics, UCL Hospitals, London, UK*

The EU Medical Exposures Directive and the consequent Ionising Radiation (Medical Exposure) Regulations 2000 require the establishment, where relevant, of whether the individual to be exposed to ionising radiation is or may be pregnant. Current guidance from the National Radiological Protection Board recommends that, for diagnostic radiology, this should apply to females of reproductive capacity presenting for a nuclear medicine procedure or for a radiographic examination where the primary beam will irradiate the abdomen or pelvis. In practice, this requires radiographers to ask females over the age of 12 years whether they may be pregnant. This is a difficult question to ask a child, particularly in the presence of accompanying parents, and can be upsetting for all concerned. This presentation highlights the difficulties faced by all radiology departments who have children as part of their workload. Following discussions during a proactive IRMER inspection at Great Ormond Street Hospital, we propose a way forward. We have calculated potential fetal doses for a range of paediatric examinations by applying Monte-Carlo techniques to our standard operating protocols and diagnostic reference levels. Taking into account current risk estimates for such exposures, we propose that the number of examinations for which pregnancy needs to be established may be refined. We conclude with suggestions for a national consensus on this issue, which will raise awareness and may go some way towards reducing the difficulties experienced in many radiology departments.

#### **The establishment and impact of diagnostic reference levels in paediatric radiography**

P J Marsden, J Hardwick, P Mashford, C Mencik and C McLaren

*Radiology Department, Great Ormond Street Hospital, London WC1N 3JH, UK*

Following the requirements of the Ionising Radiation (Medical Exposure) Regulations 2000, we have established diagnostic reference levels (DRLs) for paediatric radiology. For general radiography, these have been set in terms of delivered exposure parameters for a variety of age bands, and are related to published entrance surface dose values via calculations based on output measurements during quality assurance. For more complex procedures involving fluoroscopy, DRLs are presented as dose-area product values. We describe the process of establishing and reviewing DRLs as applied to a paediatric radiology department using a CR imaging system. An assessment is made of the usefulness of DRLs as an audit tool for equipment standards, professional technique and dose reduction.

#### **Radiation doses and radiation protection for neonates in a special care baby unit**

C I Armpilla, I A J Fife and P L Croasdale

*Medical Physics Department, Royal Free Hospital, London NW3 2QG, UK*

**PURPOSE:** Radiographs are most commonly taken in the neonatal period to assist in the diagnosis and management of respiratory difficulties. Frequent accurate radiographic assessment is required, and a knowledge of the radiation dose is necessary to justify such exposures. The aim of this study is to establish the radiation dose from neonatal radiographic examinations. **MATERIALS AND METHODS:** A survey of radiation doses to neonates from diagnostic radiographic examinations (chest and abdomen) has been carried out in the special care baby unit of the Royal Free Hospital. Entrance surface dose (ESD) was calculated from quality control measurements on the X-ray set itself. Direct measurement of radiation doses was also performed using highly sensitive LiF:Mg,Cu,P thermoluminescent dosimeters (TLDs),

calibrated and tested for consistency in sensitivity. **RESULTS AND CONCLUSION:** ESDs calculated from exposure parameters were found to range from 28  $\mu\text{Gy}$  to 58  $\mu\text{Gy}$ , with a mean ESD per radiograph of 36  $\mu\text{Gy}$  (standard deviation 6  $\mu\text{Gy}$ ) averaged over 95 examinations. ESDs derived from the TLD crystals ranged from 18  $\mu\text{Gy}$  to 32  $\mu\text{Gy}$  for 30 radiographic examinations. The mean energy imparted and the mean whole body dose per radiograph were estimated to be 14  $\mu\text{J}$  and 10  $\mu\text{Gy}$ , respectively. Assuming that neonates and fetuses are equally susceptible to carcinogenic effects of radiation (it involves an overestimation of risk), the radiation risk of childhood cancer from a single radiograph was estimated to be of the order  $(0.3-1.3) \times 10^{-6}$ . Radiation doses compared favourably with the reference ESD value of 80  $\mu\text{Gy}$  published by the CEC in 1996.

#### **Evaluation of image acquisition in digital radiography in a paediatric environment**

K E Borthwick

*Out-Patient X-Ray, Grampian University Hospital Trust, Aberdeen AB25 2XG, UK*

The aim of this work is to evaluate the different methods of digital image acquisition available for general radiography in paediatric radiology departments. In particular, this study examines computed radiography (CR) and direct digital radiography, with special reference to possible dose reduction and image quality. To establish a basis for the research, a search of the current published literature was conducted. However, the initial search relating specifically to paediatrics proved disappointing and a further search to include literature specific to adults was conducted. A questionnaire was then designed to ascertain the availability of CR in departments with paediatric patients. Hospitals were selected from the current NHS yearbook to provide a sample including the major hospital types, i.e. university teaching hospitals, district general hospitals and children's hospitals. Analysis of the results has demonstrated an increasing availability of CR, and that the technology is primarily in university teaching hospitals, with limited availability in children's hospitals. Further review of the data is in progress. The results will provide a starting point for the second part of the study. This is planned to be a practical evaluation of the different modalities using radiographic phantoms to examine the relationship between dose and image quality. It is anticipated that on completion, this work will provide a useful guide for departments looking to invest in digital technology. [This work received the Kodak Professional Development Award for Radiographers 2000, and the support of Kodak is gratefully acknowledged.]

### **Scientific Session**

#### **Skills Mix**

##### **Not just a pair of hands: the changing role of the RDA**

A M K Thomas and M D Rodrigues

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When daylight processing was introduced, the darkroom technicians in radiology departments had to change their role. They took on tasks such as clerical work and helping with ultrasound examinations. They were given no formal training. More recently, there has been a re-assessment of roles in radiology departments with the introduction of skill mix changes. Pressure on staff time resulted in further re-assessment of the role of the radiology department assistant (RDA), stimulated by the difficulty of recruitment of both radiologists and radiographers. We have recently appointed RDAs to the department and received many good applicants. We were looking for good communication skills, a mature attitude and a flexible approach to work; we were less interested in formal qualifications. The new RDAs have proven to interact well both with patients and with staff. Initial concerns about erosion of the position of the radiographer have proven unfounded. It was decided to take the RDAs down a formal training route to obtain an NVQ in Care level 3 with a diagnostic imaging module. Several of the radiographers involved with the RDAs were sent on an assessment course. Radiographers and radiologists have been involved in tutorials and informal teaching. The radiographers have benefited from the process and it has counted towards their CPD activity. There is some cross-over in training with the health care assistants, and some of the training is shared. These developments have benefited both the staff and patients of the imaging department.

### **Evaluation of angiography performed by nurses and radiographers**

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*Radiology Department, Manchester Royal Infirmary,  
Manchester M13 9WL, UK*

**PURPOSE:** To evaluate outpatient angiography performed by nurses and radiographers. **METHODS:** A protocol for outpatient angiography performed by nurses and radiographers was drawn up and approved by the Trust's Risk Management Committee. Following training, two experienced radiographers and one nurse undertook elective peripheral or renal angiography on 206 patients. Angiograms were performed using a 3 F catheter introduced into the abdominal aorta from a femoral approach. Patients were discharged after 2 h and contacted by telephone the following morning. Records of screening time, radiation dose and number of angiographic runs were compared with those of consultant and trainee radiologists over the same period. **RESULTS:** No patient refused consent for the procedure. 191 patients underwent successful catheterization without assistance from a radiologist. Radiologist assistance was required in 15 (7.3%) cases, mostly in the first few weeks. Images were considered diagnostic in all but one case who returned for further views and pressure measurements owing to an aortic stenosis of questionable significance. There were no complications requiring further management. There were no significant differences in screening time, radiation dose or number of angiographic runs between the nurse/radiographers and the consultant or trainee radiologists. **CONCLUSIONS:** Outpatient angiography can be performed reliably by nurses and radiographers. This is safe and acceptable to patients.

### **Role development: radiographer barium swallows and meals**

J E Houghton and S A Gresty  
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CH2 1UL, UK*

Following the undoubted success of radiographer barium enemas, skill mix was further developed with radiographer barium swallows and meals. Owing to a lack of formal training centres, in-house training was given following the development of a standard protocol resulting from the varied techniques of all the radiologists, studied by a senior radiographer with 5 years experience of performing barium enemas. Combined lists were performed by the senior radiographer and a lead gastrointestinal radiologist until the former acquired sufficient confidence to perform unsupervised lists, with ensured radiological cover, followed by double reporting. The purpose of the study was to meet the increasing demands of upper gastrointestinal fluoroscopy, to address the lack of available radiologist time and to develop the role of radiographers. This resulted in a better quality service, eliminated the waiting list, enhanced skill mix, standardized practice and protocols, improved teaching of trainee radiologists, acted as a platform for further role development, e.g. sialography, sinograms, screening of diaphragms and venography, freed up radiologists for other work and gave involvement at multidisciplinary gastrointestinal meetings. Disadvantages were increased demands on hard-pressed radiographers, possible de-skilling of radiologists and extra work requiring extra funding. Future requirements are: (1) formal theoretical teaching courses; (2) regular update courses and audit, as with radiographer barium enemas; and (3) increased numbers of radiographers.

### **Are radiographer-performed barium enemas as good as radiologists'?**

P G Kember, T Hutchinson and T Simpson  
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UK*

**PURPOSE:** Until recently, barium enemas were performed exclusively by radiologists. In many radiology departments they are now increasingly being performed by radiographers, and then double-reported with a radiologist. The ability of such studies in demonstrating colonic abnormality is largely dependent on their quality. Work published to date has looked at pick-up rates for colonic cancer in radiographer-performed enemas and compared them with colonoscopy, or has compared radiation doses and screening times between radiographer- and radiologist-performed studies. This study compares the actual quality of examinations performed by the two groups. **METHODS:** The four overcouch films (supine anteroposterior, prone angled down, and two lateral decubiti) from 100 barium enemas were reviewed

retrospectively. Half of the studies were performed by one of two radiographers who have been performing enemas for 3 and 4 years, respectively. The other half were performed by one of seven consultant radiologists. Each study was graded blindly by a single observer (PGK) on three separate criteria: quantity of barium, mucosal coating and degree of colonic distension. Screening times and doses were subsequently compared. **RESULTS:** In all three criteria categories, the radiographer-performed studies scored higher than the radiologists', although the difference was not statistically significant. In agreement with previously published work, screening times and doses for the radiographer-performed studies exceeded those of the radiologists', but the doses were still well within the NRPB standards. **CONCLUSION:** Radiographers are not only able to perform barium enemas as well as radiologists, but may actually be better at it.

### **Radiographer reporting of barium enemas**

C Bloor, R Farrow and G F Maskell  
*Department of Clinical Imaging, Royal Cornwall Hospitals  
Trust, Truro TR1 3LJ, UK*

**PURPOSE:** To evaluate a system of double reporting of barium enema examinations (DCBEs) by a gastrointestinal (GI) radiologist and a GI radiographer. **METHOD:** A radiographer underwent a targeted training programme in DCBE interpretation. On completion of the training programme, 169 DCBEs were prospectively selected for double reporting. The images were independently reviewed by the radiographer and one of two GI radiologists. If there was a discrepancy, the films were independently read by the second GI radiologist. **RESULTS:** There was complete agreement between the radiographer and radiologist in 147 (87%) cases. There was disagreement between the radiographer and radiologist in 22 (13%) cases, which were then interpreted by the third reader. In 12 (7%) cases the third reader agreed with the radiologist and in 5 (3%) cases the third reader agreed with the radiographer. In 5 (3%) cases all three readers disagreed. In three cases the radiographer considered views of the right colon to be non-diagnostic, but the radiologists reported normal findings. In one case considered to be normal by the radiographer, the radiologists raised the possibility of an abnormality at the caecal pole. No abnormality was found at colonoscopy. The remaining discrepancies all related to the presence or significance of small filling defects. There were no cancers or polyps larger than 8 mm detected by the radiologists but missed by the radiographer. **CONCLUSION:** A suitably trained GI specialist radiographer can make a valuable contribution to the reporting of DCBEs.

### **Assessment of radiographer interpretation and performance of barium enemas**

P Dowle, C Searle, C Horrill, B Fox and S Jackson  
*Imaging Directorate, Derriford Hospital, Plymouth PL6 8DH, UK*

**PURPOSE:** Three trained radiographers currently perform barium enema examinations at Derriford Hospital. Data from these examinations are recorded on a dedicated form, which includes space for the radiographer to provide an initial interpretation. The final report is issued by a consultant radiologist. This study was designed to prospectively assess radiographer fluoroscopy times, radiation dose and technique (overall colonic demonstration). In addition, assessment was made of the accuracy of radiographer's initial interpretation. **METHOD:** 150 radiographer barium enema studies were assessed by two consultant gastrointestinal radiologists. Information was recorded on fluoroscopy time, radiation dose and adequate completion of the form. The films were assessed for overall colonic demonstration as well as accuracy of radiographer's initial interpretation compared with the final issued report. Differences in assessment of colonic demonstration were resolved between the radiologists by consensus. **RESULTS:** The radiographer form was completed in 96% of the studies. 80% of examinations had a recorded fluoroscopy time of less than 3.5 min (mean 2.8 min). 93% of examinations recorded a radiation dosage of less than 4000 cGy cm<sup>2</sup>. Overall colonic demonstration was assessed by consensus as good or better in 97% of studies. The initial radiographer report agreed with the final report in 83% (124) of examinations. A false negative radiographer report was issued in 4% (6) of studies. **CONCLUSIONS:** Radiographers can perform high quality barium enema examinations with acceptable fluoroscopy times and doses. An initial interpretation recorded by appropriately trained radiographers provides valuable information for double reporting of examinations.

**Radiographer endoscopy: training and initial experience**

C Bloor, R Farrow, G F Maskell, H R Dalton, S H Hussaini and D F Levine

*Department of Clinical Imaging, Royal Cornwall Hospitals Trust, Truro TR1 3LJ, UK*

**PURPOSE:** To design, pilot and evaluate a training and assessment programme for a gastrointestinal specialist radiographer to perform flexible sigmoidoscopy (F/Sig). **METHODS:** A radiographer with 5 years experience of performing barium enemas (DCBEs) was selected and underwent a staged training programme, starting with observation of F/Sig, progressing to withdrawal of the endoscope, and then performing full F/Sig. After training and a formal assessment, the radiographer was able to practise independently. After 6 months of independent practice the assessment was repeated, followed by a personal appraisal. The quality of F/Sig was assessed by a retrospective analysis of depth of insertion in the first 100 independently performed examinations. DCBE was used to validate the results of F/Sig in 39 examinations. **RESULTS:** During the training programme the radiographer undertook 25 observations, 40 withdrawals and 85 full procedures, followed by a formal assessment. Retrospective evaluation of the first 100 independently performed examinations revealed that insertion was carried out to the descending colon in 67 patients, the proximal sigmoid in 22 patients and the distal sigmoid in 11 patients. In 29/39 (74%) cases there was complete agreement between the findings of F/Sig and DCBE. In 8/39 (21%) cases with normal F/Sig, DCBE showed minor abnormalities (7 diverticulosis, 1 small polyp). F/Sig showed a <5 mm polyp in 2 (5%) cases with normal DCBE. There were no complications. **CONCLUSION:** With suitable training, specialist gastrointestinal radiographers can extend their role to perform safe and effective F/sig.

**Interobserver variation: a challenge for skill mix**

H Lloyd, M Bolger and I Roberts

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**INTRODUCTION:** Delegation is made more difficult if the task has acknowledged interobserver variation. We present our experience of training radiographers in bone age assessment. **METHOD:** Radiographers have taken over departmental responsibility for bone age assessment by the method of Tanner and Whitehouse. The observer scores a film on a total of 20 criteria, and a numeric score is used to assign bone age. Interobserver error varies with observer experience and can be as much as 18 months. All films were double-read by a radiographer and a radiologist over a 3-month period. All discrepancies were resolved by consensus. Consensus discussions identified sources of variability and helped to develop strategies to standardize film scoring. **RESULTS:** Initial variability was in line with published studies and gave discrepancies of up to 1.6 years. Variability is significantly reduced after 3 months ( $p < 0.05$ ) and probably already matches that which existed before radiographer reporting. Furthermore, radiographers are well placed to judge quality control issues such as positioning. Double-reading will continue for all patients where the bone age estimation differs from chronological age by more than a year, or when clinicians indicate that the results carry significant implications for treatment. **DISCUSSION:** Interoperator variability is a challenge in delegation but can be managed successfully if anticipated. It also provides a good opportunity for audit.

**Scientific Session****Computer-aided Diagnosis****Generation of realistic synthetic spiculated lesions for training in mammography**

S J Caulkin, S M Astley and C R M Boggis

*Department of Imaging Science and Biomedical Engineering, University of Manchester, Manchester M13 9PT, UK*

**PURPOSE:** We have developed a new computer-based method for generating large numbers of different, realistic, spiculated lesions in mammograms. These lesions are superimposed on normal digital mammograms and may then be used to train radiologists to search the films effectively. **METHODS:** Our method involves gathering statistical information regarding lesion and spicule properties from a training set of 57 digitized spiculated lesions, which are a consecutive sequence of such lesions found during routine screening. Size, shape and patterns

of brightness within lesions are modelled, as are spicule properties such as curvature, orientation and length. The information is encapsulated in statistical shape and appearance models from which new examples can be generated. Each new synthetic lesion is unique, but is consistent with those in the training set. Since the contribution to the appearance of lesions owing to underlying tissue was estimated and removed prior to modelling, generated lesions may simply be superimposed on normal mammograms. **RESULTS:** Examples of real and synthetic lesions are presented for comparison. We have found that the majority of synthetic lesions are indistinguishable from real lesions. The factor affecting realism most is the position in which a synthetic lesion is placed within a normal mammogram, particularly with respect to underlying breast structure. **CONCLUSIONS:** We have developed a successful method for modelling spiculated lesions in mammograms. Lesions generated from our statistical model are sufficiently realistic to use in computer-based learning systems for training in mammography.

**Computer-aided mammography: evaluation of a commercial prompting system**

S Tomkinson, S Astley, C R M Boggis and K Walker

*South Manchester University Hospitals Trust, Manchester M20 0PT, UK*

**PURPOSE:** There is evidence that prompting systems, which automatically detect and attract attention to potential abnormalities on mammograms, can improve the detection performance of radiologists, providing that the prompts are sufficiently accurate. The purpose of the study was to evaluate the performance (sensitivity, specificity and reproducibility) of a commercial prompting system (Second Look™) using data that closely emulates the National Health Service Breast Screening Programme. **METHODS:** 106 unequivocally normal consecutive screening cases and 118 biopsy-proven malignant cases were processed through Second Look™. To assess reproducibility, 2-view cases were processed four times. **RESULTS:** The system produced 1.45 false positive prompts per film for unequivocally normal cases and 1.25 false positive prompts per film for malignant cases. The sensitivity was 75.4% per cancer case and 63.5% for each malignant abnormality, with false positive prompt rates being approximately three times the true positive prompt rates. Reproducibility for the 2-view cases was 73.5% per cancer. **CONCLUSION:** At present, the performance of Second Look™ is unlikely to lead to a significant improvement in detection performance. The system demonstrates high sensitivity (92.1%) only when a prompted malignancy is detected on both views. Further research is necessary to determine the impact of the system on radiologists' performance.

**Computer-aided detection of breast cancer in routine clinical practice**

K Walker, S Astley, C R M Boggis and D Comerford

*South Manchester University Hospitals Trust, The Nightingale Centre, Nell Lane, Manchester M20 0PT, UK*

**PURPOSE:** Computer-aided detection systems are designed to detect and direct attention to abnormalities in mammograms. Two such systems are now available, but their impact on detection performance in the context of the NHS Breast Screening Programme is still largely unknown. Our aim was to investigate the feasibility of using a commercial system (SecondLook™) in routine clinical practice. **METHODS:** Our trial, involving three radiologists and a radiographer, ran for 4 weeks alongside normal screening at a centre that screens approximately 900 women per week. Each week, one day's screening films were read by two readers with the aid of SecondLook, whilst another day's films were read by two readers unprompted. In all, 1581 cases were reviewed. Readers' assessments were compared with those of at least one other experienced breast radiologist as well as the results from the follow-up clinic. **RESULTS:** The effect on readers' detection performance is consistent with published data. Reading with the aid of prompts slowed our readers by approximately 35%. At present, a single SecondLook system is unable to cope with the throughput of films required by a large screening centre, since it can only process 15 1-view or 9 2-view cases per hour. **CONCLUSIONS:** To achieve a statistically significant improvement in detection performance, computer-aided detection systems must be both highly sensitive and specific. Throughput may remain a significant issue in the implementation of computer-aided interpretation in the national breast screening programme.

### Image normalization

<sup>1</sup>A Horwood, <sup>1</sup>J Hogan and <sup>2</sup>P Goddard  
<sup>1</sup>Bristol University and <sup>2</sup>Bristol Royal Infirmary, Bristol  
BS2 8HW, UK

A computer algorithm capable of differentiating healthy from abnormal lung tissue in CT scans requires an input of consistent grey scale data across all images. Experience shows, however, that irregularities in the match of tissue density and corresponding modal distribution are common in such data. A method of normalization is suggested to minimize the problem. Basically, selected image features are used as a guide for adjusting the brightness parameter to a common standard. The normalized data can then be entered into computer programs for computer-assisted diagnosis (CAD).

### Computer-assisted diagnosis of CT pulmonary images

<sup>1</sup>A Horwood, <sup>1</sup>J Hogan and <sup>2</sup>P Goddard  
<sup>1</sup>Bristol University and <sup>2</sup>Bristol Royal Infirmary and UWE,  
Bristol BS2 8HW, UK

The sensitivity of CT to small density differences in lung parenchyma suggests that deviations from expected grey scale values in image data might make good indices of disease. Tissue density is decreased below the healthy norm for a given location by lesions involving residual air pockets beyond the terminal bronchioles, and is increased by fibrosis. As such conditions often occur together, average density cannot be used as a discriminator. A set of three "panning" windows are devised, one to "see" only a range of darker pixels, another the "normal" ones and the third the unnaturally light ones. Each resulting segmented pattern is quantified in terms of intensity and fractal dimension, the latter to characterize pixel distribution within the pattern.

### Image data fusion to support breast triple assessment

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N Moore, R English, P J Clarke and C Hardingham  
Departments of Radiology, Surgery and Engineering Science,  
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Breast cancer diagnosis and treatment in the UK and elsewhere is based on a "triple assessment", which is a systematic collaboration of clinicians, radiologists, surgeons and histopathologists who have available the results of clinical breast examination, imaging and fine needle aspiration cytology. Inherent to this approach is the use of many different imaging modalities, such as mammography for screening and biopsy, contrast enhanced MRI for diagnosis and surgical staging, and ultrasound for biopsy and lesion detection. In a typical clinical environment, implementation of triple assessment involves a range of clinical experts with different degrees of competency in the various imaging techniques. As a consequence, there is a need for information sharing and the comparison of breast pathological indicators between modalities in a consistent and expertise-independent fashion. Clinical decision-makers want to be able to combine, or fuse, information from the various imaging modalities despite the considerable variation in representation of the breast and breast cancer in each case. Additionally, image data fusion has the potential to assist early diagnosis and treatment of breast cancer. To realize a clinically useful system to support triple assessment, we have implemented a wide range of component modules, including temporal mammography registration (matching), 2D-3D data fusion between mammography/MRI and 3D MRI registration for chemotherapy assessment.

### Workshop

#### Breast Imaging Mammography

Invited Review  
Difficult calcifications  
S J Vinnicombe

Department of Imaging, St Bartholomew's Hospital, West  
Smithfield, London EC1A 7BE, UK

Invited Review  
Difficult tumours

S McWilliams  
Department of Radiology, Guy's Hospital, Guy's & St Thomas'  
NHS Trust, London SE1 9RT, UK

### British Institute of Radiology Kodak Mayneord Memorial Lecture Eponymous Lecture

The impact of new technologies on radiological practice

E Zerhouni

Russell H Morgan Department of Radiology and Radiological  
Sciences, Johns Hopkins Medical Centre, Baltimore, MD  
21287-0842, USA

Emerging technologies have had a profound impact on medical imaging over the past 20 years. New modalities have made diagnosis of overt clinical disease a simple and ubiquitous task in the care process of virtually every patient. Newer advances in computing power and image analysis, and better image acquisition methods are likely to move the field further in the future. Detection of subclinical disease, image guided innovative forms of therapy, expansion of imaging as a research tool in the post-genomic era most particularly as it relates to *in vivo* molecular events not accessible *in vitro*, and the growing role of imaging to assess effectiveness of therapy will change the landscape of radiology. Examples of recent developments supporting such a potential evolution will be presented and discussed.

### Advances

#### Radiology and the Internet

Invited Review

Research and the Internet

D J Lomas

Radiology Department, Box 219, University of Cambridge,  
Cambridge CB2 2QP, UK

Invited Review

Education and the Internet

A Downie

Department of Radiology, Victoria Infirmary, Glasgow  
G42 9TY, UK

Invited Review

Frustrations and hiccups—a tale of two  
technologies: does the Internet have a place in  
diagnostic imaging?

M Tattlow

Division of Professions Allied to Medicine, Faculty of Health  
Sciences, South Bank University, London SE1 0AA, UK

### Hot Topics

#### MRCP: GI stenting

Invited Review

Endoscopic ultrasound

W R Lees

Imaging Department, The Middlesex Hospital, Mortimer  
Street, London W1N 8AA, UK

Invited Review

Gastrointestinal stenting—new developments

A F Watkinson

c/o X-ray Department, Royal Free Hospital, Pond Street,  
Hampstead, London NW2 2QG, UK

### Advances

#### Contemporary Neuroimaging Techniques: clinical indications and impact on service provision

Invited Review

Diffusion weighted imaging

D Jones

Department of Radiology, Leicester Royal Infirmary NHS  
Trust, Leicester LE2 2RD, UK

**Invited Review**

**Mapping cerebral blood flow with MRI: techniques and applications**

F Zelaya

*Neuroimaging Research Group, Institute of Psychiatry, De Crespigny Park, Denmark Hill, London SE5 8AF, UK*

**Invited Review**

**Seeing is believing: clinical applications of contemporary neuroimaging techniques**

V W K Ng

*Neuroimaging Research Group, Institute of Psychiatry, De Crespigny Park, Denmark Hill, London SE5 8AF, UK*

**Debate**

**MR Arthrography**

**Invited Review**

**MR arthrography**

V Pullicino

*Department of Radiology, RJAH Orthopaedic Hospital, Oswestry, Shropshire SY10 7AG, UK*

**Invited Review**

**MR arthrography**

J Beltran

*Department of Radiology, Maimonides, 4802 Tenth Avenue, Brooklyn, New York, NY 11219, USA*

**Debate**

**Advances in Breast Imaging**

**Invited Review**

**Stereotactic-guided breast procedures—a case for skill mix**

S Trask

*Dorset Breast Screening Unit, Shaftesbury Road, Poole, Dorset BH15 2NT, UK*

**Invited Review**

**Digital imaging of the breast**

R Roberts

*Manchester Breast Screening Unit, Nightingale Centre, Withington Hospital, Manchester M20 0PT, UK*

**Nurses Symposium**

**Legal limits for radiographers and nurses**

**Patient sedation**

**Patient consent**

L Pearson

*Southampton General Hospital, Southampton, UK*

**Skill mix insertion of central lines**

S Taylor

*Royal Preston Hospital, Preston, UK*

**Debate**

**Ultrasound Screening for Ovarian Cancer**

**Invited Review**

**Screening for ovarian cancer—a client perspective**

S Miles

*Touchwood, The Square, Herstmonceux, Sussex BN27 4LD, UK*

**Invited Review**

**Ovarian cancer screening—the science and logistics**

K Sibley

*Gynaecology Research Unit, St Bartholomew's Hospital, West Smithfield, London EC1A 7BE, UK*

**Advances**

**Developments in the Physics of Ultrasound**

**Invited Review**

**Recent advances in ultrasound technology—imaging**

K Martin

*Department of Radiology, Leicester Royal Infirmary NHS Trust, Leicester LE2 2RD, UK*

**Invited Review**

**Recent advances in ultrasound technology—Doppler and related techniques**

P Hoskins

*Department of Radiology, Edinburgh Royal Infirmary, Lauriston Place, Edinburgh EH3 9YW, UK*

**Advances**

**Advances in Ultrasound**

**Invited Review**

**Tumour studies**

D O Cosgrove

*Hammersmith Hospital NHS Trust, Du Cane Road, London W12 0HS, UK*

**Invited Review**

**Functional studies**

M Blomley

*Department of Radiology, Hammersmith Hospital NHS Trust, Du Cane Road, London W12 0HS, UK*

**Refresher Course**

**MRI of Liver Tumours: is enhancement necessary?**

**Invited Review**

**Role of unenhanced and gadolinium enhanced MRI vs CT**

J Olliff

*Department of Radiology, Queen Elizabeth Hospital, Edgbaston, Birmingham B15 2TH, UK*

**Invited Review**

**The role of MnDPDP contrast agents**

J Healy

*Department of Radiology, Chelsea & Westminster Hospital, 369 Fulham Road, London SW10 9NH, UK*

**Invited Review**

**Role of SPI0 contrast agents**

A Padhani

*The Paul Strickland Scanner Centre, Mount Vernon Hospital, Rickmansworth Road, Northwood HA6 2RN, UK*

**Refresher Course**

**Anatomy and Pathology of the Skull Base and Parasellar Region**

**Invited Review**

**Anatomy and common pathology of the skull base**

N M Antoun

*Radiology Department, Addenbrooke's Hospital NHS Trust, Hills Road, Cambridge CB2 2QQ, UK*

**Invited Review**

**Anatomy and common pathology of the skull base**  
P Anslow  
*Neuroradiology Department, Radcliffe Infirmary NHS Trust,  
Woodstock Road, Oxford OX2 6HE, UK*

**Invited Review**

**Anatomy of the parasellar region and the techniques  
that demonstrate it**  
D Hadley  
*Institute of Neurological Sciences, Southern General Hospital,  
1345 Govan Road, Glasgow G51 4TF, UK*

**Refresher Course**

**Diagnostic Dilemmas**

**Invited Review**

**Bone marrow imaging**  
R W Whitehouse  
*Department of Clinical Radiology, Manchester Royal Infirmary,  
Oxford Road, Manchester M13 9WL, UK*

**Invited Review**

**Imaging soft tissue masses**  
M Davies  
*MRI Centre, Royal Orthopaedic Hospital, The Woodlands,  
Bristol Road South, Birmingham B31 2AP, UK*

**Invited Review**

**Synovial disease**  
I Watt  
*Department of Radiology, Bristol Royal Infirmary, Marlborough  
Road, Bristol BS2 8HW, UK*

**State of the Art Symposium**

**Reading and Reporting Mammograms:  
patient support and the role of the  
radiographer**

**Invited Review**

**Developing the radiographer as an advanced  
practitioner for mammography**  
P J Pearce  
*Jarvis Breast Screening Centre, Stoughton Road, Guildford  
GU1 1LJ, UK*

**Invited Review**

**Supporting the patient with breast cancer**  
E Smith  
*South West London Breast Screening Service, Duchess of  
Kent Unit, 205 Blackshaw Road, London SW17 0BZ, UK*

**Refresher Course**

**Transvaginal Ultrasound: techniques to  
chaperone or not**

**Invited Review**

**Techniques to practice in transvaginal ultrasound**  
F Pocock  
*Division of Professions Allied to Medicine, South Bank  
University, 103 Borough Road, London SE1 0AA, UK*

**Invited Review**

**Transvaginal ultrasound and issues related to  
chaperonage**  
N Thomson  
*Ultrasound Department, Colchester General Hospital,  
Colchester CO4 5JL, UK*

**State of the Art Symposium**

**Developments in Mammographic  
Imaging Technology**

**Invited Review**

**Digital mammography**  
A Workman  
*Department of Medical Physics, Forster Green Hospital,  
Belfast BT8 4HD, UK*

**Invited Review**

**Phase contrast mammography**  
C J Kotre  
*Regional Medical Physics Department, Newcastle General  
Hospital, Westgate Road, Newcastle upon Tyne NE4 6BE, UK*

**Invited Review**

**Ultrasound and mammography**  
J A Evans  
*Leeds General Infirmary, Great George Street, Leeds  
LS1 3EX, UK*

**Invited Review**

**MRI in mammography**  
M O Leach  
*CRC Clinical Magnetic Resonance Research Group, Institute  
of Cancer Research, Downs Road, Sutton, Surrey SM2 5PT, UK*

# Posters

## General

### **A pictorial review of local and distant complications of intravenous drug abuse**

<sup>1</sup>J Evans, <sup>1</sup>R Hanlon, <sup>1</sup>E O'Grady, <sup>2</sup>N J Beeching, <sup>1</sup>J Curtis and <sup>1</sup>F A Smethurst

<sup>1</sup>Radiology Department and <sup>2</sup>Infectious Diseases Unit, University Hospital Aintree, Liverpool L9 7AL, UK

The abuse of drugs by injection leads to complications related to the injection site itself as well as to more distant complications. As a large University Teaching Hospital with an active Infectious Diseases Unit, we have extensive experience in imaging these complications. We illustrate the radiographic, vascular radiology, CT and MRI features of these complications, with particular reference to infective and vascular complications.

### **Participatory learning in radiology: creating a climate for learning**

I F Roberts

Department of Radiology, Sheffield Children's Hospital, Sheffield S10 2TH, UK

**INTRODUCTION:** Are you "a sage on the stage" or "a guide on the side"? The objective of this poster is to encourage participatory learning in radiology. Readers are asked to consider a number of challenges that face teaching in radiology, and are encouraged to include participation in their daily routine. Why is teaching about the only thing we are allowed to do without any formal training, sharing of ideas or audit of practice? **LEARNING STYLES:** Kolb's learning styles are described. Readers will be asked to explore their own learning style through a questionnaire and are then encouraged to recognize the diversity of learning styles among colleagues and students. **TEACHING STYLES:** Participatory learning means a change for most of us. Readers are encouraged to compare their radiology teaching with how they might teach a learner driver. **FILM VIEWING:** Questions are a crucial part of teaching but receive scant attention. A typical teaching image will be used to illustrate the number of questions that might be generated in teaching. Readers will look at the order in which they arise and how this might promote or frustrate learning. **LECTURES:** "A means of transferring information from the notes of the lecturer to those of the student without passing through the mind of either". The ever increasing demands on trainees deserve new initiatives. Lesson plans are described with an emphasis on student participation. **SUMMARY:** Four exercises in participatory learning are used to illustrate and encourage its use.

### **Use of an active filter to aid medical Internet search**

A McCulloch, C Burgess, S Khan, P Davison and M R Rees  
University Department of Radiology, University of Bristol, Bristol, UK

**BACKGROUND:** A filtering agent was developed to facilitate searching of the Internet for medical and radiological topics. It was developed as a result of research by our department that showed that radiologists searching for information on the Internet spent considerable time on sites that were not relevant or functional, or were used as advertising. **METHODS:** The filtering agent was used to search for topics on cardiac disease and renal stones. This was compared with searching for the same topics by radiologists with experience of Internet use. Search time was half an hour. **RESULTS:** The active filter produced sites excluding advertising, patient-based sites and "dead sites", by screening sites against a pre-set dictionary. The three radiologists produced hits ranging from 0–16 320. Of the sites produced by the active filter on a renal topic, 30% were identified as possible veterinary or alternative medicine sites, and 50–70% were deemed useful and relevant to the topic. Of the sites identified by the radiologists, the majority were not relevant. Search engines that produced few sites had low relevance (0–15% relevance). Search engines that produced a large number of sites could not be assessed, but the highest ranked sites produced by these engines also had a low relevance. Therefore, the active filter considerably reduced the time wasted on searching the Internet for relevant medical information. **CONCLUSIONS:** An

active filter considerably increased the efficiency of Internet search for relevant medical information and could provide a method for obtaining relevant full papers from the Internet.

### **Plain radiography of the lumbosacral spine: a preliminary study comparing AP and PA radiography**

J Jones and A Brooks

The Royal London Hospital, London, UK

**PURPOSE:** Plain radiography of the lumbosacral spine (LLS) is a commonly performed investigation that is associated with significant radiation dose. Using the posteroanterior (PA) rather than the traditional anteroposterior (AP) radiographic technique reduces the effective dose from 0.56 mSv to 0.36 mSv, a reduction of 36%. Several authors have therefore advocated the routine use of the PA technique. In this study we compare the ability of both techniques to define anatomical features. **METHODS:** A retrospective review of 50 consecutive AP and PA full length radiographs from adult intravenous urography (IVU) series was performed. The radiographic technique of full length IVU radiographs and LSS radiographs are similar in centring point and exposure factors. Visualisation of all elements of the lumbosacral spine, sacroiliac joints and soft tissues were compared and subjectively reviewed by two independent radiologists. **RESULTS:** There were 20 males and 30 females with a mean age of 49.1 years (range 18–76 years). The PA technique defined virtually all anatomical structures as well as the AP. In particular it was superior in defining the intervertebral disc spaces and end plates at the extremes of the LSS and also the sacroiliac joints. The AP technique was only superior at defining soft tissue structures. **CONCLUSION:** PA radiography of the lumbosacral spine should be used routinely as it leads to superior anatomical visualisation and a significant reduction in radiation dose.

### **Sensitivity and specificity as outcome measures in radiological interpretation**

D M Carr and A G Gale

Radiography Education & Institute of Behavioural Sciences, University of Derby, Derby DE1 2QY, UK

With increasing emphasis being placed on using appropriate methods for evidencing best practice, the use of appropriate outcome measures has taken on increased importance. In the context of radiological procedures, the terms sensitivity and specificity are widely used to define the efficacy of radiological procedures and techniques. A review of the literature regarding the interpretation of radiological images shows that the terms can also be used to assess observer performance. This presentation seeks to review the use of sensitivity and specificity as measures of observer performance. An overview of the terms will be made, together with an illustration of their application. The link between sensitivity/specificity and receiver operating characteristic curves (ROCs) will also be explored. Using sensitivity and specificity in the context of observer performance inevitably focuses on the end point of the interpretation process—the "accuracy" of the decision made by the observer, usually against some reference or gold standard. Using this decision as the sole arbiter of effectiveness, however, is somewhat limiting. **LEARNING OBJECTIVES:** To define what is meant by the terms sensitivity and specificity. To provide an overview of how the terms are used in assessing observer performance. To highlight the merits and limitations of using sensitivity and specificity to assess observer performance.

### **Work in Progress**

#### **Prior knowledge of disease prevalence: the influence of context bias on visual search**

S C Ethell and D Manning

Department of Radiography and Imaging Science, St Martin's College, Lancaster LA1 4AU, UK

Research regarding disease prevalence has indicated that sensitivity and specificity in an observer's performance are influenced by knowledge of the prevalence. The cause of this modified performance and decision-making is not fully understood. Theory suggests that observers may alter their criterion level in line with the statistical probability

that a given image contains an abnormality when the prevalence is known. If this is the case, to achieve a high sensitivity for abnormality detection in conditions of high prevalence, observers may use diagnostic strategies that are less dependent on systematic visual search. To investigate this theory, novice radiography students were randomly assigned to one of three digitized test banks of 72 wrist images. Test bank A, B and C represented a fracture prevalence of 50%, 83% and 22%, respectively. Half of the observers from each group were made aware of the prevalence of their respective test bank; the remainder were blind to the ratio of normal/abnormal images. Observers recorded their decisions on an operator rating scale. Results showed significant differences in overall Az between the 50% and 83% prevalence sets ( $p < 0.05$ ) and the 50% and 22% prevalence sets ( $p < 0.005$ ). Knowledge of the prevalence influenced both sensitivity ( $p < 0.05$ ) and specificity ( $p < 0.03$ ) values at the 83% prevalence level but not at the lower levels. Analysis of eye movement patterns of observers under conditions of varying prevalence is in progress and early results will be presented.

## Cardiovascular

### Direct stenting in acute thrombotic disease

M R Rees and U Amendy

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**BACKGROUND:** Direct stenting has become common practice in coronary artery disease, although direct stenting of acute thrombotic disease is rare. Direct stenting in peripheral disease has not yet become standard practice, whilst treatment of acute thrombotic disease is by mechanical methods or thrombolysis. We present two cases of life threatening acute thrombosis that were treated by direct stenting. **METHODS:** Two patients with acute thrombotic disease were treated by direct stenting using the Wall stent. The first patient had acute occlusion of the aorta, and the second had acute occlusion of the left common iliac artery. Both patients were ill with threatened cardiovascular decompensation. In both cases a heavy-duty wire was placed through the lesion and the stent system passed and expanded with further balloon expansion to fully dilate the stent. A 12 mm  $\times$  75 mm stent was used in the aorta and an 8 mm  $\times$  55 mm stent was placed in the iliac artery. No embolism was seen in either patient, although the patient with the iliac occlusion had a concurrent second embolus to the popliteal artery, which was seen on the initial angiogram. This was treated surgically. **RESULTS:** Both patients recovered from the procedure and were ambulant with viable limbs. Both patients were re-imaged 3 months later, the aortic stent by spiral CT and the iliac stent by angiography, when a procedure on the other limb was scheduled. Both stents were patent. **CONCLUSION:** Acute direct stent placement in thrombotic disease is an alternative to mechanical treatment of thrombolysis.

### Venocaval filters: indications, deployment techniques, radiographic appearances and complications

T Mills, M Ahmad, M Matson and O Chan

*The Royal London Hospital, London, UK*

Pulmonary embolus (PE) is a major cause of mortality and morbidity. Effective anticoagulation may not be achievable due to lack of patient compliance, or may be contraindicated due to co-existing pathology. Even when therapy is initiated it may be ineffective in preventing recurrent PE in up to 16% of patients. For these reasons, various methods of caval interruption of thrombi have been developed. The history and development of caval filters are reviewed, from the original Greenfield filter to currently available devices. The indications and contraindications of the different types of filters are discussed, allowing an evidence-based approach to choice of device from the spectrum available, including temporary, permanent retrievable and permanent devices. Choosing the correct device for a particular clinical indication is important in successful patient outcome.

### Complications after endovascular abdominal aortic aneurysm repair: a pictorial review

R Magennis, D White, J Martin, D Gould, P Rowlands and R McWilliams

*Radiology Department, Royal Liverpool University Hospital, Liverpool, UK*

There is a burgeoning population of patients who have undergone endovascular repair of abdominal aortic aneurysms. This technique is

relatively new and is performed in specialized units. One of the major aspects of this treatment is post-procedural surveillance to detect actual or impending late complications. Patients generally return to the base hospital for follow-up, however, there is increasing likelihood that the non-vascular radiologist will be involved in the post-procedural radiological care. The purpose of this review is therefore to illustrate the important radiological issues in the detection of late complications on plain film radiography, ultrasound and CT. We demonstrate the normal appearance of differing devices (single, modular or multi-modular) and the abnormal appearance on radiographs of disconnection of a modular device and graft migration. CT and ultrasound appearances of different devices vary and both the normal and abnormal features are addressed and the potential pitfalls highlighted. Endoleak is the major problem and can be due to graft related problems or aortic side-branches. Examples of endoleak are discussed and illustrated. Less common complications including peri-aneurysmal fibrosis, infection, aneurysm enlargement in the absence of endoleak and renal infarction are also demonstrated.

### The role of percutaneous transluminal angioplasty in the treatment of renovascular hypertension in childhood neurofibromatosis

R L Preston, C Booth, T Sabharwal, G Clark and J Reidy  
*Department of Radiology, Guy's Hospital, London SE1 9RT, UK*

**PURPOSE:** Renovascular disease in neurofibromatosis presents a difficult management problem with hypertension and subsequent renal impairment often being refractory to treatment. The aim of this study was to review the role and outcome of percutaneous transluminal angioplasty (PTA) in patients with neurofibromatosis and hypertension secondary to intrinsic renal arterial lesions. **METHODS:** Over the past 28 years, 11 patients (mean age at presentation 7.5 years) with neurofibromatosis and renovascular disease have been treated at our institution. All patients had severe hypertension at presentation (mean blood pressure 154/104). Diagnostic angiography and PTA were performed under general anaesthetic or with sedation and analgesia. **RESULTS:** Renovascular disease was seen in each case. Four patients also had mid-aortic syndrome. Subjects were managed with combinations of PTA, surgery and antihypertensive medication. One patient achieved cure with PTA alone and a second improved with percutaneous renovascular embolisation. Five other patients underwent PTA and surgery, most of these also requiring antihypertensive drugs. Two children required nephrectomies, while two other children were managed medically. Overall, PTA, either alone or in combination with surgery, produced improvement or cure in 56% of cases. No major complications were seen in this study. If surgery was subsequently required, prior angioplasty had no detrimental effect. **CONCLUSION:** In this complex patient group, management should involve a multidisciplinary team. PTA has an important role alongside surgery and antihypertensive therapy in these patients.

### Independent origin of hepatic and splenic arteries: CT findings

T Luminati, E Tagliafico and C Frola

*Radiology, Ospedale Evangelico Internazionale, Genova 16122, Italy*

**AIM:** The aim of this work was to show the capacity of spiral CT to evaluate the independent origin of hepatic and splenic arteries from the aorta. **METHODS:** We retrospectively reviewed 330 abdominal spiral CT scans performed in our department from May 2000 to September 2000. Two different techniques had been applied; 185 patients were examined with standard abdominal protocol (10 mm collimation, pitch 1.5, iv administration of 150 ml contrast medium at an infusion rate of 2.5 ml s<sup>-1</sup>); and thin section CT (5 mm collimation, pitch 2, iv administration of 180 ml contrast medium at a rate of 3 ml s<sup>-1</sup>) had been performed on the other 145 patients. Evidence of hepatic and splenic arteries and the percentage of an independent origin were assessed. **RESULTS:** An independent origin of hepatic and splenic arteries was found in 8 (2.4%) cases. However, in one of these a very short common trunk was probably present. The two protocols, with different scan thickness, showed no significant differences. **CONCLUSIONS:** Knowledge of this anatomic variation may assume an important role in the evaluation of aortic aneurysms and dissection and in pre-surgical assessment to avoid misinterpretation with the celiac trunk. Angiographics and surgical literature report a much lower

incidence of this variant. CT may play an important role in the evaluation of this anatomic variant.

#### **Myocardial perfusion imaging: second or first fiddle?** C J Cooke and N W Garvie

*Departments of Nuclear Medicine and Cardiology, The Royal London Hospital, London E1 1BB, UK*

**PURPOSE:** In some institutions, myocardial perfusion imaging (MPI) is a routine part of the work-up leading to coronary angiography, but it is more commonly reserved for those patients in whom coronary disease is suspected but exercise stress testing either cannot be undertaken or cannot be interpreted. MPI used in this way excludes patients with normal scans from the invasive and uncomfortable investigation, which is perceived as the ultimate arbiter. In clinical practice, MPI is frequently undertaken after angiography when the result of this investigation is equivocal. Impairment of coronary blood flow occurs at about 70% reduction in coronary lumen. This is not always easy to determine anatomically. MPI detects ischaemia physiologically and, in practice, it often judges the angiogram. **METHODS:** We examined 500 consecutive MPI studies. In 54 cases the study was undertaken after angiography. These were subdivided into four categories: (A) angina with apparently normal coronaries (6); (B) persistent angina following coronary stenting (15); (C) persistent angina following coronary bypass surgery (9); and (D) angina with equivocal angiogram (24). Reversible ischaemia was detected in 12 (22%) of this cohort: Group A, 0/6; Group B, 5/15 (33%); Group C, 2/9 (22%); and Group D, 5/24 (21%). **CONCLUSION:** In summary, it is reassuring that no ischaemia was detected in patients with normal angiograms. MPI revealed ischaemia in 29% of those patients referred after revascularization (Groups B & C) and also in a significant proportion (21%) of patients with equivocal angiograms. In contrast to how it is generally perceived, MPI commonly plays lead fiddle in the investigation of angina.

#### **Embolisation of a traumatic aneurysm of the upper limb in a volleyball player**

M Vlychou, G Spanomichos, A Petinelli, M Georganas, P Papadopoulou, S Pantou, S Stathopoulou and G M Zavras

*KAT Hospital, Athens 14564, Greece*

A case report is presented of a male volleyball player with a traumatic aneurysm of the posterior circumflex humeral artery (PCHA), which was treated successfully with endovascular embolisation. **METHODS:** A 19-year-old, right-handed male professional volleyball player experienced pain for the previous 24 h, coolness and paleness of the right upper limb, with dysesthesia in the fingers and absence of pulsations of the right radial and ulnar artery. The chest radiograph did not reveal any cervical rib. Angiography of the right upper limb demonstrated peripheral emboli, the source of the clots being an aneurysm at the origin of the right PCHA. At the time the aneurysm was revealed, therapeutic embolisation was performed. 5 spiral Gianturco coils (four coils 5 cm x 8 mm and one coil 5 cm x 5 mm) were used as embolic agents, which resulted in total occlusion of the PCHA. **CONCLUSION:** Embolisation is a preferable treatment for traumatic aneurysms of the upper limb compared with surgical excision, since selection of the arteries is easy and deployment of the coils is safe, with permanent exclusion of the sac.

#### **Technical and methodological features in the study of pulmonary arteries in the paediatric patient: cardiac catheterization and MRI**

<sup>1</sup>F Maiuri, <sup>1</sup>MA Ciccone, <sup>1</sup>M Oddone, <sup>2</sup>G Pongiglione, <sup>2</sup>M Marasini and <sup>1</sup>P Toma

*<sup>1</sup>Radiology Department and <sup>2</sup>Invasive Cardiology Laboratory, "G Gaslini" Children Hospital Genova, Genova 16147, Italy*

**PURPOSE:** Pulmonary artery stenosis late after surgical correction of complex congenital heart disease is a common finding in the paediatric patient. In the past, when the pulmonary artery branches could not be visualized echocardiographically, cardiac catheterization was the diagnostic tool of choice. During recent years, MRI has evolved sufficiently to be recognized as a useful complementary non-invasive method to echocardiography. The purpose of this study is to illustrate the technical and methodological aspects of the two diagnostic modalities. **METHODS:** 18 patients (age range 5–18 years) with pulmonary artery stenosis were studied with both methods. For cardiac

catheterization, we show details of the angiographic procedure and the radiological projections for the different clinical cases; the contrast medium injections also are explained. Using MRI to visualize the pulmonary vascular system, we use 3D gadolinium enhanced magnetic resonance angiography (3D-Gd-MRA). The sequences, called ultrashort 3D fast low angle shot, have a short TR and an imaging time ranging from 15–24 s. We also normally use these sequences in non-cooperating patients. All post-processing methods (MIP, MPR, volume rendering) are performed. **RESULTS AND CONCLUSIONS:** MRI has some advantages over cardiac catheterization. MRI is, without doubt, a less invasive technique (no ionizing radiation, no catheterization, no sedation in many cases). Technological improvements will increase the diagnostic role of MRI, leaving cardiac catheterization in most cases to interventional applications. The complexity of both techniques requires a specific technical and anatomical knowledge.

#### **Covered stent implantation in a lateral tunnel following fenestrated total cavopulmonary connection**

B D Barton and M L Rigby

*X-ray Department, Royal Brompton & Harefield NHS Trust, London SW3 6NP, UK*

In 1991, a three-year-old female with double inlet and outlet right ventricle and pulmonary stenosis, underwent a fenestrated, total cavopulmonary connection (TCPC) and subsequent transcatheter closure of the fenestration. In 1996 she presented with persistent cyanosis and clubbing. Cardiac catheterisation (CC) demonstrated atypical veno-atrial malformation with right to left shunting, deemed unsuitable for transcatheter closure. In 1998 the patient presented with increasing cyanosis, decreased exercise tolerance and O<sub>2</sub> saturations of 74% at rest. Chest X-ray showed mild cardiomegaly. CC demonstrated a superior baffle leak at the upper end of the atrial tunnel forming a leash of fistulae traversing the atrial myocardium and entering the left atrium. Two small collateral vessels were also demonstrated between the right pulmonary arteries and right pulmonary veins. 2 years later, because of more profound cyanosis and decreasing exercise tolerance, she was readmitted for stenting of the baffle leak. Chest X-ray demonstrated normal heart size and slightly diminished pulmonary vasculature. At CC, selective IVC angiography confirmed a large, superior baffle leak with right to left shunting. Via a 20 French delivery system a 20 mm covered stent was deployed within the lateral tunnel constructed at the time of the TCPC. Immediately, systemic arterial O<sub>2</sub> saturations increased to 98%. Subsequent selective IVC angiography demonstrated no right to left shunting. In conclusion, when conventional venous stents are inappropriate, a covered stent can be used safely and effectively despite the need for an extraordinarily large transvenous sheath.

#### **Integration of MRA to an existing vascular imaging and intervention service**

L Grosvenor, D Kathuria and K Blanshard

*Leicester General Hospital, Leicester, UK*

**PURPOSE:** Contrast enhanced magnetic resonance angiography (MRA) has advanced to a level where it is possible to integrate it into the routine evaluation of central vascular disease as the investigation of choice. Results in our institution have been very encouraging. **METHODS:** We investigated 24 patients using MRA as a first line test during a 2-month period. Limited MRA was introduced when aortoiliac, renal arterial or central venous disease was suspected or needed excluding, thereby avoiding retrograde femoral or upper limb arterial punctures. MRI was performed on a 1.0 T unit. A 3D spoiled gradient echo vascular time of flight sequence was used for all patients (23 s acquisition time) with 30 ml gadolinium-DTPA bolus injection. Post-acquisition maximum intensity projection (MIP) images were reviewed. Images were interpreted by a consultant vascular radiologist and correlated with interventional findings post MRA. **RESULTS:** To date, we have investigated three patients with suspected aortoiliac disease using MRA as the first line investigation. MRA was considered adequate for all patients, with 100% clinical concordance confirmed at intervention. In the investigation of renal arterial disease, we reviewed 20 patients having renal MRA. Images were adequate for all patients, and to date 2 (10%) patients have had findings confirmed at intervention. Additionally, one patient has been investigated for central venous disease, with MRA demonstrating a tight left

innominate vein stenosis. **CONCLUSION:** In our experience, MRA in central vascular disease gives accurate diagnostic results and should therefore be considered as a first line investigation.

#### Phase II studies of Gd-BOPTA for MR angiography

<sup>1</sup>M V Knopp, <sup>1</sup>H Von Tengg-Kobligk, <sup>1</sup>S O Schoenberg, <sup>1</sup>F Floemer and <sup>2</sup>H R Hentrich

<sup>1</sup>German Cancer Research Center 69120 Heidelberg and <sup>2</sup>Bracco-Byk Gulden, 76420 Konstanz, Germany

**PURPOSE:** To perform European multicentre studies to assess the dose efficacy of Gd-BOPTA (MultiHance, Bacco) for MR angiography. **METHODS:** 14 experienced European centres participated. A total of 392 patients were included; 161 for carotid artery MRA, 94 for abdominal vessel MRA and 137 for pelvic vessel MRA. Imaging was performed on several different 1.5T MRI systems. A non-enhanced study was always performed for comparison to the enhanced MRA. Detailed safety assessments were performed concurrently. Four different doses were administered in a double blinded fashion based on randomization tables (0.025 mmol kg<sup>-1</sup> body weight, 0.05 mmol kg<sup>-1</sup> body weight, 0.1 mmol kg<sup>-1</sup> body weight and 0.2 mmol kg<sup>-1</sup> body weight). A test bolus scheme was used for timing. The carotid imaging volume had to include the aortic arch. Abdominal imaging could concentrate either on the aorta or the renal arteries. The pelvic imaging volume had to include the aortic bifurcation. On site reading as well as off site reading by two experienced radiologists was performed. **RESULTS:** Overall image quality was determined to be excellent starting at doses of 0.05 mmol kg<sup>-1</sup> body weight. A total of 34 adverse events considered to be possibly study drug related were reported for 24 (8.7%) patients; the overwhelming majority were classified as mild in intensity. Three serious adverse events were reported but all were classified as not study drug related. No relevant dose dependent association was noted. The assessment of quality by diagnostic score revealed a saturation pattern at 0.1 mmol kg<sup>-1</sup> body weight for both blinded readers. A clear diagnostic gain was found compared to the unenhanced study. While the 0.5 mmol kg<sup>-1</sup> dose was frequently considered to be diagnostic, further improvement was detected at the next higher dose of 0.1 mmol kg<sup>-1</sup>. No substantial improvement was seen with a further dose increase. This pattern was determined for several criteria. **CONCLUSION:** Gd-BOPTA was demonstrated to be a safe and highly effective contrast agent for MRA in all three vascular territories. The dose response data indicate a saturation pattern at around 0.1 mmol kg<sup>-1</sup> body weight.

#### Work in Progress

##### Colour duplex ultrasound and sclerotherapy: a new approach in the management of patients with peripheral vascular malformations

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**PURPOSE:** Colour duplex ultrasound (CDU) is a useful adjunct to the clinical classification of peripheral vascular malformations (PVMs) into high and low flow types, and to subcategorize them based on flowimetry parameters. Since most of these lesions are amenable to sclerotherapy, knowledge of the flow pattern of these lesions would be valuable in planning sclerotherapy. CDU can also be used to assess the response of these lesions to sclerotherapy. **METHODS:** This was a prospective study, from April 1996 to October 1998, of PVMs in 75 patients using CDU. Patients (age range 5–65 years) with a history of prior interventions were excluded. Clinically, 33 patients had high flow lesions and 42 had low flow lesions. 16 high flow and 24 low flow lesions that were not near the eye, on the tongue or in the digits were selected for sclerotherapy with 3% sodium tetradecyl sulfate, on an outpatient basis without an anaesthetic, for a maximum of six sittings of sclerotherapy. Patients were followed up for 2 years. **RESULTS:** CDU findings correlated well with clinical findings in the 33 high flow lesions, where the spectral trace was pulsatile and demonstrated continuous forward diastolic flow. The Pulsatility Index (PI), Resistivity Index (RI) and systolic/diastolic ratio (SDR) were 0.776, 0.522 and 2.47, respectively, in the intralesional arteries and 0.87, 0.586 and 2.89, respectively, in the supplying arteries. Seven lesions had direct arteriovenous communicating channels visualized on CDU (arteriovenous fistulas (AVF)). The mean PI, RI and SDR were 0.707, 0.525 and 1.956, respectively, in the supplying arteries and 0.546, 0.404 and 1.814, respectively, in the intralesional arteries. 25 lesions

had no direct arteriovenous communicating channels visualized on CDU (AVMs without AVF). The mean PI, RI and SDR were 0.915, 0.602 and 3.134, respectively, in the supplying arteries and 0.838, 0.553 and 2.65, respectively, in the intralesional arteries. These differences in the flowimetry parameters of the two types of high flow lesions were found to be statistically significant ( $p < 0.001$ , Mann-Whitney Rank Sum Test). One mixed lesion had both arteriovenous and purely venous components seen on CDU. 16 high flow lesions underwent sclerotherapy: 3 lesions were AVFs that regressed, 1 was a mixed lesion that also regressed and 12 were AVMs without AVF, 9 (75%) of which regressed. CDU findings correlated well with clinical findings in the 42 low flow lesions, where no arterialized channels were seen and the spectral trace was non-pulsatile and demonstrated venous flow pattern. On the basis of CDU, they could be categorized into the following types: (1) no intralesional or supplying arteries seen (12 lesions); and (2) both intralesional and supplying arteries seen (30 lesions). The mean PI, RI and SDR were 1.427, 0.714 and 4.9, respectively, in the supplying arteries and 1.279, 0.704 and 4.04, respectively, in the intralesional arteries. Type 2 lesions could be further subcategorized based on the spectral trace of their supplying and intralesional arteries: (2a) with no or reverse diastolic flow (25 lesions); and (2b) with a small forward diastolic flow (5 lesions). 24 lesions were subjected to sclerotherapy: 7 Type 1 lesions, 3 (43%) completely regressed and 4 (57%) partially regressed (>50% reduction in size); 12 Type 2a lesions, 3 (25%) completely regressed, 7 (58.3%) partially regressed and 2 (16.7%) did not regress; and 5 Type 2b lesions, 2 (40%) completely regressed, 1 (20%) partially regressed and 2 (40%) did not regress. Differences in the mean PI, RI and SDR of the vessels seen in the high flow and low flow lesions were found to be statistically significant ( $p < 0.001$ , Mann-Whitney Rank Sum Test); Doppler flowimetry parameters have been suggested for differentiating between them. **CONCLUSION:** CDU findings correlated well with the clinical appearances of PVMs and helped to subcategorize the lesions based on differences in vascularity. We have attempted to classify PVMs into high and low flow lesions based on differences in their flowimetry parameters on CDU. We believe this would be of use in cases where the diagnosis is uncertain. In addition, this would have an important bearing on sclerotherapy technique. During sclerotherapy of high flow lesions, applying a tourniquet allows the sclerosant to remain in the lesion for longer. CDU is also useful in guiding sclerotherapy and in the non-invasive follow-up of these lesions.

#### Gastrointestinal

##### When ultrasound of the gall bladder shows no stones does oral cholecystography increase the yield?

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**PURPOSE:** In our hospital, some clinicians still occasionally request an oral cholecystogram (OCG) if clinical suspicion of cholelithiasis is high, even if ultrasound (US) of the gall bladder is normal. Current literature suggests that in these cases an OCG will add no further information. **METHOD:** A retrospective study was made of all OCGs performed in the previous 3 years. Oral cholecystography and US results were compared. The standard is that in all cases when an US examination of a satisfactory technical standard shows no gall stones, then neither should an OCG. **RESULTS:** 31 OCGs were requested within 5 months of normal US studies. A telephone poll of seven other hospitals in our region, including a teaching hospital, showed a similar yearly average of 11 cases. US was suboptimal in only 2 (6%) cases. There were, however, 8 (26%) cases of failure to opacify the gall bladder on oral cholecystography. In no cases where the US examination had previously reported normal findings were stones seen on the OCG. In one case where the gall bladder was reported at US to be contracted and therefore presumed to be full of stones, this was confirmed on the OCG. In 20 (65%) cases, US yielded additional information that oral cholecystography could not, by its nature, evaluate, e.g. liver abnormalities. **CONCLUSIONS:** Where clinical suspicion is high and US is normal, it is recommended that the case is discussed with the radiologist. A repeat US may be more appropriate than an OCG. Clinicians have been informed of these findings. A re-audit should be performed in 1 year to see whether there is a change in requesting patterns.

### **MRCP: an accurate method of diagnosis of proximal bile duct disease**

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Obstructive jaundice caused by proximal bile duct disease is uncommon. However, accurate diagnosis of the cause of the obstruction is extremely important to plan the most appropriate treatment option. Disease processes within this region can be difficult to demonstrate endoscopically, with limited filling of the intrahepatic components owing to the presence of a stricture. MRCP offers a simple non-invasive alternative. This is a clinicopathological review of proximal bile duct disease, with MRCP correlation. All images were obtained on a 1 T Siemens Magnetom scanner, after 4 h fasting. This review of disease of the proximal bile ducts includes cholangiocarcinoma (both operable and inoperable), gall bladder malignancy causing obstruction, intrahepatic ductal calculi post cholecystectomy, Mirizzi's syndrome and iatrogenic trauma to the duct, and demonstrates the versatility of this imaging method. All cases presented have image correlation with either PTC or ERCP, and where necessary surgical evaluation. This pictorial review demonstrates the important developing role of MRCP in the accurate diagnosis and management of proximal bile duct obstruction.

### **Normal variants of the liver**

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**PURPOSE:** To illustrate the diagnostic pitfalls due to normal variations in the appearance of the liver. The liver is imaged frequently and study of the liver is of considerable importance to patient management. Despite the liver being imaged extensively, normal variants of the liver can mimic pathologies and create unnecessary confusion. **METHODS:** This is a pictorial collation of cases that created diagnostic difficulties due to the varied appearance of normal liver. This collection of cases is from various diagnostic modalities including plain films, ultrasound, CT, MRI, CT arterial portography and nuclear medicine. Variations are either due to anatomical factors or technical factors. **RESULTS:** All illustrations exhibit a normal variant that increases the bias for a pathological diagnosis. Careful evaluation of these depictions of normal variants of liver during imaging eliminates the diagnosis of pathology when there is none. **CONCLUSION:** Certain pitfalls in imaging and interpretation of the liver are avoidable by careful differentiation between normal variants and pathologies.

### **Morphological and functional MRI of focal nodular hyperplasia with gadobenate dimeglumine**

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**PURPOSE:** To determine whether the morphological and functional information available on MRI with gadobenate dimeglumine (MultiHance®, Gd-BOPTA) is of benefit for the characterization of focal nodular hyperplasia (FNH). **METHODS AND MATERIALS:** 63 patients (mean age 36.8 ± 10.8 years, range 7–60 years) with 100 FNH lesions were studied. Lesion confirmation was obtained by surgical specimen (10 FNH), FNAB (45 FNH), additional imaging (<sup>99</sup>Tc-IDA, CT) and follow-up (at least 2 years). MRI was performed at 1.5 T with turbo T<sub>2</sub> weighted SE (T2wTSE: 4000/108 ms) and T<sub>1</sub> weighted GE (T1wGE: 140–120/4 ms; 80°) sequences. Images were obtained before contrast medium injection (T2w and T1wGE), during the dynamic phase of contrast medium enhancement after a bolus injection of 0.1 mmol kg<sup>-1</sup> Gd-BOPTA (T1wGE, arterial, portal-venous and equilibrium phases) and during the delayed phase after Gd-BOPTA administration (T1wGE, 1 h, 2 h and 3 h post injection). **RESULTS:** The size of lesions ranged between 0.6 cm and 10 cm (mean 4 ± 2.2 cm). 18/100 (18%) FNH were not evident on unenhanced T1wGE images, while 17/100 (17%) FNH were not evident on T2w images. The signal intensity was homogeneous in 81/82 (98.8%) visible FNH on unenhanced T1wGE and in 82/83 (98.8%) visible FNH on T2w images. Heterogeneous signal intensity on T1w and T2w images was recognizable for one FNH due to haemorrhage. A central hyperintense scar was detectable in 24/100 (24%) FNH on T2w images. On

unenhanced T1wGE images, a hypointense scar was noted in 36/100 (36%) FNH. For 35/100 (35%) FNH, a hyperintense scar was noted during the equilibrium phase after contrast medium administration. A consistently hypointense scar was evident in 51/100 (51%) FNH at 1–3 h post injection. Three different enhancement patterns were observed on the delayed phase images: homogeneous enhancement with or without central scar ("full moon": 55/100 FNH), heterogeneous enhancement ("salt and pepper": 26/100 FNH) and peripheral enhancement ("doughnut": 19/100 FNH). **CONCLUSIONS:** MRI with gadobenate dimeglumine during the dynamic and late phases provides both morphological and functional information ("two in one") for FNH characterization.

### **"Barium swallow": explore your diagnostic ability with a self-assessment quiz based on pharyngoesophagograms**

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"Barium swallow" requires examination of the pharynx, oesophagus and gastric cardia. In this exhibit, we illustrate a wide variety of structural and functional diseases along with the upper alimentary tract, as well as iatrogenic complications, ingestion of foreign bodies or congenital abnormalities, and traumatic lesions, which are presented as a diagnostic quiz. Some of the many examples will include pharyngeal diverticula or tumours, gastroesophageal reflux disease, oesophagitis due to different causes, oesophageal tumours, varices, mobility disorders and many more. Each case will be linked with an extensive list of radiological signs that are suggestive or diagnostic of these specific disorders. For each case, the correct diagnosis will be available on a hidden window. The differential diagnosis will also be discussed. All cases have been selected by reviewing our plain radiograph and barium studies teaching files. The main aim of this exhibit is to provide a pictorial review of many interesting upper alimentary disorders that can be diagnosed or suggested on radiographs.

### **Tumours of the appendix: differential diagnosis and imaging findings**

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**PURPOSE:** Our aim is to discuss the differential diagnosis and imaging findings of tumours of the appendix. In our exhibit, we present the imaging findings in six patients with tumours of the appendix. **RESULTS:** In all patients, the diagnosis was confirmed histologically with specimens obtained during surgery. Two patients had carcinoid tumours, two had cystadenomas and two had cystadenocarcinomas. **CONCLUSION:** Tumours of the appendix are uncommon. The clinical findings and the presenting symptoms are non-specific. As a result, many of these tumours are only identified during surgery for appendicitis. We believe that the radiologist must be familiar with these entities and must include tumours of the appendix in the differential diagnosis of tumours of the right iliac fossa.

### **Imaging features of combined pancreatic and renal transplantation**

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**AIM:** To demonstrate the radiological appearances of combined pancreatic and renal transplantation as well as some of its complications. **METHOD:** Combined pancreatic and renal transplantation is performed at our institution for insulin-dependent diabetic patients with renal failure. The renal transplant is placed in the left iliac fossa, with vascular anastomosis to the iliac vessels. The pancreatic graft is placed in the right iliac fossa, vascular anastomoses are performed to the iliac vessels and exocrine secretions are drained into the bladder via a loop of duodenum. Over the past 5 years, 32 patients have undergone this procedure with excellent success rates. 92% of patients have been

rendered insulin free. Imaging plays a role in the demonstration of normal function as well as the identification of complications following surgery. Ultrasound, CT and MRI findings as well as angiograms were reviewed. **RESULTS:** Two failures have been encountered owing to pancreatic graft thrombosis. A number of other complications have been encountered, some of these being well demonstrated on imaging, e.g. renal graft artery stenosis and pancreatitis, and in other cases the imaging finding being rather non-specific, e.g. ascites. A number of therapeutic procedures have been performed, including drainage of collection and renal graft artery angioplasty. **CONCLUSION:** Imaging plays a useful role in the diagnosis and management of these complex cases. However, some of the appearances can be non-specific.

#### **A pictorial essay illustrating the diagnosis and imaging appearances of gastrointestinal stromal tumours**

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Gastrointestinal stromal tumours (GISTs) constitute the largest category of primary non-epithelial tumours of the stomach and small bowel. Malignant GISTs are, however, still relatively rare lesions, representing <1% of all primary gastric malignancies and 10% of all sarcomas. GISTs can be defined broadly as mesenchymal neoplasms, arising either from intestinal or vascular smooth muscle, the commonest site being the stomach or distal small bowel. These tumours show incomplete differentiation into normal cellular components. Tumour cells are thought to represent expressions of a primitive mesenchymal precursor cell with smooth muscle potential. There are four main types: smooth muscle; neural; combined smooth muscle/neural; and uncommitted. GISTs may be submucosal, subserosal or intraluminal. Delay in diagnosis is common owing to non-specificity of symptoms and signs; the commonest symptoms are abdominal pain, bleeding and a mass. Intraluminal tumours result in obstruction and present earlier. Barium imaging studies may be unhelpful since no mucosal abnormality may be apparent. CT and ultrasound are most useful; arteriography may delineate hypervascular lesions. GISTs spread directly into adjacent organs and haematogenously to liver, lungs and bone. Lymph node metastases are uncommon. We present a review of the imaging and diagnosis of five cases of GIST.

#### **Acute appendicitis: diagnostic evaluation with helical CT**

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**PURPOSE:** To investigate the diagnostic value of helical CT in the assessment of patients referred with clinical suspicion of acute appendicitis. **METHODS:** During a 2-year period, 51 consecutive patients were assessed for acute appendicitis using thin section helical CT. 500–1000 ml of oral contrast medium were administered to all patients, at 20 min intervals, 1–1.5 h prior to scanning. Eight patients required additional intravenous contrast medium administration. Conventional scanning involved a single breath-hold and covered the area from the upper abdomen to the pubic symphysis. Thin sections were obtained scanning the area of the appendix with 5 mm collimation, a pitch of 1.5 and 5 mm image spacing. All scanning results were correlated with the surgical–histopathological findings (33 patients), as well as with the clinical and laboratory assessment of the patients (18 patients). **RESULTS:** Radiological findings were positive in 27 patients (25 true positive and 2 false positive) and negative in 24 patients (23 true negative and 1 false negative). 13 of the above 24 results (54%) identified an alternate diagnosis. These results translated into 96% sensitivity and 92% specificity for helical CT. Radiological findings include: inflammatory changes in the surrounding fat (96%), dilatation of the appendix (92%), focal caecal apical thickening (65%), regional lymphadenopathy (42%), appendicoliths (40%), peri-appendiceal abscess (12%) and phlegmon (8%). **CONCLUSION:** Our results are consistent with the related current bibliographic data and advocate that, diagnostically, helical CT is a highly accurate method for evaluating patients with appendicitis, making it the initial study of choice in these situations.

#### **The appearances of pseudomembranous colitis on CT of the abdomen: a pictorial review**

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The appearance on abdominal CT of colonic wall oedema has been described as a non-specific finding owing to a number of causes. When oral contrast medium is given, the resulting appearance in the presence of colonic wall thickening sometimes has an “accordion” pattern, and this is then more specific for the diagnosis of pseudomembranous colitis (PMC). When intravenous contrast medium is given, the resulting mucosal enhancement gives the appearance of an “enhancing accordion” pattern, a new sign that is more specific for PMC as it represents the intense mucosal inflammation found (albeit not exclusively) in PMC. We present a pictorial review of the CT imaging of patients with PMC, emphasizing the enhancing accordion pattern and the common differential diagnoses of the appearances. We believe the radiologist should be making the diagnosis before the microbiologist in many cases.

#### **A screening programme for colorectal cancer using CT virtual colonoscopy: a preliminary report**

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**PURPOSE:** To describe our initial experience at Royal Perth Hospital utilizing CT virtual colonoscopy (VC) as a screening tool for colorectal carcinoma. **METHODS:** So far, 348 asymptomatic individuals have been invited to participate in the CT VC screening programme, with an acceptance rate of 25% (66 patients). To date, 52 patients have proceeded to VC. The VC procedure involves full bowel preparation, supine and prone scanning and interpretation of axial images with selective use of reformatted and 3D images. Any colonic abnormality was further evaluated by colonoscopy. The acceptability of the VC procedure as well as the reasons for participation were assessed by questionnaire. **RESULTS:** Colonic polyps were diagnosed at VC in 14 patients, with 4 false positive results as diagnosed at subsequent colonoscopy. In addition, eight other polyps were demonstrated. All polyps measured 2–8 mm in diameter. No carcinomas have been demonstrated. The procedure was well tolerated. **CONCLUSION:** Initial experience has shown VC to be an acceptable screening technique. Continuing work will help to assess the true specificity and feasibility of VC as a screening tool for colorectal carcinoma.

#### **Adult living donor right lobe liver transplantation: assessment before surgery with multidetector multiphase CT**

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Living donor liver transplantation allows healthy adults to donate a portion of their liver to a compatible recipient. The right lobe is removed and transplanted without compromising the vascular supply or function of the remaining donor liver. We describe the use of multidetector multiphase CT in the assessment of potential liver donors, including optimal scanning techniques, postprocessing methods used to demonstrate vascular anatomy, variations of normal anatomy and the relevance of these to subsequent surgery.

#### **Oesophageal tuberculosis: a pictorial review**

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**PURPOSE:** To illustrate the radiological features of oesophageal tuberculosis. **METHODS:** We present two patients with oesophageal tuberculosis secondary to mediastinal and spinal disease. The diagnosis was initially considered owing to the radiological findings. We have reviewed the findings on plain films, contrast studies, CT scans and MR imaging in this pictorial review. Tuberculosis is known to affect virtually any organ in the body. Oesophageal tuberculosis is an uncommon condition usually resulting from direct extension of caseating mediastinal lymph nodes. Dysphagia, odynophagia or haematemesis are the usual clinical presenting symptoms. The increasing prevalence of TB in the immunocompetent and

immunocompromized host is a reason for concern and a prompt diagnosis is vital for appropriate management. The clinical diagnosis of this condition can be difficult and histological diagnosis based on oesophageal biopsies is not always definitive. Radiological investigations can often be useful in demonstration of the pathology in this condition. This pictorial review illustrates the manifestations of oesophageal tuberculosis on plain films, contrast studies and cross-sectional imaging. **CONCLUSION:** In conclusion, oesophageal tuberculosis is a relatively uncommon but potentially curable condition. This pictorial review depicts the different manifestations of oesophageal tuberculosis and its radiological features in different modalities of imaging.

#### **A standardized reporting form for colorectal cancer CT staging**

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**PURPOSE:** Colorectal cancer is a common adult malignancy with significant impact on radiological resources. In our institution, 167 new colorectal cancer patients are seen annually and 659 CT examinations are performed in the staging and follow up of this disease. 40% of new colorectal cancer patients have distant metastases at presentation. CT scan of the chest, abdomen and pelvis is the gold standard preoperative staging investigation to identify liver and pulmonary metastases, as well as giving useful information on local extension of the primary malignancy. **METHOD:** We have designed a standardized reporting form for colorectal cancer staging, which allows for a comprehensive and consistent report and also for prospective data entry into the local colorectal cancer database. The form is a single sheet, which covers the TNM staging of the disease, with entry of bi-dimensional measurements of tumours and lymphadenopathy and the image number on which measurement was made. The presence of relevant normal findings is also recorded. **CONCLUSION:** It is anticipated that this will be an important tool in increasing the utility of reports to surgeons and oncologists, as well as being useful in clinical audit and governance. This presentation will detail the design and content of this form and how the database has been constructed.

#### **The various appearances of intestinal malrotation**

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Malrotation of the bowel is a potential surgical emergency and is a common cause of mid-gut volvulus and of intestinal obstruction in children. The main imaging techniques for diagnosing malrotation are ultrasound and a contrast swallow. CT has also been described in the diagnosis of malrotation. However, each technique has limitations. Ultrasound may give poor views due to bowel gas, especially when complicated by a volvulus. CT faces problems with availability and there is limited experience in this relatively new technique. The upper GI contrast examination is the most widely used and accepted method in the diagnosis of malrotation. However, it has to be performed in a sedated child by an experienced operator. The duodenal-jejunal (DJ) junction is fixed in the left upper quadrant by the ligament of Trietz. In the "classical" appearance of malrotation on the contrast study, the DJ flexure does not reach the level of the pylorus on the lateral view and does not cross to the left of the mid-line on the anteroposterior view. In a retrospective survey of small bowel studies during a five-year period in our department, we found a variety of appearances of malrotation that were in variance with the "classical" appearance described. We present a pictorial essay on these appearances with data on pre-operative diagnosis and surgical correlation.

#### **The clinical utility of spiral CT cholangiography**

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**PURPOSE:** An illustration of the clinical utility of spiral CT cholangiography (sCTC) in patients with suspected choledocholithiasis. **METHODS:** 34 patients were investigated with symptoms or signs of choledocholithiasis. 56% of patients were female. The average age was 60.5 years. 65 % of patients had undergone previous

cholecystectomy. Meglumine iotroxate was infused intravenously and a single breath-hold data acquisition was obtained (Toshiba Asteion). The findings were reported using a workstation with axial multi-planar (MPR) and maximum intensity projection (MIP) reformats. **RESULTS:** sCTC depicted common duct stones in 12 of 34 cases (7 patients with no previous surgery and 5 post-cholecystectomy). Eight of these patients underwent ERCP, all with positive result. sCTC produced a negative result in 18 cases (15 post-cholecystectomy). ERCP was performed on 6 of the 18 negative cases and revealed 1 false negative result. In this patient, ultrasound identified a gallstone in the gall bladder; sCTC was negative but ERCP 3 months later revealed a 6 mm common duct stone. There were four cases of technical failure of sCTC due to abnormal liver function and failure of contrast excretion into the biliary tract. The average bilirubin in the cases of technical failure was 30  $\mu\text{mol l}^{-1}$ . No major adverse reactions were reported. One minor reaction with skin itching and rash over the neck and thorax was experienced. This settled over 30 min with oral chlorpheniramine. **CONCLUSION:** sCTC provides high resolution images of intraductal and perampullary anatomy. It is a useful, non-invasive tool, which may avoid ERCP where the indication is uncertain, and where the quality and availability of MRCP is suboptimal.

#### **Appendicitis: spectrum of appearances on helical CT**

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Acute appendicitis is a very common cause of an acute abdomen. It has a wide range of clinical presentations and, indeed, on occasions these are obscure. As a result, severe complications due to missed or delayed diagnosis are not uncommon. CT is an effective imaging modality that can play an invaluable role in diagnosis and is able to detect the presence and severity of complications. However, the CT appearances of acute appendicitis can be varied, reflecting in part its varied clinical presentations. On occasions, these appearances can be quite subtle. In this exhibit we will present illustrative examples from our experience in identifying appendicitis with helical CT. The cases will demonstrate the wide spectrum of appearances of acute appendicitis on CT. These vary from early and typical features to phlegmon-like masses, collections (some in unusual locations), and perforation. Radiological signs including appendicoliths, peri-appendiceal and pericaecal inflammation, fascial and caecal apical thickening, and the arrowhead sign will be illustrated. CT findings will be correlated with the clinical presentations and findings at surgery and pathology. We will also present some cases that, even in retrospect, evade accurate diagnosis, and some pathological entities that may mimic acute appendicitis. Radiologists should be alert to the varying spectrum of CT appearances of acute appendicitis, particularly since CT is being increasingly utilized in the evaluation of patients with acute abdominal symptoms, and missed or delayed diagnoses can have untoward sequelae.

#### **Pictorial review of appearances and artefacts at CT virtual colonoscopy**

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At Royal Perth Hospital, 100 virtual colonoscopies (VCs) have been performed on symptomatic patients with full colonoscopic correlation. In addition, to date, over 50 screening VCs have been performed on asymptomatic volunteers. The VC procedure used has evolved to include full bowel preparation, colonic distension with carbon dioxide or air, supine and prone scanning and the use of antispasmodics. As with any new technique there is a learning curve, and familiarity with the appearances of common pathologies and with the pitfalls leading to false positive and false negative results is essential in accurate interpretation. We present examples of proven pathology and artefacts using real colonoscopy as the "gold standard". The pictorial review demonstrates axial images and correlation with reformats, three-dimensional reconstructions and colonoscopic images where appropriate.

### **CT of small bowel obstruction: a pictorial review**

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Small bowel obstruction is traditionally diagnosed on plain radiographs whilst contrast studies may be helpful in confirming or refuting the diagnosis. CT, however, not only confirms the presence of small bowel obstruction but may reveal additional information regarding the level of obstruction and the possible underlying cause. In the majority of patients, small bowel obstruction is due to hernias or adhesions. External hernias are usually clinically obvious but internal hernias (congenital or post surgery/trauma) are difficult diagnoses to make without imaging or direct visualization. Complications of hernias, such as strangulation and ischaemia, may be confirmed on CT. Adhesions are not easily identified unless associated with inflammation or carcinomatosis. In this event they may be seen as soft tissue density bands. Tumours, although uncommon, are recognized most commonly to be carcinoid, metastases and lymphoma. Carcinoid tumours may provoke a desmoplastic reaction. Metastases may be serosal or peritoneal and lymphoma may infiltrate the bowel wall. Any of these processes can result in small bowel obstruction. Infective, inflammatory and large bowel pathology are also potential causes. We present a pictorial review of patients with small bowel obstruction in whom the underlying cause was identified at CT. We include cases of hernias, intussusception in a patient with celiac disease, lymphoma, peritoneal metastases from an oesophageal primary tumour and caecal carcinoma.

### **Effect of the addition of senna to standard bowel preparation for barium enema examination**

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**PURPOSE:** Polyp detection at double contrast barium enema is highly dependent on effective bowel preparation. We have assessed the effect of the addition of Manevac (senna granules) to our standard bowel preparation on the amount of fecal residue at barium enema. **METHODS:** 100 patients referred for barium enema were allocated into two groups. One group received our standard bowel preparation of diet restriction plus two sachets of PicoLax, while the second group had the same protocol plus two sachets of senna granules (3 and 2 days prior to the examination). The 100 barium enemas were assessed by a consultant gastrointestinal radiologist and were graded according to the amount of fecal residue. The large bowel was scored in three areas: Rt, caecum to mid transverse colon; Lt, mid transverse colon to distal descending colon; and RS rectosigmoid. Each area was scored from 0 to 3: 0 = gross residue (solid feces >2 cm); 1 = moderate residue (solid feces 1–2 cm); 2 = mild residue (solid feces <1 cm); 3 = no residue. The scores were analysed according to any difference between areas, and a total bowel residue score was given (max. score = 9, i.e. completely clean bowel). **RESULTS:** Mean scores for each area with no senna were: Rt, 1.7; Lt, 2.1; and RS, 2.2. Mean scores for each area with senna were: Rt, 1.9; Lt, 2.5; and RS, 2.4. Combining areas, total bowel fecal residue scores for the large bowel were 6.1 without senna and 6.8 with senna. Statistical analysis of the groups using the *t*-test showed an almost significant difference between the two groups ( $p=0.07$ ). **CONCLUSION:** The simple addition of two sachets of senna to our normal bowel preparation for barium enema has improved colonic clearance of feces at very low cost. We now use this new regimen on a routine basis.

### **Work in Progress**

#### **Pictorial review demonstrating the use of multislice CT in the evaluation of biliary tumours**

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As a tertiary referral centre, we have a large number of patients with pancreatic and periampullary tumours and extrahepatic cholangiocarcinomas. With the recent introduction of multislice CT, we have noticed improved visibility of tumours on the coronal and sagittal reformats, thus improving our ability to detect the tumour and to determine whether the tumour is operable. Curved reformats along the line of vessels determine patency as well as vascular invasion. We have reviewed the imaging performed during a 6-month period and

demonstrate some of the advantages of multiplanar CT compared with conventional spiral CT. We feel the extra time required to report CT scans is justified by the improved ability to stage tumours accurately.

### **Work in Progress**

#### **The use of secretin in CT of the pancreas**

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Secretin is a polypeptide hormone widely used in MRI to enhance pancreatic ductal visualization. In this pictorial review, we discuss and evaluate the role of secretin in patients undergoing CT of the pancreas for suspected ampullary/periampullary lesions. Secretin improves visualization of the pancreatic ductal anatomy, delineating the main, ventral and duct of Santorini. The duodenal distension produced enhances visualization of the ampulla and duodenal wall. Improved lesion conspicuity allows accurate differentiation between ampullary and periampullary lesions. In this review, we depict various benign and malignant ampullary and periampullary lesions and discuss differentiating features. The images obtained are those from a conventional spiral CT scanner as well as from multislice CT. With the recent introduction of multislice CT, the advantages of secretin are even more apparent, particularly on the sagittal and coronal reformats, demonstrating the importance of duodenal distension and the improved ability to demonstrate ductal anatomy.

### **Work in Progress**

#### **Bowel visualization at CT colography**

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**PURPOSE:** Computed tomographic colography (CTC), or virtual colonoscopy (VC), is a new imaging technique with potential to alter clinical approaches to detecting colorectal polyps and cancer. Lesion detection is dependent on many variables, including bowel visualization due to degree of distension, faecal residue and residual fluid. We have assessed the effect of these three variables on bowel visualization. **METHODS:** Patients are given standard bowel preparation (Fleet and diet restriction). CTC is performed following colonic air insufflation and a muscle relaxant (Buscopan). Thin section spiral CT is performed in both supine and prone positions using a single breath-hold. The images are reviewed on lung and soft tissue settings and eight anatomical areas/segments are scored for bowel distension, faecal residue and residual fluid. A scoring scale of 0–3 was used for all three parameters, e.g. for fluid, 0 = no fluid in bowel segment, 1 = <1 cm of fluid, 2 = 1–2 cm of fluid and 3 = >2 cm of fluid. **RESULTS:** To date, 70 patient data sets have been assessed. On the supine scans, only 26/70 (37%) cases showed complete bowel distension of all areas from rectum to caecum compared with 47/70 (67%) on prone scanning. On supine scans: 16 (23%) cases showed slight collapse of two or less areas, 8 (11%) cases showed moderate collapse of two or more areas; and 20 (29%) cases showed complete collapse of two or more areas (generally the rectosigmoid area). Comparative figures for prone scanning were 21%, 7% and 5%, respectively. On supine images, the bowel was clear of fluid in 26% and of faeces in 76%. Severe fluid residue and faecal matter were a problem in 31% and 11%, respectively. **CONCLUSIONS:** To fully assess the bowel at CTC, both supine and prone scans are required, primarily to shift fluid and to achieve good bowel distension, which appears superior on prone imaging. Full results will be presented.

## **Oncology**

#### **Posterior nasal space radiography has poor clinical utility in the initial staging of non-Hodgkin's lymphoma**

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**PURPOSE:** To evaluate the clinical utility of post-nasal space (PNS) radiography in the initial staging of non-Hodgkin's lymphoma (NHL). PNS radiography is frequently used in addition to CT of the body to evaluate possible disease in Waldeyer's ring. **METHODS:** Patients presenting with NHL and patients who had PNS radiography at the

Christie Hospital in 1999 were identified from the computer records. PNS radiograph reports and the case notes of those patients with an abnormal report were examined to determine the influence of an abnormal report on clinical management. Reports of other modality head and neck imaging were reviewed and correlated with the reports of PNS radiography. **RESULTS:** PNS radiographs were requested and performed on 80 of 107 (75%) patients presenting with NHL. 73 of the 80 (91%) radiographs were reported. 4 of these 73 (5%) reported PNS radiographs were interpreted as abnormal: 3 demonstrated increased soft tissue in the posterior nasal space region and 1 had an enlarged pituitary fossa. No further investigation or change in clinical management resulted from the abnormal PNS radiograph reports. In one other patient, a PNS abnormality was demonstrated on CT but the corresponding PNS radiograph was reported as normal. **CONCLUSION:** PNS radiography has poor clinical utility in the initial staging of NHL.

#### **Accuracy of pre-operative CT in evaluating advanced ovarian carcinoma**

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**PURPOSE:** There is insufficient evidence to support the view that laparotomy for advanced ovarian carcinoma provides a survival benefit. For these patients, primary chemotherapy is an alternative treatment. The role of imaging in replacing laparotomy is unclear. This study evaluates whether CT can replace this regimen. **MATERIALS AND METHOD:** In this retrospective study, 77 patients who had undergone CT and laparotomy for ovarian carcinoma were identified. The CT hard copy images were reviewed. The CT findings of ovarian mass, presence of peritoneal, omental and bowel deposits, as well as liver, lung parenchymal and abdominal wall deposits were then correlated with the surgical notes, histological findings and CA 125 levels. **RESULTS:** CT correctly predicted stage III disease in 23/26 (88.5%) patients and stage IV disease in 1/1 (100%) patient. The sensitivity, specificity and accuracy of CT staging of advanced ovarian carcinoma, that is stage III and IV disease, are 88.9%, 93.7% and 89.6%, respectively. Of the remaining 3 out of 26 patients with stage III disease, CT incorrectly diagnosed stage I disease. Two patients with stage I disease and one with benign disease were incorrectly predicted as having stage III disease. CT parameters that were significantly associated with residual disease ( $p < 0.05$ ) were ascites, omental cake, mesenteric disease, paracolic gutter deposits, diaphragmatic deposits and pleural effusion. CA 125 levels were not helpful where CT was incorrect. **CONCLUSION:** Pre-operative CT provides an accurate staging of advanced ovarian carcinoma and can replace laparotomy in some patients, thereby avoiding the morbidity and mortality associated with laparotomy.

#### **Sentinel lymph node lymphoscintigraphy in the diagnosis of metastatic malignant melanoma**

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**PURPOSE:** Current methods of evaluation of metastatic malignant melanoma involve clinical assessment of Breslow tumour thickness or dissection of thicker tumours. These methods have been shown to be inaccurate and at times misleading and unnecessary. A more accurate method of evaluation would be invaluable and would significantly reduce patient morbidity and mortality. Our poster describes a novel technique utilizing radiopharmaceutical mapping of the sentinel lymph node (first draining node imaged) following local excision of histologically proven malignant melanoma performed previously and found to have a Breslow thickness of  $< 1.5$  mm. **METHODS:** Following injection around the operative scar with intradermal <sup>99m</sup>Tc-labelled nanocolloid, the local area was dynamically imaged with a LEHR gamma camera until the sentinel lymph node was visualized. This was accurately localized with a gamma probe and the node was marked. The patient then went on to surgery (the same day), with gamma probe guided excision of the sentinel lymph node, which was sent for specialized histological analysis. **RESULTS:** We have undertaken 11 such procedures to date, 1 of which was positive for metastatic disease.

The remainder showed no evidence of micrometastatic disease in the sentinel node. **CONCLUSIONS:** This relatively new technique offers certain advantages compared with clinical evaluation and elective lymph node dissection. It delineates the actual lymphatic drainage of the melanoma, unlike elective lymph node dissection, which may biopsy uninvolved lymph nodes thus yielding false negatives. It has also provided one positive diagnosis that would have otherwise been followed up clinically with potential life-threatening consequences.

#### **Imaging metastatic melanoma**

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The incidence of melanoma has increased greatly in recent years. Although most patients present with clinically localized disease, many of these patients go on to die with metastatic disease. Malignant melanoma can involve virtually every organ system. Radiology has an important role to play not only in the detection of metastases, but also in assessing response to treatment. Imaging of the common foci of metastatic melanoma, including the lymph nodes, lungs, liver and CNS, is indicated in all patients suspected of having advanced disease. This poster demonstrates the various typical and atypical appearances of metastatic melanoma in common as well as unusual sites. MRI, CT, scintigraphy and plain radiography are demonstrated.

#### **Imaging strategies in oropharyngeal cancer**

H G Lewis-Jones, S Niven, S Babu and N A Barnes  
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This is a pictorial review of staging tumours of the oropharynx. We present protocols of investigation dependent on site of the primary tumour and initial clinical staging. The strengths and weaknesses of plain films, CT, MRI & ultrasound are discussed in relation to staging the extent of the primary tumour. Our experience suggests that MRI is superior in the delineation of the primary tumour. Oropharyngeal tumours are conspicuous on STIR sequences in particular but these sequences do tend to overstage the primary tumour, showing high signal within tumour and adjacent oedema also. This is particularly noticeable in tongue cancers. The role of isotope bone scanning both for detection of distant metastases and for assessment of bone invasion by tumour is also illustrated. Examples of floor of mouth, tongue, alveolar margin, retromolar fossa, buccal and palatal cancers are presented. The poster illustrates each tumour and its likely mode of spread. The concept of sentinel node involvement for each tumour type based on specific lymphatic drainage anatomy is discussed. There is a high reported incidence of synchronous primary tumours of the thorax. The literature is presented and the role of routine CT of the thorax is discussed.

#### **The usefulness of ultrasound examination in the evaluation of patients with malignant melanoma treated by chemotherapy**

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**PURPOSE:** To clarify the usefulness of ultrasound examination of peripheral lymph nodes in the evaluation of the effect of chemotherapy on advanced malignant melanoma. **METHODS:** Clark's level, primary lesion site, metastatic sites, advancement of disease and treatment type were analysed at the start of therapy. During treatment, IL-2 (proleukin) and concomitant chemotherapy side effects were evaluated using the WHO scale. Ultrasound of peripheral lymph nodes was performed in 16 patients (13 male, 3 female; median age 47 years, range 22-77 years) with advanced malignant melanoma, before, during and after chemotherapy with IL-2. Assessment included size, shape, echogenic hilus and vascular pattern as revealed by power Doppler ultrasound. All ultrasound examinations were performed with a 6-11 MHz linear probe. **RESULTS:** Malignant lymph nodes were identified in eight patients. There was a difference in the largest longitudinal diameter between benign and malignant lymph nodes. All of the malignant lymph nodes had a round or lobular shape. The vascular pattern of benign lymph nodes was predominantly of avascular or hilar type. Malignant lymph nodes showed spotted, marginal or mixed type vascular pattern. **CONCLUSION:** Ultrasound examination of peripheral lymph nodes is useful in the evaluation of chemotherapeutic effects on malignant melanoma.

**Image guided core biopsy of peripheral nodes and superficial masses in the diagnosis of lymphoma**

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**PURPOSE:** In recent years the approach to the routine diagnosis of lymphoma has changed. Attempts have been made to obtain a pathological diagnosis using less invasive techniques. Image guided core needle biopsy has become an important diagnostic tool. While use of this method on deeply seated lymph nodes is accepted, it is not the rule for peripheral lymph nodes. The traditional approach for sampling peripheral lymph nodes is surgery. The purpose of this study is to present the findings of image guided core needle biopsy of peripheral lymph nodes and superficial masses to evaluate its reliability in the diagnosis of lymphoma. **RESULTS:** The results of 46 image guided core needle biopsies of peripherally located lymph nodes performed in 45 patients were analysed. The biopsies were performed on ambulatory patients under local anaesthesia. A positive diagnosis of lymphoma was obtained in 34 patients, with an overall success rate of 74%. There were 29 non-Hodgkin's lymphoma patients. 24 of these patients were diagnosed according to biopsy results, with an accuracy rate of 82.8%. 93% of the patients received therapy on the basis of biopsy results without the need for subsequent surgery. There were 14 Hodgkin's lymphoma patients, 10 of whom were diagnosed and treated according to biopsy results alone, with an accuracy rate of 71.4%. There were no major complications. **CONCLUSION:** Our data indicate that image guided core needle biopsy of peripheral lymph nodes should become the preferred initial diagnostic procedure for obtaining histological samples in patients with suspected lymphoma.

## Chest

**Pulmonary sarcoidosis: atypical appearances and complications**

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The purpose of this poster is to present a pictorial review of the atypical appearances and complications of pulmonary sarcoidosis. Sarcoidosis has typical appearances on the plain chest radiograph and on high resolution CT (HRCT). However, atypical appearances may mimic other pathologies and cause diagnostic confusion. We present plain radiograph and HRCT images of cases of miliary, nodular and alveolar sarcoidosis as well as sarcoid presenting as a unilateral hilar mass. In addition, the imaging findings of the sarcoid variant necrotizing sarcoid granulomatosis are depicted. This condition presents on the chest radiograph as multifocal areas of ill defined shadowing predominantly at the lung bases. HRCT imaging shows that these areas tend to be subpleural and frequently cavitate. The lower incidence of mediastinal lymphadenopathy distinguishes this condition from classical sarcoidosis. We also present examples of complications of pulmonary sarcoidosis. These include HRCT findings of progressive massive fibrosis, traction bronchiectasis and aspergilloma formation in end-stage cavitating sarcoidosis. We further illustrate examples of air trapping on inspiratory and expiratory HRCT associated with other changes of sarcoidosis such as bronchovascular beading and subpleural nodule formation.

**Mediastinal vascular anomalies: a pictorial review**

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A working knowledge of the various presentations of anatomical variants in any part of the body is a vital pre-requisite to diagnosing pathology. We aim to summarize such anomalies of the mediastinum in the form of a pictorial review. This will encompass an exhaustive list of all known variations of normal vasculature, using plain films, CT and MRI for illustration.

**Multislice CT: imaging protocols for the chest**

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The introduction of multislice helical CT in 1998, which allows high quality volume imaging with excellent 3D and multiplanar image (MPI) reconstruction, has been a major leap forward in CT technology. However, effective and user friendly protocols for the different thoracic applications have not yet been established. Large numbers of images can be obtained using this technology, and guidelines on the most appropriate MPI reconstruction and image selection on hard copies are required. MPI reconstruction can be time consuming and there is the temptation to produce a large number of images on hard copies, which can be expensive. In this exhibition we will present protocols to stage lung cancer using volume imaging (contiguous imaging of the whole lung in a single breath-hold employing collimation of 2.5 mm/slice thickness) and for high resolution volume imaging of lung parenchyma and airways (contiguous imaging of the lung from lung bases to lung apices in a single breath-hold using 1 mm collimation). Combinations of axial, coronal and sagittal images are used. Pedal wheel MPI reconstruction is used for imaging the airways along their long axis.

**MRI in the staging of lung cancer: a pictorial review**

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**PURPOSE:** To demonstrate the role of MRI in the staging of lung cancer when CT has been equivocal. **METHODS:** We reviewed patients in whom MRI was performed as part of their work-up for staging of lung cancer. In all these patients, initial staging was performed using CT. MRI was used to assess local T stage or to help delineate whether there was metastatic disease. We discuss the different sequences used in MRI for staging in these patients and present a pictorial review. **RESULTS:** In all these patients, MRI was able to clearly assess local T stage and delineate whether there was metastatic disease. **CONCLUSION:** CT has been well established in the diagnosis and staging of lung cancer. MRI is extremely useful in limited instances, especially in evaluating aortic, pericardial and chest wall invasion. It is also useful in evaluating adrenal and liver lesions. We present a pictorial review of the role of MRI in the staging of lung cancer.

**The radiology of pulmonary haemosiderosis in children**

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Pulmonary haemosiderosis is a rare condition characterized by abnormal accumulation of haemosiderin in the lungs. Haemosiderin deposition follows diffuse alveolar haemorrhage, which may be primary or secondary to cardiac or systemic vascular disease. The onset of primary pulmonary haemosiderosis usually occurs in childhood. This poster presents the radiological findings and clinical histories of five cases of pulmonary haemosiderosis in children. We describe the typical acute and chronic presentations on the plain chest radiograph together with the clinical findings. In the acute phase, diffuse alveolar infiltrates are seen on the chest radiograph associated with a history of frank haemoptysis. In chronic pulmonary haemosiderosis, the chest radiograph appearances include transient alveolar shadowing, atelectasis and hyperinflation on a background of interstitial fibrosis. We further describe an example of secondary pulmonary haemosiderosis with pulmonary ossification. An MRI scan performed to investigate a diaphragmatic hernia demonstrated areas of low signal in the lungs corresponding to areas of ossification. Many patients with pulmonary haemosiderosis are misdiagnosed as having bacterial pneumonia. It is important to consider this condition, particularly in children presenting with transient shadowing on the chest radiograph together with a history of iron deficiency anaemia.

**CT findings in hepatopulmonary syndrome**

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**PURPOSE:** To describe CT findings in hepatopulmonary syndrome involving pulmonary circulation. **METHODS:** From May 1999 to September 2000, 11 patients with cirrhosis, hypoxemia and dyspnea

(hepatopulmonary syndrome) were evaluated with spiral CT and thin section CT to compare the diameter of central main pulmonary arteries and peripheral pulmonary vasculature in the posterior basal segments with those of healthy subjects. **RESULTS:** Patients with hepatopulmonary syndrome showed significantly dilated peripheral pulmonary vessels in the lower lung zones, compared with healthy subjects. Thick scans depict peripheral vascular abnormalities better than thin scans (high resolution). Thin section CT showed no evidence of fibrosis. Central pulmonary arteries were not significantly dilated. **CONCLUSIONS:** CT scans in hepatopulmonary syndrome show that basal nodular opacities seen on conventional radiographs represent dilated peripheral lung vessels. High resolution CT is useful to exclude pulmonary fibrosis as a cause of those opacities.

#### **Imaging tracheal lesions: a pictorial review**

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Although rare, disorders of the trachea are an important cause of intrathoracic morbidity. The posteroanterior chest radiograph provides only a two-dimensional image and as a result tracheal pathology is occasionally overlooked or misinterpreted as extra-tracheal mediastinal or pulmonary pathology. We extensively illustrate the plain film and cross-sectional imaging findings of a variety of congenital and acquired tracheal disorders. The pitfalls in plain film interpretation and the aetiology of each of these disorders are discussed.

#### **A radiological safari**

S C Bonington and S Kampondeni  
*Queen Elizabeth Hospital, Blantyre, Malawi*

I review my experience of working at Queen Elizabeth Hospital in Blantyre, Malawi, in February 2000, and discuss the difficulties and differences between radiology in this developing country and in the UK. Malawi is an extremely poor country, ranking 188/191 for infant mortality. Similar to much of Africa, there is a very high prevalence of HIV infection, estimated at 1/4 of the sexually active population and 90% of the medical inpatients at Queens. The radiology department of this university hospital has no radiologist working at the hospital, although on a daily basis the sole radiologist in the country comes to teach the radiographers ultrasound. For a British-trained radiologist, whilst there is a plethora of radiological abnormalities to be found, striking differences in practice include: the differential diagnosis list, which is often in reverse order of likelihood compared with the UK; the size of masses, making localization on ultrasound difficult; the degree of abnormality, often owing to late presentation; and the lack of definitive diagnosis owing to limited availability of histology/pathology services and only few cases being taken to surgery. Selected interesting cases will be presented illustrating these differences.

#### **Radiological manifestations of cystic fibrosis in adults**

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Cystic fibrosis is an autosomal recessive disorder, characterized by defective chloride transport across cell membranes. The radiographic appearances reflect the underlying accumulation of viscous secretions within viscera and their ducts. Pulmonary disease remains the principle cause of morbidity and death. Dramatic improvements in patient survival have led to an increase in the gastrointestinal and hepatobiliary manifestations of this condition. Pulmonary changes include air trapping, mucus plugging, bronchiectasis and cysts. These may be complicated by recurrent infections, cor pulmonale and pneumothoraces. Pancreatic abnormalities are common, with atrophy, fibrosis and fatty replacement. Calcification and cystic change are sometimes seen. The spectrum of hepatic abnormalities includes fatty infiltration, biliary cirrhosis and portal hypertension. There is also an increased prevalence of cholelithiasis and gall bladder abnormalities. Both adult and child cystic fibrosis patients may suffer from intestinal obstruction and intussusception. Bowel wall thickening, pericolonic fat proliferation and fibrosing colonopathy have also been described. Illustrative examples of the main radiological features of adult cystic fibrosis will be included in this pictorial review, drawn from imaging of approximately 240 patients from our local specialist unit.

#### **Work in Progress**

##### **Comparison of lung biopsies using spiral CT with spiral CT fluoroscopy**

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**PURPOSE:** To compare diagnostic yield, examination time and dose rate using conventional spiral CT and spiral CT fluoroscopy. **METHOD:** A retrospective comparison of 20 cases comparing examination time, diagnostic yield and radiation dose for consecutive lung biopsies. **RESULTS:** These will demonstrate the median and mean figures for the examination time, radiation dose and diagnostic yield. **CONCLUSIONS:** Conclusions will be reached regarding the benefits to patients and clinicians of the use of spiral CT fluoroscopy.

#### **Paediatrics**

##### **The value of lung CT in diagnosis of childhood TB compared with other diagnostic criteria**

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**PURPOSE:** Diagnosis of tuberculosis (TB) in children is a health problem in any society. Thus, in paediatrics, many different methods and approaches have been used for confirmation of the disease. Diagnostic criteria currently used for detection of childhood TB include clinical symptoms, history of close contact with active tuberculous patients, radiological findings suggestive of tuberculosis, PPD test, positive bacteriology or pathology, and the presence of at least three of the above-mentioned criteria. Since each of these methods is accompanied by false positive or negative results, it is necessary to find a better method for prompt diagnosis. Technological developments as well as accessibility of high resolution CT (HRCT) and CT provide further sensitivity in parenchymal and mediastinal disease, which leads to timely and prompt diagnosis. This study was conducted to determine the value of lung CT in diagnosis of childhood TB compared with other diagnostic criteria. **METHODS:** 30 children suspected of having TB who had been in intimate contact with patients with smear-positive pulmonary TB were enrolled in this study. The studied parameters included age, gender, nationality, history of BCG vaccination, the size of PPD induration test, microbiological results, chest radiography and CT. There were 12 girls and 18 boys, ranging in age from 4 months to 13 years ( $9.5 \pm 4.2$  years); 16 children were Afghani and 14 were Iranian. **RESULTS:** None of the children presented with any clinical symptoms relevant to TB. Radiological findings were present in five patients, there was a positive PPD test in five patients and positive bacteriology in five patients. All patients underwent CT with contrast enhancement; in 26 of them there was evidence of parenchymal and hilar involvement. According to our results, positive CT findings suggestive of pulmonary involvement were found in 18 cases. Treatment began despite the absence of any other diagnostic criteria. **CONCLUSION:** Although the survey was carried out on only a few children suspected of having TB, the results obtained show the value of CT in the prompt diagnosis of primary pulmonary TB in children.

##### **Fatty lesions in children and their nomenclature**

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Not all fatty lesions in children are simple lipomas. There are, in fact, a large variety of lipomatous disorders that affect the paediatric population. These include lesions such as lipomas, lipoblastomas, lipomatosis, liposarcomas and mixed fatty tumours such as neural fibrolipomas (macro dystrophia lipomatosa). There is great variety in the clinical presentation, appearances and radiological features of these diseases. Accurate diagnosis is important for further management and this can provide quite a diagnostic challenge to the radiologist. We present a pictorial review to illustrate the various forms of fatty pathologies in children, to help clarify and classify these disease entities.

### Anaesthesia of children in an open MRI scanner environment

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Administration of general anaesthesia (GA) to children undergoing MRI scanning on the Siemens open MRI scanner has become a routine procedure within the UBHT. We now have experience of GA on 80 patients in this environment and we are able to compare our experience with over 10 years practice of GA using closed systems (Picker, IGE and Philips). Problems for the anaesthetist working in an MRI setting include the unfamiliar environment and difficulties in communication with families. The following are required: experienced radiographers and anaesthetists; MR-compatible monitoring and apparatus; and good nursing support and preparation. Advantages of the open scanner include direct visualization of the patient and ease of access to lines and monitoring equipment. The main disadvantage of the 0.2 T open system is that of reduced speed. This is usually overcome by a reduction in the number of averages, which decreases the resolution. This can be a problem in assessing the spine, but longer acquisition times can be tolerated if the patient is anaesthetized. The open system is more child friendly and some children can avoid GA. They are scanned with the help of play therapists. Avoidance of GA is a benefit, but the scans will be of lower quality if the child moves. The open MRI environment provides considerable advantages over closed MRI systems for administration of GA to children. The future development of MRI systems will combine the architecture of open systems with the speed and resolution of higher field closed apparatus.

### "Double incontinence": twins with continuous wetting and occult ectopic ureteroceles

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**PURPOSE:** To demonstrate the imaging findings of monozygotic twins with continuous wetting and to review the current literature on the imaging of continuously wet children. **METHODS:** Two 5-year-old monozygotic twins presented to the department with identical histories of continuous wetting despite normal development. Both twins underwent ultrasound and a MAG3 renogram. **RESULTS:** Both twins had identical ultrasound appearances demonstrating a small cystic dysplastic left kidney with an associated ectopic ureterocele indenting the bladder base and intimately related to the cervix. One child demonstrated fluid within the uterus. Both right kidneys were normal. Renal scintigraphy demonstrated only 5% and 7% function, respectively, in the left kidney. **DISCUSSION:** Causes of continuous wetting in a child include neurogenic bladder, detrusor instability, sphincter dysfunction and congenital malformations. In girls, incontinence due to an infrasphincteric ectopic ureterocele must be excluded. Ultrasound of the whole renal tract including the bladder and urogenital tract is an important initial imaging modality and can be valuable in defining an anatomical cause for urinary incontinence. The twins had previously undergone several ultrasound examinations without identifying a cause for the incontinence. Further imaging such as intravenous urography, renal scintigraphy and to a lesser extent CT and MRI are useful in situations where doubt remains.

### Patient dose and image quality in the neonatal unit

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**PURPOSE:** This study looked at the implementation of the European guidelines for quality criteria in diagnostic imaging in paediatrics in the neonatal unit at Nottingham City Hospital. **METHOD:** Using these guidelines, an audit was carried out against which current practice was compared, and the factors collected were used to calculate effective doses. Dose modelling was employed to assess the degree of reduction made with the implementation of the guidelines, and finally image quality was assessed to determine any changes in contrast. **RESULTS:** Results of the initial audit showed that whilst the quality

of the images was good, the tube potential was too high and there was not enough filtration in the beam. The dose modelling showed that a reduction in kV, an increase in mAs and the use of additional filtration required to bring the unit in line with the European guidelines could reduce the dose to a standard neonate by 30% while maintaining the dose to the imaging plate. Analysis of the mAs settings available indicates a dose saving of between 23% and 40%. Assessment of image quality using a test object has not shown a significant difference between the mAs settings. **CONCLUSION:** The reduction in tube potential from 66 kV to 62 kV with the addition of 0.5 mm Al and 0.2 mm Cu may reduce the dose to an average neonate by between 23% and 40%. Initial results from a clinical trial comparing image quality have shown no statistically significant difference between mAs settings.

### Imaging appearances of colonic carcinoma in children

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**PURPOSE:** Colonic carcinoma is extremely rare in childhood and adolescence. Predisposing conditions include ulcerative colitis, familial polyposis coli, cystic fibrosis, Gardner's, Turcot's and Peutz Jegher's syndromes. However, these are not prerequisites for development of the disease. The prognosis is poor because of delayed diagnosis owing to a low index of suspicion and the generally unfavourable mucinous histology. These patients often undergo ultrasound examination for non-specific abdominal symptoms. This may demonstrate bowel wall thickening, secondary deposits and ascites; findings which should then be pursued with CT. A tissue diagnosis may then be obtained by either endoscopic biopsy or percutaneous sampling of metastases. We describe the imaging appearances in three children with colonic carcinoma (age at presentation 11–16 years) with review of relevant clinical and pathological data. **RESULTS:** Two patients had no predisposing condition, and the third had cystic fibrosis. All presented with advanced disease, and the diagnoses were confirmed without recourse to barium enema. Survival ranged from 17 days to 4 years and in the two who survived longer, CT was used to monitor their progress during chemotherapy. **CONCLUSIONS:** Despite its rarity, clinicians and radiologists should consider the possible occurrence of colonic carcinoma in childhood, particularly where prolonged or atypical abdominal symptoms occur in children with conditions such as cystic fibrosis.

### The radiology of haemoglobinopathies: a pictorial review

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There are three main types of haemoglobin variant (haemoglobinopathy); sickle cell disease (HbS), which is the most important, and thalassaemia and sickle-thalassaemia syndromes. Their diagnosis rests on the detection of abnormal haemoglobin synthesis. Both thalassaemia and sickle cell disease are associated with extensive skeletal abnormalities that are readily displayed by imaging. In addition, sickle cell disease causes thoracic and abdominal syndromes. We illustrate the extensive array of plain film and cross-sectional imaging findings encountered in sickle cell disease and thalassaemia. The mechanism by which these changes arise is discussed.

### A pictorial atlas of paediatric head and face lumps

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There are many causes of head and facial lumps in the paediatric population. Their differentiation may be clinically difficult and imaging plays a role in cases where the location, age of onset and clinical features are inconclusive. In addition to characterising the lesion itself, imaging is extremely valuable in determining the origin of the lesion and its relationship with adjacent structures, especially in cases where surgery is to be considered. In some cases FNA may also be required to make a diagnosis. We present an atlas of head and facial lumps. We illustrate the familiar features of epidermoid, neurofibroma, eosinophilic granuloma, haemangioma and cephalohaematoma. We also include examples of less common lesions which were diagnosed on histology; haemolytic uraemic syndrome, atypical *Mycobacterium* and parotid haemangioma and schwannoma.

## Genitourinary

### The benefit of hysterosonography in the diagnosis of uterine abnormalities

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Transvaginal ultrasound and hysterosonography are well established techniques in the diagnosis and evaluation of uterine abnormalities such as endometrial polyps, endometrial hyperplasia, endometrial carcinoma, uterine leiomyomas and the causes of infertility. Hysterosonography is performed by inserting a 5F hystero-graphy catheter into the endometrial cavity and injecting sterile saline while scanning transvaginally. Representative transverse and longitudinal images are obtained. Hysterosonography is more specific than transvaginal ultrasound in distinguishing focal intracavitary masses such as polyps, asymmetric hyperplasia and localized neoplasia, which are best managed with hysteroscopy and targeted biopsy rather than blind endometrial biopsy. Hysterosonography is also beneficial in the evaluation of submucosal leiomyomas as the percentage of extension into the myometrium determines if the lesion is hysteroscopically resectable.

### The incidental adrenal nodule revisited

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**PURPOSE:** To report the incidence of incidental adrenal lesions using state of the art CT. A significant discrepancy exists between previous CT studies, which have reported an incidence of 0.4–2%, and autopsy studies that report 2–8% of patients as having incidental adrenal masses. **METHODS:** Adrenal size and densitometry on lesions greater than 1 cm diameter was assessed on the abdominal CT scans of 202 consecutive patients, by two independent CT radiologists. Patients with adrenal pathology, malignancy, haemorrhage, trauma and sepsis were excluded. Allocation to three categories was by agreement; no adrenal nodules, adrenal nodules greater than 10 mm maximal diameter in the axial plane, and adrenal nodules less than 10 mm diameter. Densitometry was calculated by averaging the values from five separate "region of interest" measurements. **RESULTS:** 202 patients were included: 123 male; 79 female; mean age 59 years; age range 16–91 years. There were 27 (13.4%) adrenal lesions greater than 10 mm diameter, 36 (17.8%) lesions less than 10 mm diameter. The overall incidence of incidental adrenal lesions is 32.2%. Densitometry range of lesions greater than 10 mm diameter was –36 to +86 HU. **CONCLUSION:** State of the art CT demonstrates that overall incidence of incidental adrenal masses is substantially higher than reported in previous CT studies and more comparable to incidence demonstrated at autopsy.

### MRI of the male pelvis as a planning tool

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**PURPOSE:** To update a traditionally diagnostic investigation with co-registration to CT to provide a useful and accurate radiotherapy planning tool. **MATERIALS AND METHOD:** A 0.2 T open magnet, with specifically designed lightweight table inserts and radiotherapy positioning lasers, are used. Patients undergo a radiotherapy planning CT scan followed by a planning MRI scan. These are performed in identical positions by using positioning lasers, markers and "vacfix" immobilization. The MR images are corrected for geometric distortion using an in-house software package, co-registered with the CT scan and sent to the radiotherapy planning computer and used to plan the radiotherapy treatment field. **RESULTS:** MR images demonstrate superior tissue delineation and greater conspicuity of pathology. Normal anatomy, including seminal vesicles (essential for prostate planning in particular), can clearly be seen. CT images demonstrate the patient outline more accurately, and the Hounsfield numbers can be used to assess absorption and dosage from the planned radiotherapy field. **CONCLUSION:** Once corrected and co-registered, the resultant image can be viewed by the oncologist. With increased tumour delineation, treatment fields and target volumes can be made smaller and more accurate.

### The role of ultrasound in the diagnosis of testicular tumours

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**PURPOSE:** Ultrasound is a safe and established method of examining the testicles, particularly if a tumour is suspected. Because of these advantages, there has been a recent increase in use of this diagnostic test. The aim of this study is to evaluate the role of ultrasound in the detection of testicular tumours. **METHOD:** A comparative retrospective study was performed correlating the testicular ultrasound examinations with the operative and histology findings of all patients undergoing orchidectomy over a 2-year period in a single large centre. Patients operated on for testicular tumours without prior ultrasound scans were also investigated. During this 2-year period, 1488 patients were examined. 40 patients underwent at least one further follow-up examination. In this large group, a testicular tumour was diagnosed in 20 (1.3%) patients. Patient age ranged from 16–93 years. Over the same period, 23 patients had histologically proven tumours removed. 20 patients had these lesions diagnosed on ultrasound, and 2 patients presented directly to the urological surgeons with a palpable lump that was removed. Both of these patients had failed to attend for previously booked ultrasound appointments. One tumour was diagnosed on clinical grounds alone. This study confirms the role of ultrasound in the diagnosis of testicular tumours, although large numbers of examinations will be negative. However, in this large group no tumour developed in a patient who had a negative scan performed.

### MR urography in children: technical aspects

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**PURPOSE:** Owing to the absence of ionizing radiation, MRI is becoming a very important tool in the diagnostic evaluation of many paediatric diseases, including pathologies of the genitourinary system. A recently developed MRI technique is imaging of static fluids. Our aim is to illustrate the technique of MR urography (MRU) in paediatric patients along with the related problems. **MATERIALS AND METHODS:** During a 12-month period, 36 patients (age range 1 month to 18 years; mean age 12 years) with suspected pathology of the urinary tract were prospectively examined with MRU. We routinely used a Marconi 1.5 T imager (Marconi, Cleveland, OH) to perform the examinations. 30% of examinations were carried out with general anaesthesia. SE  $T_1$ , FSE fat suppression  $T_2$  (respiratory gated) and Gd enhanced TFE sequences were performed in all patients. In 50% of patients FSE  $T_2$  single shot and STIR sequences were also performed. Imaging subtraction and post-processing techniques such as MPR and MIP were employed. **RESULTS AND CONCLUSIONS:** Using MRU it is possible to obtain a high quality morphologic examination of the paediatric urogenital tract. To achieve this result there are some technical and methodological rules to observe, for example adequate immobilization of the patient, coil choice, good hydration (it is mandatory to utilize furosemide), long TR (>10 000 ms) in FSE fat suppression respiratory gated sequences, correct injection timing in Gd enhanced TFE sequences, use of post-processing tools, etc. MRU is still not a standardized technique in children, but the advantage of the absence of ionizing radiation improves the argument for its use.

### Quantification of prostatic motion due to bladder filling using MRI

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**PURPOSE:** Radiotherapy treatment planning of the prostate is currently performed using CT images, which locate the prostate in relation to the pelvic side-walls. However, the prostate is not a fixed organ and displacement may occur secondary to the mass effect from adjacent structures. To limit the damage suffered by other pelvic organs, only a small margin of error is employed during treatment. The effect of prostate movement on dose received is unknown. MRI can accurately locate the prostate and surrounding structures and this work concentrates on using MRI to quantify short-term prostatic motion. **METHODS:** All imaging was performed using a GE 1.5 T scanner and a commercial pelvic phased array coil. 32 patients aged 56–82 years (mean age 69 years) with suspected prostate cancer were scanned. Two sets of  $T_2$

weighted images, with an approximate 50 min interval, were obtained using a fast spin-echo sequence with an acquisition time of 6 min. After acquisition the prostate was manually segmented and the prostatic centre of mass determined. The distances between the prostate and six bony landmarks were then calculated. RESULTS: The average prostate volume was calculated to be  $56.4 \pm 27.1 \text{ cm}^3$  with no differences noted between the two scans ( $p > 0.574$ ). The mean prostate movement was less than 1 cm in all directions. However, the maximum movement was calculated to be 4.5 cm in the anterior-posterior direction. CONCLUSION: A 1 cm margin of error is often incorporated into the treatment plan to allow for misalignment. Whilst the average prostate motion was well within these confines, some patients demonstrated markedly increased movement. This implies that margins of error with treatment planning may have to be individually tailored.

#### MRI of uterine sarcomas in adults

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PURPOSE: The MRI appearances of uterine sarcomas have not been previously described. The purpose of this study is to describe the MR features of uterine sarcomas. METHOD: A retrospective review of the MR scans from all patients with histologically proven uterine sarcomas between 1993–2000 was conducted. Tumour size, its relationship to the uterus, and signal characteristics on  $T_1$  weighted and  $T_2$  weighted imaging and after gadolinium enhancement were noted. RESULTS: 20 scans from 19 patients were reviewed. 10 were leiomyosarcomas, 4 mixed Mullerian tumours, 2 rhabdomyosarcomas and 3 endometrial stromal sarcomas. 15 scans were at original presentation and 5 at recurrent disease. Two patterns of disease were observed: (a) a characteristic large heterogeneous pelvic mass (15 patients); and (b) an endometrial mass indistinguishable from endometrial carcinoma (5 patients). The large masses were characteristically of low or intermediate background  $T_2$  signal with pockets of higher  $T_2$  signal replacing the normal uterine architecture. The areas of higher  $T_2$  signal corresponded to cystic necrosis within the tumour and the pockets of high  $T_1$  corresponded to haemorrhage. Gadolinium enhancement was present in the solid components of all tumours. This pattern was observed in all recurrent sarcomas. Some correlation was shown between the histological subtypes and the MR appearances. CONCLUSION: Two distinct patterns were observed on MRI. Commonly this is a large heterogeneous mass, but occasionally sarcomas mimic endometrial carcinoma.

#### Effect of contrast medium dose in intravenous urography

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PURPOSE: To assess the effect of contrast medium dose on image quality in intravenous urography (IVU). PATIENTS AND METHODS: 200 consecutive patients (age range 19–90 years) attending for IVU were alternately allocated to receive either 50 ml or 75 ml of Iopromide 300 (Ultravist, Schering). No bowel preparation was given and there was no prior dehydration. Fluid intake in the 6 h preceding the examination as well as patient weight were recorded. Control films and radiographs immediately after injection and at 5 min, 10 min and 20 min were taken. The obtained radiographic series was reviewed blindly by six observers and the quality of nephrograms, pyelograms and visualization of ureters and bladder were assessed using a scoring system from 1 to 3 (1, poor; 2, moderate; 3, good). RESULTS: 187 examinations could be retrieved from file; 93 of these patients had received 50 ml of contrast medium and 94 patients had received 75 ml of contrast medium. Patients given 75 ml of contrast medium achieved significantly higher mean scores than those receiving 50 ml (mean score 2.56 vs 2.34;  $p < 0.001$ ; 95% confidence intervals, respectively, 2.48–2.65 and 2.25–2.43, ANOVA). There was a trend towards negative correlation between score obtained and patient weight in the group that had received the lower amount of contrast ( $r = -0.26$ ), whereas in the 75 ml contrast medium group patient weight did not influence scores significantly. Prior hydration had no noticeable impact on image quality. CONCLUSION: Significantly better quality images are obtained using 75 ml of Iopromide 300 compared with 50 ml of Iopromide 300. Prior hydration has no influence on image quality.

## Musculoskeletal

#### Bone mineral density at the forearm and hip in Greek paraplegic men after prolonged immobilization

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PURPOSE: To evaluate the decline of bone mineral density (BMD) at the forearm and hip in a group of Greek male patients with complete traumatic paraplegia after prolonged immobilization. METHODS: 56 male patients with complete paraplegia were examined by dual energy X-ray absorptiometry (DXA) to measure BMD of the forearm and hip. The mean age of patients was 37.5 years and the mean period of immobilization was 9.1 years. A control group of healthy subjects matching the main group for number, sex and age was also assessed by DXA at the same regions to provide a comparable standard. None of the patients was under any type of medication or suffered from a systemic disease that could affect bone metabolism, and no measurements were obtained in the presence of heterotopic ossifications or metal implants in the regions of interest. RESULTS: The measurements revealed a profound bone loss, mostly in the area of femoral neck ( $p < 0.001$ ) and great trochanter ( $p < 0.001$ ), despite the age, environmental factors and rehabilitation programmes of the paraplegic patients. BMD at the forearm was not abnormal, although in some paraplegic patients there was a slight decrease. CONCLUSION: Osteoporosis is present at the hip among the Greek male patients with long-standing complete paraplegia. This fact not only increases the risk of fracture but may indicate a progressive bone loss related to metabolic changes that need to be further investigated.

#### Magnetic resonance arthrography in the assessment of the dysplastic hip

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PURPOSE: The aim of the study was to assess the accuracy of magnetic resonance (MR) arthrography in the diagnosis of labral pathologies in dysplastic hips. MATERIALS AND METHOD: A consecutive series of 16 patients (6 male, 10 female) with radiologically diagnosed dysplastic hips were studied. The median age was 33 years (range 17–40 years). Patients were referred from specialist orthopaedic clinics. Eight patients underwent surgery (one shelf acetabuloplasty; one femoral and peri-acetabular osteotomy; six peri-acetabular osteotomies). At arthrography, between 12–25 ml of contrast medium (1:100 gadolinium chelate mixed with Omnipaque 240) was injected into the hip under fluoroscopic guidance. High resolution (2 mm slices)  $T_1$  (3D FLASH) and  $T_2$  (3D DESS) MR images were acquired in the transverse and coronal planes. Radially reconstructed images of the labrum were obtained off-line on a 3D workstation. MR and operative findings were compared. RESULTS: There were four true positive, two true negative and one false positive diagnoses of a labral tear on MR arthrography. There was one non-diagnostic study. The false positive was due to misinterpretation of an anterior communicating synovial track between the hip and psoas tendon sheath. The non-diagnostic study was owing to contrast equilibration due to delay in MR imaging. CONCLUSION: MR arthrography is a promising technique for assessing labral tears in dysplastic hips. Radial reconstruction helped to profile the posterosuperior and anterosuperior portions of the labrum, allowing more confident interpretation of these areas. This is important, as the favoured site for labral tears is anterosuperiorly. Problems and pitfalls are illustrated.

#### MRI of musculoskeletal tuberculosis: a pictorial review

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PURPOSE: To illustrate the MRI features of musculoskeletal tuberculosis (TB) and its associated complications. METHODS: We reviewed the results of MRI examinations performed in patients with musculoskeletal TB at our institution. DISCUSSION: The increasing incidence of TB in the immunocompromised and immunocompetent host is a cause for concern. There is also a very high incidence in the immigrant population. Musculoskeletal manifestations of TB can be

multifocal and are usually due to haematogenous spread from the lung. Early diagnosis of this insidious disease is essential, as treatment can be very effective. Delay in recognizing this condition can lead to potentially fatal complications, especially in spinal TB. Although plain radiographs are useful in the initial evaluation, MRI is being increasingly used to assess the extent and complications of this infection. The multiplanar capability and better soft tissue contrast of MRI is an obvious advantage over other imaging modalities. Use of intravenous gadolinium can demonstrate pathology very exquisitely. The MRI features and complications of musculoskeletal TB at different sites are demonstrated in this pictorial review.

#### **Pictorial review of classic failure patterns of contemporary metalwork around the shoulder**

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In modern day orthopaedic practice, as shoulder surgery has become more specialized, complex fractures are being treated more aggressively, and newer methods of surgery are being used to treat shoulder osteoarthritis, rotator cuff disease and even shoulder instability. Application of metal implants and prostheses has defied conventional methods of fixation. To the radiologist, this means a wider horizon of work, placing more demands in reporting and analysing radiographs. Behaviour of a particular metal in the tissue milieu is dictated by its biomechanical properties and, for the same reasons, its mode of failure follows a fairly predictable pattern. Common implants such as plates for proximal humerus fractures in elderly osteoporotic bone will often fail in fixation with screws backing out. k-wires are known to migrate, and intramedullary nails have an increased incidence of proximal migration leading to subacromial impingement. On the other hand, shoulder prostheses rely on rotator cuff integrity to prevent proximal migration. The glenoid component predictably reveals a rocking horse phenomenon in the presence of rotator cuff tear. Signs of stem loosening in the humerus as well as radiolucent lines over the glenoid component also follow set patterns. In this pictorial review, we present radiographs of classic examples of commonly used implants and prostheses around the shoulder, and the common patterns of failure of metalwork in shoulder surgery, so that the radiologist can identify these in their routine practice and forewarn orthopaedic surgeons of imminent complications.

#### **A retrospective epidemiological MRI study of patellar tendinitis: the effect of age and weight on mid tendon degeneration**

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**PURPOSE:** Evidence suggests that degeneration may involve central, medial or lateral portions of the patellar tendon. Few studies have attempted to establish the basis of spread of the lesion distally or the occurrence of more extensive degeneration involving the main body of the tendon, distal or proximal to the bone-tendon junctions in symptomatic tendons. Previous studies suggest that damage to the mid part of the tendon would be more likely in older and heavier individuals. **METHODS:** To determine the effect of age and weight on the occurrence of mid tendon degeneration, MR images of 41 knees from 34 patients were analysed using increased thickness to indicate damage. The thickness of the tendon in the proximal, middle and distal thirds was measured and the percentage of tendon damage was calculated. Information regarding gender, age, weight, height, duration of symptoms, sporting activities and whether there was a history of trauma was recorded from the patient files. **RESULTS:** Although the most frequent area to be affected was the proximal third of the patellar tendon, the middle third was involved in 52% of cases. Patients with mid tendon degeneration were not found to be significantly older or heavier. **CONCLUSIONS:** It appears that patellar tendinitis does not increase in occurrence with age or weight but is more common in younger individuals; however, this only applies to overuse injuries. Analysis of epidemiological data suggested that as an overuse syndrome, patellar tendinitis is predominant in young males, and that trauma is a significant causative factor.

#### **"The ossified man": an unusual case of fibrodysplasia ossificans progressiva**

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**BACKGROUND:** Fibrodysplasia ossificans progressiva (FOP) is a rare, dominantly inherited disorder associated with progressive ossification in the musculature, ligaments, fascia, tendons and joint capsules. **METHOD:** A 31-year-old male with advanced FOP was referred to our department for follow-up. The patient underwent radiological examination and CT. **RESULTS:** Radiological examination and CT revealed the following: (1) development of osseous bridges in multiple locations, which were most prominent between the right humerus and the rib cage as well as between the left iliac crest and the rib cage; (2) ossification of paravertebral muscles, femoral muscles and pelvis, extensive heterotopic ossification of both hips, deformities of the great toes and thumbs, and ankylosis of both elbows; and (3) calcification of the spinal longitudinal ligaments and fusion of the bodies and posterior elements of the cervical vertebrae. **DISCUSSION:** The radiological investigation often faces difficulties because of the excessive disability of such a patient, although it is useful for follow-up of the disease. The radiological and CT findings are specific for this disease and, in combination with the clinical investigation, may confirm the diagnosis. However, the prognosis for this disease is still unpredictable and an effective treatment is not yet available.

#### **A study of distribution of hand fractures in children**

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**PURPOSE:** To document the frequency and distribution of hand fractures in children aged up to 16 years. **METHODS:** We reviewed hand radiographs of 273 children up to the age of 16 who had documented hand fractures over a 1-year period (March 1999–March 2000). The fracture type, site, age and sex were recorded in four different age groups (0–4 years, 5–8 years, 9–12 years, 13–16 years). The mechanism of injury was not documented, as most of the request cards had no record of this. **RESULTS:** 280 fractures were recorded in 273 patients. The group of children aged 13–16 years had the maximum number of fractures. Fracture of the neck of the fifth metacarpal was the most common injury in this group. In the 9–12 years age group, fractures of the proximal phalanx of the fifth ray were the most common. In the 5–8 years age group, fractures of the distal phalanges were the most common. In the 0–4 years age group fractures of the tuft of the distal phalanges were most common. **CONCLUSION:** The incidence of hand fractures is most common in the older children. The site of injury is different in the various corresponding age groups reflecting the different mechanisms of injury.

#### **Work in Progress**

##### **The role of ultrasound in the assessment of interspinous movement in back pain**

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Reduction in movement of the lumbar spine following back injuries is associated with alterations in the mass and tone of paraspinal muscles. This study uses grey scale ultrasound measurement of spaces between lumbar spinous processes to assess the amount of mobility between individual lumbar vertebrae. The purpose of this study is to determine whether changes to ultrasound measurements of interspinous spaces provide information from which treatment efficacy of low back pain can be monitored. Currently, physiotherapists estimate changes in bony spinous movement by calculating the difference in measurements between surface landmarks (Schoeber's Index) that occur with changes in posture and flexion. However, Schoeber's Index gives an indirect measure of bony movement and may be influenced by the elastic condition of the skin and subcutaneous tissues. It is believed that direct visualization and measurement of bony spinous relationships using ultrasound will provide more accurate information on which to plan and conduct treatment. Following completion of the current pilot study, serial measurements of 30 subjects will be undertaken and

correlation between ultrasound measurements and Schoeber's Index will be investigated. Early data suggest that interspinous measurements vary not only between individual subjects but also between vertebral levels in the same subject. These variations may reflect hypermobility at one vertebral level compensating for hypomobility at the injured level. If ultrasound were to be useful in monitoring physiotherapy treatment, it would be necessary to perform baseline measurements at first consultation, which would then be compared with subsequent measurements made at intervals during treatment.

#### Work in Progress

##### Relative tibiofemoral motion: an *in vivo* study of knee kinematics using interventional MRI

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**PURPOSE:** The aim of this study was to further our understanding of relative motion between the femur and tibia during flexion, looking for the first time at deep flexion. **METHODS AND MATERIALS:** Using the "interventional" MRI scanner, 10 subjects with asymptomatic knees were studied. Their knees were scanned weight-bearing in hyperextension, and at 10° increments through to full deep flexion. Sagittal imaging planes were obtained in the mid medial and mid lateral compartments of the tibiofemoral joints. The same imaging planes were maintained by means of a "tracking" device. Reference points on the femoral condyle and the posterior tibial cortex were used to measure relative translations. **RESULTS:** The lateral femoral condyle moves posteriorly on the tibia during flexion from hyperextension to 120° by 23 mm. From 120° knee flexion to full deep flexion (average 142°) there is another 10 mm of posterior translation, with the lateral femoral condyle almost subluxing off the tibia. Medially, there is minimal posterior movement of the femoral condyle to 120°, *i.e.* there is no medial "roll-back" as is commonly believed. Thereafter, the medial femoral condyle moved 8 mm posteriorly. The differential mediolateral motion to 120° knee flexion represents external femoral rotation during knee flexion. Flexion over 120° to full deep flexion was accompanied by similar medial and lateral posterior displacement, *i.e.* the motion is no longer a net axial rotation. **CONCLUSION:** The results challenge widely accepted dogma on knee kinematics, and have major implications for understanding ligament function and injury as well as for prosthetic design.

#### Student Work

##### Snowboarding injury: fractured lateral process of the talus

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Snowboarding is becoming increasingly popular and can be defined as a "younger activity" sport, suggesting elements of speed and danger. Owing to collisions, falls and awkward landings, injuries may occur to the ankle joint. This research specifically focuses on a fracture of the lateral process of the talus. This pathology is difficult to image diagnostically and therefore a concern arises of misdiagnosis and its clinical implications. Knowledge of the normal anatomy and physiology of the talus, applied to the mechanical movements of the ankle joint, can help to evaluate and recognize the clinical symptoms for this specific injury. There is confusion over which mechanisms cause this fracture. There are three main types of lateral process fracture. This poster will review supplementary views using conventional radiography and imaging from other modalities within radiology to demonstrate this injury to the best potential. The reason for the controversy over mechanisms of injury can be understood with the knowledge that both forced eversion and inversion can cause a fracture to the lateral process of the talus, but in different ways; however, one is more common in snowboarders. Clinical indications of this injury include tenderness approximately 1 cm inferior to the tip of the lateral malleolus. A lateral image of the foot identifies the lateral process in profile, therefore demonstrating an undisplaced fracture fragment. The mortise joint view of the ankle, taken at 90° to the lateral foot projection, is more likely to diagnose a displaced lateral process fracture.

## Breast

### A pictorial review of misleading mammographic spot compression views

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Assessment of screen detected abnormalities may include additional mammographic projections, including spot compression views. These are particularly useful for the assessment of areas of stromal deformity that may represent composite shadowing or significant pathology. If the stromal deformity is shown to persist, image guided biopsy is mandatory. Conventional teaching states that "real" abnormalities will be more clearly visualized on spot compression views. We present a pictorial review of cases where the spot compression view was misleading, resulting in delay in the diagnosis of breast cancer for some women. The cases will serve to caution against over reliance on this technique as well as suggesting how diagnostic delay may be minimized.

### Cluster microcalcification: can we predict a malignancy?

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**INTRODUCTION:** Cluster microcalcification (MC) as the only finding on the mammographic examination are usually considered suspicious, yet a benign lesion is often the result of subsequent biopsy. **PURPOSE:** This study evaluates the morphology of MC and tries to determine criteria that can predict a malignancy. **METHODS:** 60 women with subclinical lesion of the breast presented with MC. We attempted to estimate the following criteria: number of MCs per cm<sup>2</sup>; mean surface area of extension; total number of MCs; irregularity of density among MCs; irregularity of size; existence of vermicular MC; linear or branching form; and high density. **RESULTS:** Biopsy revealed a malignancy in 20 women: 10 DCIS, 5 infiltrative ductal grade II & lobular *in situ*, 2 mixed *in situ*, 1 mixed infiltrative *in situ*, and 2 infiltrative ductal grade I & mixed *in situ*. Five of the criteria mentioned above were statistically significant: (i) existence of vermicular MC (30%); (ii) linear or branching appearance (68%); (iii) irregularity of size (45%); (iv) total number of MC (15%); and (v) number of MC per cm<sup>2</sup> (2%). **CONCLUSION:** The combination of the three most specific criteria, existence of vermicular MC, linear or branching form and irregularity of size, had a significant predictive value.

### Early radiographic encounters with the prone breast biopsy table

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We will describe and illustrate the radiographic challenge posed by moving from an "add-on", upright, analogue system to a digital prone table for stereotactic breast biopsy. There are clear advantages in terms of nearly instant images, patient comfort and lack of movement, which enables a more "measured" approach to stereotactic biopsy. However, even experienced radiographers find positioning patients a challenge. The versatility of the table, allowing a 360° approach to any lesion, creates radiographic problems. Radiographers used to standard breast projections are confronted with unfamiliar views, which makes patient positioning more difficult. The authors will describe various techniques employed to overcome such problems and pitfalls. Achieving a smooth transition to prone biopsy table work requires good training, experience, adequate time for procedures in the learning phase and, most importantly, team work.

### Breast screening for women with learning disability: a photographic journey

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Radiographers at the Jarvis Breast Screening Centre, together with Health Promotion for West Surrey staff from the Community Learning Disability Team at Surrey Oaklands and Bournemouth Trusts, compiled

a photographic journey through the breast screening (BS) process in the form of an A4 pack. The aim was to help women with learning disabilities to have a better understanding of BS. They would therefore be more informed and willing to complete BS. The pack evolved after radiographers expressed the view that a high standard of mammography at the mobile vans for these women was not possible owing to their special needs. The women's feedback to their key workers was also increasingly negative following the visit to the vans. The pack included guidelines for suitability for BS, carers notes explaining the process, and a photographic journey for the benefit of the women. It illustrated receiving the appointment letter, the practical process through screening, to receiving the results letter. Throughout the pack there were reminders to the women that they could, at any stage, say "No" and withdraw their consent. With each photograph there were See-Read symbols. The pack formed part of a package for which a Beacon Award was conferred in September 2000. The pack was made specifically for our BS unit but it is hoped that it could be utilized for other BS units or within other imaging modalities. We are now addressing the call back for assessment after BS in the same photographic way.

### Work in Progress

#### Monitoring the effects of chemotherapy in breast cancer patients using quantitative MRI

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**PURPOSE:** Change in tumour volume may be a relatively late manifestation of response to chemotherapy in patients with inoperable primary breast cancer. Recent MRI studies suggest that quantifying water apparent diffusion coefficient (ADC), microvessel permeability or the water:fat signal ratio could provide an early indication of ultimate treatment response. Therefore, a study was designed to compare the reliability of these three methods. **METHODS:** Five women have so far been recruited, who have since completed their treatment. All received standard dosage chemotherapy involving intravenous administration of 5-fluorouracil, epirubicin and cyclophosphamide. MRI was carried out prior to chemotherapy, between the second and third courses (TP2) and shortly after the final (fourth) course. ADC was measured using EPI with eight diffusion gradient weightings up to 680 s mm<sup>-2</sup>. Microvessel permeability was measured using a 7.5 min long dynamic FSPGR sequence (temporal resolution 13 s) combined with pharmacokinetic modelling. The proportion of signal arising from water (*i.e.*  $P_w = \text{water}/(\text{water}+\text{fat})$ ) was measured using spectroscopic imaging (STEAM, TE 135 ms) with seven 0.25 ml voxels. Tumour volume was measured using high resolution 3D, post-contrast fat suppressed FSPGR images. **RESULTS:** Preliminary results demonstrated that all five tumours responded (median final:baseline volume ratio 12%, range 5–32%). Both the TP2:baseline volume ratio and the corresponding permeability ratio accurately predicted response (by being <100%) in all five cases. The corresponding ADC and  $P_w$  ratios predicted response (by being >100% and <100%, respectively) in only 3/5 and 4/5 cases, respectively, suggesting that they may be less reliable indicators of final treatment efficacy.

## Neuroimaging

#### Residual tumour volume in glioma surgery: correlation between post-operative CT or MRI and the surgeon's impression

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**PURPOSE:** The aim of this study was to identify how reliable the surgeon's impression is with regard to the tumour volume resected in glioma surgery. **METHODS:** 27 patients treated for malignant glioma (19 glioblastoma multiform) had a post-operative enhanced CT or MRI study between the 3rd and 5th post-operative day. The surgeon recorded the amount of tumour resected in each patient as total (99–100%), near total (90–99%) or partial (80–90%). The radiologist

reporting the MRI or CT of these patients was unaware of the surgeon's impression. **RESULTS:** Surgeons believed that they had performed a complete resection in 14 patients, a near total resection in 10 patients and a partial resection in 3 patients. The surgeon's impression was correct in 8 of the 14 patients in whom he believed he had performed a complete resection. In the remaining 6 patients, the tumour was near totally resected in 5 patients and partially resected in 1 patient. In the 10 patients in whom the surgeon thought he performed a near total resection, his impression was correct in 7 of them. **CONCLUSIONS:** It is concluded that, in the population studied, the surgeon's impression regarding excised tumour volume is unreliable. Objective intraoperative evaluation is needed, probably by means of ultrasound, to perform total or near total resections that are known to have a major impact on patients' survival in glioma surgery.

#### Imaging of cervical spine trauma for the on-call radiologist

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Cervical spine trauma often presents even the most experienced radiologists and clinicians with challenging clinical and radiological problems. During their training, radiologists receive ample experience at reporting radiographs of cervical trauma, but there is invariably a lag period between the time of trauma and the time of reporting. On the other hand, clinicians are usually competent in the interpretation of cervical spine radiographs and have the added advantage over the radiologist of having examined the patient. Difficult cases that occur "out of office hours", such as inability to visualize the cervicothoracic junction or suspected subluxation, are often referred to the on-call radiologist for further imaging. Far from being a "catch-all" investigation, CT using conventional non-spiral equipment can be very difficult to interpret and may raise further doubts. We discuss the utility of CT in the investigation of cervical trauma in cases where plain radiographs have failed to answer the clinical question or when further questions have been raised. An array of cervical spine trauma will be illustrated in which CT has proved useful and where it has presented difficulties in interpretation.

#### Double-blind efficacy evaluation of gadobenate dimeglumine, a gadolinium chelate with enhanced relaxivity, in malignant lesions of the brain

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**PURPOSE:** The diagnostic efficacy of gadobenate dimeglumine (Gd-BOPTA) was compared with that of gadodiamide (Gd-DTPA-BMA) in patients with primary malignant tumours or metastases of the brain. **METHODS:** A subset of patients from the 410 enrolled in the USA in Phase III central nervous system clinical trials with gadobenate dimeglumine was evaluated. From these trials, there were 81 patients with intraaxial malignant neoplasms of the brain, which is the focus of the current study. Patients were randomized to one of three incremental dosing regimens. Imaging with gadodiamide at doses of 0.1 mmol kg<sup>-1</sup> and 0.3 mmol kg<sup>-1</sup> was compared with gadobenate dimeglumine at doses of 0.05 mmol kg<sup>-1</sup> and 0.15 mmol kg<sup>-1</sup> and at doses of 0.1 mmol kg<sup>-1</sup> and 0.2 mmol kg<sup>-1</sup>. Both the physician and the patient were blinded to which agent was injected and to the administered dose. Scans were obtained prior to contrast medium administration and within 5 min following administration of each dose. The two contrast injections in any one patient were separated by 15 min. Patient studies were evaluated by the principal investigator at each site in terms of lesion detection, enhancement and characterization. **RESULTS:** The diagnostic information contained on the MR films was comparable following the first contrast dose for all three dosing regimens. This was also true following the second contrast medium dose. However, the second dose resulted in a statistically significant improvement in diagnostic information compared with the first dose for all three dosing regimens. Confidence in MR diagnosis increased from pre dose to post first dose to post second dose for all three dosing regimens. The different dosing regimens also provided comparable results by this evaluation criterion. **CONCLUSION:** Gadobenate dimeglumine, employed at slightly lower doses, is comparable with gadodiamide in terms of efficacy in imaging

malignant intraaxial brain lesions. As with other gadolinium chelates, higher doses (0.15 mmol kg<sup>-1</sup> and 0.2 mmol kg<sup>-1</sup>) of gadobenate dimeglumine offer greater diagnostic information.

#### **Multislice helical CT scanning of patients with spinal injury**

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AIMS: Multislice helical CT, introduced in late 1998, has been a major leap forward in CT technology. It allows high quality volume imaging with excellent 3D and multiplanar image (MPI) reconstruction. The aims of this work are to present a practical protocol for volume imaging of the spine and to provide guidelines on the most appropriate MPI reconstruction and image selection on hard copies. MATERIALS AND METHODS: A total of eight cases of vertebral fracture following trauma, which were referred for multislice CT, were reviewed. They included three lumbar, three thoracic and two cervical fractures. The spine was scanned from two vertebral bodies above to two vertebral bodies below the level of injury contiguously, employing a collimation of 1 mm/slice thickness using a SOMATOM plus 4-volume zoom multislice CT scanner (Siemens). 5 mm contiguous axial and 2 mm contiguous sagittal images were reconstructed and provided on the hard copies. Oblique, coronal images (2 mm slice thickness) and 3D reconstruction were provided in some cases. RESULTS AND CONCLUSION: High quality sagittal images were possible, which provided excellent information regarding the nature and extent of the bony injury and were able to determine the alignment of the spine. They also provided detailed anatomy of the pedicles and facet joints. Reconstruction along the oblique or coronal planes, as well as 3D reconstruction, did not offer any extra useful information.

#### **Constructive interference in steady state 3D sequence: applications in neuroradiology**

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INTRODUCTION: Conventional T<sub>2</sub> weighted and fluid attenuated inversion recovery (FLAIR) sequences on MRI have low sensitivity and specificity for detecting lesions in the cerebrospinal fluid-filled spaces and ventricles of the brain. Improved detection of such lesions non-invasively can alter management and can assist in design of surgical protocols. Constructive interference in steady state 3D (CISS 3D) is a heavily T<sub>2</sub> weighted image in which lesions in cerebellopontine cisterns and within the ventricles have improved conspicuity. We studied 20 patients with lesions in the CSF spaces and ventricles using CISS 3D. METHODS AND MATERIALS: 20 patients (age range 12–55 years) were investigated on 1.5 T superconducting MR equipment. Conventional T<sub>1</sub> weighted (650/12), T<sub>2</sub> weighted (5500/90) and FLAIR (9000/120) sequences were obtained in all patients. Patients with suspected lesions in the basal cisterns and with unexplained or non-communicating hydrocephalus were included in this study. All such patients were studied with a CISS 3D sequence (12/6, 70° flip angle, eff. thickness 1 mm). Gadolinium enhanced (0.1 mmol kg<sup>-1</sup>) contrast studies were performed when required. RESULTS: CISS 3D images clearly demarcated cisternal and intraventricular lesions in all patients. Lesion to CSF differentiation was possible in all patients. Lesion to CSF differentiation was possible in all patients' intraventricular cysts causing obstructive hydrocephalus (n=8). Vascular loop causing hemifacial spasm and a retrocerebellar arachnoid cyst mimicking a mega cisterna magna were seen in one patient each on CISS 3D images. Both cases of CSF rhinorrhoea demonstrated dural breach on CISS 3D. Tumour capsule–CSF and tumour–cranial nerve interfaces were more conspicuous on CISS 3D than on conventional sequences. CONCLUSIONS: CISS 3D sequences are more sensitive than T<sub>1</sub> weighted, T<sub>2</sub> weighted and FLAIR sequences in detecting cisternal and intraventricular lesions. CISS 3D is diagnostic for intraventricular cysticercal cysts. This sequence is useful in the investigation of suspected lesions in the basal cisterns and in unexplained or non-communicating hydrocephalus.

#### **Abnormal cerebral cortex shown on high resolution ultrasound in term neonates with severe brain damage**

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PURPOSE: The CT and MR appearances of the term infant brain with hypoxic ischaemic injury (HII) are well recognized. Transfontanelle cranial ultrasound scanning is an accessible bedside test, but abnormalities are often difficult to detect or are non-specific. We describe a characteristic evolving appearance of the cerebral cortex seen with cranial ultrasound scanning of four term infants with clinical evidence of HII and IN two infants with intracranial infection. We correlate this with their CT and MR findings. RESULTS: Using 7–12 MHz ultrasound, the normal cerebral cortex deep to the anterior fontanelle appears hypoechoic superficially and hyperechoic in the deeper layers. On serial ultrasound scans over 4–14 days in six term infants with clinical evidence of either severe HII or intracranial infection, the posterior frontal cortex first became uniformly hyperechoic and then a "reversal" pattern of echogenicity to the normal was seen. Correlation with CT or MR scanning was obtained in five cases. In three cases, CT or MRI revealed changes of HII in areas corresponding to the abnormal areas seen with ultrasound. In one case, MR revealed extensive meningeal and ependymal infection. In one case, CT scanning revealed extensive haemorrhagic venous infarction. In all cases, short- and medium-term clinical outcome was poor in terms of neurological morbidity or death. CONCLUSIONS: We conclude that serial cranial high frequency ultrasound offers valuable prognostic information from the bedside, when these characteristic changes are seen in term infants with clinically suspected brain damage.

#### **Imaging the child's ear: a pictorial review of common ear problems in children**

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Hearing loss early in life can have a profound effect on speech and language development. This pictorial review will demonstrate the spectrum of common abnormalities encountered by the radiologist when imaging the child with deafness. A range of conditions will be shown illustrating problems along the auditory pathway, from the external auditory meatus through the middle ear cavity to the inner ear structures and brain. Conditions such as microtia, cholesteatoma, wide vestibular aqueduct syndrome and the Mondini malformation will be shown. The role of CT and MR will be highlighted with emphasis on the assessment of the child with conductive, sensori-neural and mixed hearing loss.

#### **Radiological anatomy of the anterior skull base**

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AIM: CT of the sinuses is routinely performed prior to functional endoscopic sinus surgery (FESS). The role of CT is to define the pattern of sinus disease and to demonstrate, in particular, the osteomeatal complex and anatomical variants relevant to the endoscopist. The majority of FESS related complications occur in relation to the skull base, where anatomy is variable and of great importance. This study of 150 CT scans of the sinuses aims to define the normal variation in position of the cribriform plate in relation to the hard palate and superior orbital ridge, and to define variation in shape of the anterior skull base including the cribriform plate and fovea ethmoidalis. METHOD: 150 consecutive scans were analysed. A method of measuring the skull base position and pattern is presented. There were five different patterns of skull base shape, which are illustrated. RESULTS: The mean height of the cribriform plate above the hard palate was 4.52 cm with a standard deviation of 0.42 cm, giving a normal range of 4.1–4.94 cm. Similar data for the relationship of the cribriform plate to the orbital ridge are presented. CONCLUSION: There was no statistical difference between left and right sides and there was no association of sinus pathology on CT with a particular pattern or position of the skull base.

### Comparison of MRI brain scans on 1 T and 0.2 T systems

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**METHODS:** We evaluated the diagnostic quality of images produced on a series of patients having MRI brain scans on both low (0.2 T) and mid (1.0 T) field systems. 30 patients undergoing follow-up for brain tumours were scanned on both an open 0.2 T and an 1.0 T MRI scanner within a short period of time.  $T_2$  weighted transverse,  $T_1$  weighted coronal and post-gadolinium  $T_1$  weighted transverse and coronal sequences were performed on both scanners. The images were assessed blind by two radiologists. **RESULTS:** Images were of comparable diagnostic quality on both scanners. Finer structures were adequately demonstrated on both sets of scans but were slightly better demonstrated on the 1.0 T scans. On the images produced from the 1.0 T scanner, a significant number of post-gadolinium  $T_1$  scans demonstrated an artefact in the posterior fossa, thought to be due to flow, which was not present on any of the scans produced on the 0.2 T scanner. Motion artefact was present on scans of two patients scanned on the 1 T machine but on no scans from the 0.2 T machine. The motion was postulated as being due to claustrophobia. Both systems produce images of a suitable quality for follow-up of patients with primary brain tumours. There is potential for missing very small focal lesions on the low field system owing to decreased resolution, and of missing lesions in the posterior fossa on the 1.0 T system owing to artefact.

### Assessment of brain metastases by means of dynamic susceptibility contrast enhanced MRI

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**PURPOSE:** To assess if pretherapeutic measurements of regional cerebral blood flow (rCBF) and volume (rCVB) are able to predict the response of brain metastases to radiation therapy, and to assess the influence of radiosurgery on rCBF and rCVB in brain metastases and normal surrounding tissue. **METHODS:** 25 patients with brain metastases were examined prior to high dose radiosurgery with conventional  $T_1$  and  $T_2$  weighted MRI and dynamic susceptibility contrast enhanced MRI (DSC MRI). For DSC MRI, 55  $T_2$  weighted GE images of two sections were acquired after bolus administration of 0.1 mmol kg<sup>-1</sup> gadoteridol (ProHance) for the simultaneous measurement of brain feeding arteries and brain tissue, allowing an absolute quantification of rCBF and rCVB. Follow-up examinations were performed 6 weeks and 3 months after radiotherapy and the acquired perfusion data were related to a three point scale of treatment outcome. Radiosurgery was performed by a linear accelerator with an 80% isodose of 18–20 Gy. The heads of the patients were immobilized by means of a cast mask. **RESULTS:** DSC MRI was able to assess perfusion data in all patients. Higher pretherapeutic rCBV seems to predict a poorer treatment outcome. After radiosurgery, patients with tumor remission and stable disease presented a decrease of rCBV over time regardless of temporary increase in tumour volume. Patients with tumour progression at the 3 month follow-up presented an increase of rCBV. Effects on normal surrounding tissue could not be observed. **CONCLUSION:** DSC MRI using gadoteridol allows the non-invasive assessment of rCBV and rCBF of brain metastases and changes in these due to radiosurgery. The method may also be able to predict treatment outcome. Furthermore radiotherapeutic effects on surrounding unaffected tissue can be monitored.

### Dysplasia epiphysealis multiform: a rare case of cervical cord compression

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This is a case study of a 50-year-old male with high cervical cord compression caused by the rare genetic disorder dysplasia epiphysealis multiform. The presentation includes a description of the main clinical and radiological features of the condition. Also included are the patient's case history, surgical treatment and post-surgical follow-up. The presentation is illustrated with CT and MR images.

### Work in Progress

#### Evaluation of cross-sectional lumen morphology in carotid atherosclerotic disease using spiral CT angiography

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**PURPOSE:** To determine the frequency of non-circular lumens in patients with significant carotid atherosclerotic disease, and to evaluate the effect of non-circular lumens on stenosis measurement derived from angiographic projections. **METHODS:** 100 consecutive patients presenting with an internal carotid artery stenosis of at least 50% were imaged with spiral CT angiography. The transverse morphology of the diseased lumen was assessed on axial images, and the frequency of non-circular lumens was determined. In these cases, maximum intensity projection (MIP) angiograms were reconstructed in standard angiographic planes and in a plane selected according to the lumen obliquity, chosen to optimize the angiographic representation of the maximal stenosis. North American Symptomatic Carotid Endarterectomy Trial (NASCET) measurements were calculated from the MIP images, and differences between values obtained from standard and optimized projections were recorded. **RESULTS:** Non-circular lumens were observed in 18 of 100 patients, and consisted of elliptical and linear transverse profiles. The transverse orientation of the lumen in these cases ranged from +90 to -870 relative to the anteroposterior plane. An increase in the calculated NASCET stenosis was demonstrated when measurements were obtained from angiographic reconstructions obtained in the exact plane of the lumen obliquity compared with standard angiographic projections. As a result, the stenosis severity was upgraded from moderate to severe in one case. **CONCLUSIONS:** Non-circular transverse lumen profiles are not uncommon and may introduce error into NASCET calculations obtained from standard angiographic projections.

### Work in Progress

#### Imaging considerations in the demonstration of the post-traumatic syrinx in spinal cord in MRI

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**PURPOSE:** To review the MRI considerations when demonstrating a syrinx in post-traumatic spinal cord. **METHOD:** A pictorial review of development of the post-traumatic syrinx and differentiation from cyst and myelomalacia. To demonstrate the minimum MR sequences necessary in acute and chronic follow-up. **CONCLUSION:** Syrinx is a well recognized complication of spinal cord injury and requires specific sequences for delineation. The poster aims to show images of the condition, the minimum sequences used and a comparison with cysts and myelomalacia.

## Physics

### Correlation of the apparent diffusion coefficient and R2 in the normal and diseased prostate

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**INTRODUCTION:** Although MRI has become a useful tool for imaging the prostate, there is still overlap in the many techniques currently used. Previous work has shown that the apparent diffusion coefficient (ADC) is correlated with T2 in healthy tissues but not in those that have undergone changes in the extracellular space. This work looks at the correlation of the ADC and T2 in healthy and diseased prostatic tissue. **METHODS:** 8 healthy volunteers and 15 patients with PCa and/or BPH were imaged using a  $T_2$  weighted FSE sequence and diffusion weighted imaging in the x, y and z directions to allow calculation of a trace value. T2 and ADC values were calculated in the peripheral zone and central gland of the volunteers, and in the peripheral zone, PCa and BPH of the patients. R2 (1/T2) and average ADC values were correlated using the Pearson correlation coefficient. **RESULTS:** The average of the trace showed no correlation with R2 for any tissue type. When the individual components of the ADC were correlated with R2 only the y component of the ADC correlated with R2 in the peripheral zone in the patients. However, when the Bonferroni correction is applied, this is no longer significant and may be an artefact

of the multiple comparisons made. DISCUSSION: That no correlation is seen between the ADC and R2 is slightly surprising in view of correlations seen in other tissues. However, this implies that the ADC offers further information on the disease processes than  $T_2$  imaging alone.

#### **A study of radon levels in NHS premises in radon-affected areas around the UK**

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**PURPOSE:** Employers in radon-affected areas are required by the Management of Health and Safety Regulations 1999 to assess the risk to staff from radon and to take remedial action if levels are above 400 Bq m<sup>-3</sup>. Assessment is achieved by placing etched track detectors in occupied ground floor and basement rooms. Radon-affected areas are defined by the National Radiological Protection Board (NRPB) in terms of results in domestic houses, where the action level is 200 Bq m<sup>-3</sup>. The question arises as to whether this is representative of levels in the workplace. **RESULTS:** Results of initial surveys in NHS premises in Northamptonshire, north Oxfordshire and north Wales are presented and compared with the NRPB results for domestic houses in the same area. In four large district general hospitals the surveys found that the radon levels had a log-normal distribution, as is the case for houses, but the percentage of rooms over 400 Bq m<sup>-3</sup> in NHS premises was similar to, or slightly above, the percentage of houses found by the NRPB to be above 200 Bq m<sup>-3</sup>. In one smaller hospital in north Wales, in an area where few houses have been tested by the NRPB, some elevated radon levels have been found. This suggests that houses in the vicinity should be targeted for radon assessment.

#### **The role of timer error in the administration of specified doses and its determination**

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Timer error determinations were made on an SSDL <sup>60</sup>Co teletherapy unit of type Eldorado 8(#104) over a period of 9 months up to March 2000. Five ionization chambers and three electrometers were used, combined in various ways to give seven dosimeter sets. Out of the four well documented determination methods, namely the two-exposure method, the single/double exposure method, the single/multiple exposure method and the graphical method, this work has used only the graphical method as it can confirm the linearity of the dosimeters. Using this method, a straight line graph of exposure  $R$  vs timer setting  $s$  gives an intercept on the time axis equal to the timer error, and the correlation ( $r^2$ ) gives an indication of dosimeter linearity. Exposure measurements were made with the seven dosimeter sets and 19 graphs were obtained, each with six points, most of these points being the average of five readings. The timer errors obtained from the seven dosimeter sets show excellent reproducibility, being consistent with each other and with the overall average of  $1.2799 \pm 0.0386$  s. Since there is a very small chance of the timer error being greater than the 3-standard uncertainty value of 1.4 s, it is possible to neglect the error for irradiation times greater than 140 s, thus satisfying the IAEA recommendation that the dose uncertainty should be less than 1%. If the prescribed time  $T$  is corrected by setting the timer to  $T + 1.2799$  s, the dose uncertainty is then determined only by the uncertainty in the timer error, which is 0.0386 s, and is therefore much less than 1% for irradiations of normal duration. When the timer setting is greater than the actual exposure time, as it is here, then the graphical method gives a positive timer error. If the timer is regarded as a pre-set adjustment, however, then it is logical to think of a negative error occurring when the actual time is less than the pre-set value, and this usage is in accordance with IAEA recommendations. Both sign conventions are found in the literature, resulting in some authors making confusing statements.

#### **Multislice CT: everything you wanted to know but were afraid to ask**

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In the latter half of 1999, new CT scanners were installed at both the John Radcliffe Hospital and the Churchill Hospital, two sites in the Oxford Radcliffe Hospitals NHS Trust. The unit chosen for each site was the IGE LightSpeed QX/i computed tomography scanner. This scanner represents one of a number of units that incorporate the new technology of multislice image acquisition, both in axial and helical (spiral) mode. The complexity of both the physics and technology involved has increased compared with the more familiar single slice scanners and this can be somewhat confusing, especially when considering parameters such as pitch and patient dosimetry. This poster presentation displays a novel approach to providing advice and teaching to radiologists, radiographers and other interested staff groups. Information regarding the new scanning capability, technology and dosimetry were compiled into a wall poster for display in the scanner control room. It seeks to present in a clear and concise fashion how the scanner achieves multislice image acquisition. Furthermore, it provides information on parameters such as "radiation" pitch and "image" pitch and their relationship, something not always obvious but that has significant radiation dose implications. The poster is primarily a teaching aid, but also acts as a ready source of reference material for staff (about the unit they are actually using) and gives points of contact for further information and advice. Should it prove successful, it is hoped that this methodology could be applied to other complex X-ray equipment.

#### **Air-gap and grid technique for high kilovoltage digital chest radiographs: comparison of dose and image quality**

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**PURPOSE:** To compare the image quality and radiation dose between air-gap and grid techniques for high kilovoltage digital chest radiographs. **METHODS:** 25 patients were selected that had a previous chest radiograph using the grid technique and a recorded dose area product (DAP) meter reading. These patients were X-rayed again (as follow-up requests) using the air-gap technique, and DAP meter readings were recorded. Each X-ray image was then observed by two consultant radiologists under the following criteria: best visualisation of lung vessels; and adequate mediastinal penetration. Effective doses (ED) were calculated using a programme called PCXMC. **RESULTS:** Image quality; radiologists correctly identified the radiographic technique of 42% of the images and preferred the images taken using air-gap technique (58%) without knowing what technique was used. Radiation dose; average ED for air-gap technique was 0.017 mSv compared with ED for grid technique of 0.029 mSv. **CONCLUSION:** Neither radiographic techniques demonstrated an improvement of image quality therefore the radiographic technique that produces the lowest dose (air-gap) should be used.

#### **Audit of patient and staff doses in orthopaedic hip procedures**

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**METHODS:** A dose audit was carried out on three orthopaedic hip procedures; variwall nail, dynamic hip screw and cannulated screw. No comparable audit had been carried out previously, and neither of the two mobile Phillips BV29 C-arm image intensifiers used had been fitted with a dose area product meter. These techniques were selected as they represent some of the most common procedures carried out within orthopaedic theatre. Staff doses were estimated from dose rate measurements in realistic scatter conditions. Projected workloads were incorporated and resultant doses compared with personal dosimetry measurements, assessed both inside and outside a lead rubber apron. **RESULTS:** Unshielded dose rates of around 300  $\mu$ Sv h<sup>-1</sup> to the surgeon.

60  $\mu\text{Sv h}^{-1}$  to the attending nurse and 10  $\mu\text{Sv h}^{-1}$  to the anaesthetist were found, highlighting the large range of doses encountered and the importance of appropriate personal protective devices. Patient doses were assessed from a radiographer's log of technique factors and screening times, accumulated over a 3 month period and from recent quality assurance data. Although very large variations were found, average screening times were 3.12 min for variwall nail, 0.76 min for dynamic hip screw and 0.95 min for cannulated screw. Maximum overall screening time was 3.9 min for variwall nail. Patient doses, analysed by surgeon and by room, showed significant variation indicating scope for further optimisation. CONCLUSION: It was concluded that dose audits, particularly those associated with equipment and techniques not previously subject to such audits, are a valuable radiation protection tool.

#### Time-dependent dynamics of radiative antagonism and hormesis owing to the action of irradiation and free radicals on DNA

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The main effect of the action of ionizing radiation on biological systems is the creation of double breaks in DNA. It was shown that the energy of interaction between the end-pairs of nucleotides on the opposite sides of a break is under the control of: (1) the width of the break  $L$ ; (2) coulomb interaction of charges distributed on the surfaces of these nucleotides; and (3) dispersion features of dielectric permeabilities of the nucleotides and intermolecular salt-aqueous medium. The formation of hydrated electrons and heavy ions influences the energy of interaction in two main ways: (1) by changing the dielectric permeability of salt-aqueous medium and (2) by changing the coulomb interaction between nucleotides. For the first time, it has been established that at low concentration of hydrated electrons (or at high acidity of salt-aqueous medium), the energy of mutual interaction of some end-pairs of nucleotides (AT-AT, CG-CG) has a repelling barrier with value  $V:(1-3)$  KT at  $L:7-8$  A. If this concentration is increasing, the barrier is reducing and disappears. All other transversal end-pairs of DNA nucleotides experience only attraction. The time-dependent dynamics of the processes of depolymerization and autorepairing of DNA (the dynamics of birth and destruction of DNA double breaks) owing to the separate or combined action of slight and intensive ionizing radiation as well as the action of free radicals (including problems of DNA radiation antagonism and synergism at combined irradiation, the phenomenon of hormesis, the low dose problem for the cases of short- and long-term intensive and weak irradiation) was studied based on these processes.

#### The method of spatial diagnostics and imaging of solitary radioactive sources by radiation intensity correlation

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The intensity correlation method of spatial and angular (three-dimensional) location, spatial diagnostics and imaging of solitary active or passive (scattering exterior radiation) sources of radiation is suggested and investigated. This method is based on the phenomenon of pair correlation of intensities sums of pulse spherical waves of X-radiation,  $\gamma$ -radiation or neutrons (correlation of 4th order of amplitudes of these waves), coming from a solitary radioactive object, the location of which is to be found. The intensity correlation method is related to availability of partial mutual intensities correlation of radiation field from one source, registered by detectors, situated in the different points of space. This effect takes place in that case, if the partial mutual field coherence exists in the places of detectors disposition. The photoelectrons arising in the detector as a result of registration of a single event (arrival of quantum or particle) generate fluctuating exit currents in the electronic schemes of signals treatment. These currents contain coherent component corresponding to low frequency intensities fluctuations of registered radiation flow induced by fluctuations of activity of radiation source. For three-dimensional location of the radiation source it is necessary to use three or more spatially separated independent detectors. By this method the space location and imaging of investigated active and passive sources with an error about 1 cm in biological and human investigation is possible.

#### Evaluation of image quality on modern fluoroscopy systems and the development of reference contrast detail curves

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METHODS: A comparative assessment was made of a number of modern multipurpose C-arm fluoroscopy systems. A series of performance tests was carried out on each unit, including measurement of radiation dose and image quality. Maximum and typical patient doses and the input kerma to the image intensifier were measured. Imaging performance in fluoroscopy mode was evaluated using typical contrast detail test objects as well as an objective assessment of limiting resolution, field size and image geometry. Additional measurements were made for digital image acquisition. Compliance with appropriate requirements and legislation covering electrical, mechanical and radiation safety was checked. RESULTS: Measured patient doses on all units assessed complied with recommendations given in current guidelines. The results also indicate that image intensifier input dose levels on modern systems are generally lower than for earlier generation units. In terms of image quality, the modern systems show a significant improvement both with respect to older units and to existing reference data. As the suppliers of all systems evaluated had suggested optimal operation, the data collected were used to produce updated reference threshold contrast detail detectability (TCDD) curves for fluoroscopy. The data are normalized both for field size and for image intensifier input kerma. New TCDD curves were additionally produced for digital image acquisition through the image intensifier, with the data normalized for field size only.

#### Fabrication and validation of a female reproductive stereolithographic biomodel derived from spiral CT

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PURPOSE: This study investigates the fabrication of a biomodel with the aid of stereolithography. It was undertaken to determine the dimensional accuracy of a female reproductive biomodel derived from spiral CT and fabricated using the rapid prototyping technique of stereolithography (SLA). METHODS: Distance measurements were taken to compare the resulting biomodel with the original organs. 14 measurements were taken using three different observers for objectivity and accuracy. RESULTS: The 160 g biomodel is slightly more voluminous than the original organs, with a mean difference of +0.89 mm and a stand error from the mean of 0.86 mm. The average absolute difference is 1.96 mm, with a stand error from the mean of 0.82 mm. Student's one-sample  $t$ -test at 5% probability indicates that the differences are insignificant, representing an accuracy of 97.34%. CONCLUSION: These results support the use of SLA modelling of female reproductive organs in the pursuit of further aims in this research programme.

#### Dose optimization for barium enema examinations

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PURPOSE: At Nottingham City Hospital, barium enemas are conducted by consultant radiologists, registrars in training and radiographers. This study investigated various optimization strategies to reduce dose whilst maintaining diagnostic quality, including use of copper filtration and computed radiography. MATERIALS AND METHODS: Barium enema doses were monitored using dose-area product (DAP) meters. Ancillary information collected by questionnaire included patient height and weight, operator's name, screening time and number of images. RESULTS: On adding 0.1 mm copper filtration, the mean DAP was reduced from 17.7 Gy  $\text{cm}^2$  (95% CI 15.6-20.2 Gy  $\text{cm}^2$ ) to 11.2 Gy  $\text{cm}^2$  (95% CI 9.7-13.0 Gy  $\text{cm}^2$ ). There was no measurable degradation of image quality. To determine how much copper filtration may be added, local image quality criteria have been developed. There was no significant difference between mean DAPs for examinations carried out by radiographers (16.3 Gy  $\text{cm}^2$ ; 95% CI 14.8-18.1 Gy  $\text{cm}^2$ ) and consultant radiologists (12.3 Gy  $\text{cm}^2$ ; 95% CI 8.0-20.2 Gy  $\text{cm}^2$ ). However, the mean DAP for registrars was

twice as high, at 35.1 Gy cm<sup>2</sup> (95% CI 30.2–41.1 Gy cm<sup>2</sup>). Use of computed radiography (CR) for the overcouch radiographs would increase patient dose, since the CR "speed" required would be slower than the film–screen combination currently in use. The process of reading CR plates can increase the examination time by up to 8 min. **CONCLUSION:** The use of additional copper is recommended. The higher DAP for registrars is partly due to patient selection bias, but also raises issues about the level of supervision required for registrars in training. Each Trust must justify its local practice. The potential increased dose and the logistical difficulties with CR need to be overcome before our Trust can move to a filmless environment.

#### **Reduction of radiation dose due to micturating cystourethrography using digital fluoroscopy**

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**PURPOSE:** The purpose of this study is to evaluate the reduction of radiation dose in patients undergoing micturating cystourethrography (MCU) using digital fluoroscopy compared with MCU using conventional fluoroscopy. **METHODS:** We compared the screening time and dose–area product (DAP) reading in 181 patients who underwent MCU using digital fluoroscopy with 147 patients using conventional fluoroscopy. **RESULTS:** The mean screening time in the group using conventional fluoroscopy was 1.395 min (range 0.2–4.8 min) and the mean DAP was 124.02 cGy cm<sup>-2</sup> (range 9–1206 cGy cm<sup>-2</sup>). Using digital fluoroscopy, the mean screening time was 1.890 min (range 0.2–7.8 min) and the mean DAP was 69.42 cGy cm<sup>-2</sup> (range 1–1871 cGy cm<sup>-2</sup>). In a subgroup of patients who had the examination performed using digital fluoroscopy within the last 3 months of our study, the mean screening time was 1.44 min and the mean DAP was 32.63 cGy cm<sup>-2</sup>; this was probably as we became more familiar with the digital equipment. Analysis of covariance shows that although the screening time (adjusted for age, sex not being significant) in the group using the digital technique is significantly higher ( $p < 0.001$ ) than in the group using conventional fluoroscopy, there is a two-third reduction in DAP reading in the group using digital fluoroscopy (mean difference is 67.7 between these groups, adjusted for age and screening time). The mean calculated effective doses are 1.257 mSv and 0.599 mSv in the groups using conventional and digital fluoroscopy, respectively. **CONCLUSION:** Digital fluoroscopy produces a significant reduction in radiation dose in children undergoing MCU. These data will help to develop reference radiation dose values for this very commonly performed procedure in children.

#### **The relative character of genetic mechanisms of people's radioresistance**

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**PURPOSE:** Evaluation of the role of genetic factors in the development of radiation effects has relevance for the solution of theoretical and practical problems. Genetic polymorphic systems that remain invariable throughout life have important value in this respect. The purpose of the present research was to evaluate the role of some genetic polymorphic systems in the development of chronic radiation syndrome (CRS) in atomic industry workers. **METHODS:** 1177 workers at atomic enterprise PA "Mayak" who were exposed to external  $\gamma$ -radiation in summary doses from 0.1–760 cGy were investigated. Haptoglobine (Hp) and group-specific protein (Gc) types as well as ABO blood groups were determined. The relevant role of the Hp genetic system in the development of CRS in atomic industry workers caused by chronic external  $\gamma$ -irradiation was established. It was established that workers with type Hp 2-2 had higher relative risk of CRS (2.0) compared with the 0.6 relative risk of workers with types Hp 1-1 and 2-1 under identical exposure doses in dose diapason from 100–400 cGy. The contribution of Hp types to CRS development is not implemented in all dose diapason causing CRS (50–760 cGy), but only in definite interval of expose doses, *i.e.* it had relative character. **CONCLUSIONS:** Thus, genetic mechanisms defining differences in people's responses to radiation do not have an absolute character, which is why they are not significant at relatively small expose doses, but are implemented at intermediate expose doses, and have no essential value at considerable expose doses.

#### **The objective structured clinical examination: station validity**

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**PURPOSE:** The objective structured clinical examination (OSCE) has been used as an assessment tool at South Bank University for the last 10 years. During the academic year 1999/2000, OSCE stations were developed to assess level 2 skills in accordance with the re-validated course. Each station was reviewed by two lecturers before being included in the examination. This paper examines the validity of each of the 20 stations used. **METHOD:** The distribution of results for 27 students across all stations within the seven competence areas examined was investigated. Distribution curves were produced for each station. Those stations with abnormal distribution curves were re-examined for content, clarity and allocation of marks. **RESULTS:** 7 out of 20 stations were not represented by normal distribution curves. Five competence areas were involved. There were three stations in the competence area "Identification of radiographic anatomy", all three of which had mean scores of over 72. The other stations were in competence areas: "Image evaluation", mean 30; "Patient preparation", mean 26; "Radiographic technique", mean 77; and "Radiographic positioning/practical", mean 75. **CONCLUSION:** The competence area with the highest number of skewed distribution curves was "Identification of radiographic anatomy". All seven stations not represented by normal distribution curves will be further considered by a larger team before further use or application.

#### **Research into reference dose levels for barium enema and barium meals**

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In response to the 97/43/Euratom directive, the School of Diagnostic Imaging in Dublin, Ireland has completed a study establishing diagnostic reference dose levels for four of the most common diagnostic examinations (chest, abdomen, pelvis and lumbar spine). The research indicated reference dose levels up to 40% lower than the UK's. The next step was to progress to fluoroscopic examinations. A study currently underway by our group aims to establish reference dose levels for barium enemas and barium meals. 16 hospitals nationwide have been randomly selected to take part in the study and ethical approval has been obtained. Dose area product meters will be used, as they are the preferred method of dose measurement for fluoroscopic examinations. A minimum of 10 patients per examination will be required and the radiographers will be relied upon to record patient, examination and dose details. Information on all relevant equipment *e.g.* filtration, film/screen, will also be collected and analysed and a reference dose level for groups of standard sized patients will be obtained at the third quartile value. These reference dose levels are hoped to act as a guide for Irish hospitals and trigger investigations in hospitals where levels are consistently being exceeded. Available data will be presented.

#### **Digital systems for X-ray chest screening in Russia**

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**PURPOSE:** An extreme increase in the prevalence of tuberculosis in Russia and other countries has made chest X-ray screening of the population, including children, necessary. Low image quality and high doses restrict the use of traditional film fluorography techniques. To overcome this problem, inexpensive digital X-ray units suitable for chest radiography must be designed. **METHODS:** In recent years, Russian research and industry companies, including the Moscow Research and Practical Centre of Medical Radiology, have designed a variety of models of digital, low radiation chest X-ray units, with four different types of detector: gas (xenon) and solid (photocells) for scanning systems; optics; CCD matrix; and detectors based on X-ray image intensifiers. The cost of these new systems is similar to that of general film fluorography units. Each of these digital chest X-ray units has been tested in tuberculosis hospitals across Russia, providing the opportunity to compare their technical characteristics and medical efficiency. **RESULTS:** This poster will include the main technical characteristics of the detectors. Following analysis, it became clear that each type of unit provided images of high enough quality to achieve a

reliable diagnosis of lung malignancy. Patient radiation doses are reduced by a factor of 5–20 compared with film fluorography. The efficiency of these units was also confirmed by software designed specifically for screening digital chest systems. **CONCLUSION:** 2 years experience has confirmed that these Russian digital X-ray systems provide high quality images at low radiation doses, thus making them suitable for chest screening of the general population, including children.

#### **Entrance dose measurement using LiF TLD rods without build-up cap**

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**PURPOSE:** Nowadays, verification of tumour dose for all patients undergoing external beam radiotherapy is mandatory as part of quality assurance programmes in radiation oncology departments. **METHOD:** Among the various methods, entrance dose measurement is more reliable for this purpose. A simplified technique to measure the entrance dose is developed using LiF thermoluminescent dosimeters (TLDs) without build-up cap, and calibrating them at the surface of the phantom against the maximum dose. **RESULTS:** The dose measured in the phantom using TLDs calibrated for entrance dose was found to agree with the maximum dose determined from the treatment planning system (TPS), with maximum discrepancies of 5% for 6 MV and 10 MV X-rays, and 3% for 9 MeV electron beams. Consequently, the entrance dose measured during dose delivery to patients with prescribed geometry for the same beams was found to be compatible with the maximum discrepancies of 4.2% compared with the dose determined by TPS. **CONCLUSION:** Careful implementation of this technique provides assurance in accepting the treatment algorithms derived by the TPS or in re-evaluating the simulation procedure.

#### **Hand doses in interventional radiology: how can they be assessed?**

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**PURPOSE:** Radiologists undertaking interventional procedures can receive doses to their hands that are high enough to warrant that they be classified as radiation workers. The dose received by the hands can be monitored using thermoluminescent dosimeter (TLD) rings worn at the base of the fingers. However, the Ionising Radiations Regulations 1999 stipulate that the dose to the most exposed 1 cm<sup>2</sup> of skin should be assessed. This requires knowledge of the dose distribution across the hand. **METHODS:** Doses to the hands of radiologists performing a wide range of diagnostic and therapeutic interventional procedures have been studied at centres throughout the West of Scotland. Each assessment involved attaching 20–100 LiF:Mg,Ti TLD chips at various locations on both dorsum and palmar aspects of the hands. The doses per procedure or per session are measured. **RESULTS:** Initial results show that the hand nearest to the radiation field is likely to receive the highest dose. This tended to be the left hand, but was dependent on factors such as room layout. Doses ranged from 0.2–5 mSv per session, which was typically 25–30% higher than the dose to the other hand. The doses recorded generally increased along the hand from the wrist to the fingertips. The dose gradient varied with procedure, being steeper for biliary procedures for which manipulation required the hand to be closer to the radiation field. The influence of equipment type, room layout and clinical protocols on doses and dose distribution will also be discussed.

#### **An investigation of X-ray beam energy influencing radiographic image quality: a comparison of screen-film, photostimulable storage phosphor and selenium drum acquisition systems during chest radiography**

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**AIM:** The aim of this study is to compare the influence of beam energy on radiographic image quality for chest radiographs acquired using screen-film, photostimulable storage phosphor and selenium drum acquisition systems. The system response to increased beam energy will be assessed to determine whether there is a proportionate response for all three acquisition systems. **METHODS:** Image quality of

posteroanterior (PA) and lateral chest radiographs, taken at three beam energies (90 kVp, 110 kVp and 125 kVp), will be evaluated for each image acquisition system ( $n=540$ ). The influence of beam energy on image quality, for individual image acquisition systems, will be assessed. Influence of beam energy on image quality for each system will be compared to determine whether there is an equal response to increased beam energy and whether the response is proportional. Two radiologists, two radiographers and a medical physicist will rank the image quality of the PA and lateral chest radiographs. Image quality will be assessed using the European guidelines on quality criteria for diagnostic radiographic images (EUR 16260EN). These image quality criteria specify important anatomical structures that should be present on a radiograph. They have been checked for acceptability in Europe-wide trials. These trials were carried out on hard copy radiographs. The validity of these image quality criteria for the assessment of digital soft copy radiographic images will be evaluated.

#### **A practical method for establishing diagnostic reference levels in diagnostic radiology**

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**PURPOSE:** In the UK, it is law (Ionising Radiations Regulations 1999 (IRR99)) that diagnostic X-ray departments have quality assurance (QA) programmes in place. QA is about producing quality images at acceptable dose levels. The latest legislation, the Ionising Radiations (Medical Exposures) Regulations (IRMER), introduced the concept of diagnostic reference levels (DRLs) into legislation for the first time. IRMER emphasizes the need to set local DRLs appropriate to the equipment and techniques performed. **MATERIALS AND METHODS:** This project examines dose measurement techniques and data to facilitate the implementation of local DRLs in a busy X-ray department. An audit of dose-area product data from the Patient Administration System (PAS) was performed to provide data for preliminary DRLs. This allows retrospective identification of examinations performed at high patient doses. **DISCUSSION:** Ideally, the potential dose would be assessed prior to the examination. This approach would involve complex calculations for each examination, which, in a busy department, is impractical. A novel algorithm is used to predict patient doses from exposure parameters for standard set-ups (European Guidelines on Quality Criteria for Diagnostic Radiographic Images) from QA data specific to each room. The data produced by this algorithm will be used to construct a nomogram to indicate the effective dose from kV and mAs set by the radiographer. The nomogram will be specific to an examination and room. The PAS audit will be used to set initial DRLs for the nomograms. The nomograms provide pre-exposure warning or immediate indication that a patient dose exceeds the DRL.

#### **A practical testing methodology for image guided surgery systems**

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**PURPOSE:** To develop a practical test methodology for examining the accuracy of image guided surgery (IGS) systems for a range of conditions. **METHODS:** A skull phantom containing a number of ball bearings and fiducial markers was imaged using 1 mm CT slices. Data were then transferred to two IGS systems and reconstructed into a 3D volume. The skull and image data set were registered and the localization accuracy was assessed by comparing the physical location of the ball bearings with the location in the image. Accuracy and precision were assessed under a range of conditions, such as when rotating the probe through its full range of trackable movement. The test methodology that has been devised also considers the accuracy of the virtual tip and the fluoroscopy distortion correction. **RESULTS:** The two units assessed were extremely accurate and precise under a large majority of the measurement conditions. Using the protocol, it was possible to assess the units under extreme conditions, at which the accuracy was found to deteriorate. **CONCLUSION:** A protocol has been developed that has been used to assess two IGS systems. The protocol can be used to assess the accuracy of the systems under standard conditions and when forcing the unit to operate under extreme conditions. It was found that the skull phantom was acceptable but was difficult to use. Therefore, it is believed that a standard physics test object is required that allows for quick and simple testing of IGS units.

### **Prediction of clinically relevant details in mammography**

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This work presents an approach to the assessment of dose reduction techniques that can be achieved without compromising image quality. It uses the versatile method of simulation employing Monte Carlo techniques, rather than using invariant physical phantoms and test objects. In such simulations the imaging parameters and geometry are carefully prescribed for digital mammography systems, with imaging performance being assessed by examination of the resultant photon distributions emanating from "computational" phantoms. Simulations have produced aerial photon distributions, which are used to form pseudo digital images. The capability of different imaging parameters and geometries to visualize details of interest is analysed by examining these images using indicators including SNR and contrast resolution. Analysis of SNRs has yielded optimum energies to visualize details of subject contrast pertinent to mammography. These are in agreement with existing literature, between 16–22 keV for 100–500  $\mu\text{m}$  calcium hydroxyapatite microcalcification embedded at depths in 3–6 cm average breast tissue. A subjective interpretation of the images combined with the SNR has revealed that for these subject contrasts, imaging parameters and geometries that produce SNRs of 2.0–2.5 are required for the details to be in the region of "borderline detectability". The requisite exposure parameters and geometries to present these SNRs to mammography receptors are discussed. Simulations of the imaging process can potentially offer a step forward in ensuring effective use of X-ray procedures—the right procedure for the right patient—and the reduction of unnecessary radiation dose to patients referred for diagnostic investigations.

### **Work in Progress**

#### **New developments in ultrasound equipment evaluation**

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AIMS: The Ultrasound Equipment Evaluation Project (UEEP) funded by the Medical Devices Agency carries out independent testing of medical ultrasound imaging equipment. However, the technical assessment methods used suffered from a degree of subjectivity and were unable to address fully the capabilities of state-of-the-art equipment. At the end of 1999, a development programme was begun with the aim of improving the UEEP test protocols. MATERIALS AND METHODS: In collaboration with colleagues at Nottingham City Hospital, a Matlab program was introduced for the analysis of test object images. A new protocol for testing Doppler performance, which uses a combination of string and flow phantoms, has been developed in collaboration with colleagues at Edinburgh Royal Infirmary. RESULTS: Data collected using the existing UEEP protocol were compared with the automated analysis of captured images and it was found that the subjectivity involved in calliper placement and object detectability was removed. The effect of system controls, including harmonic imaging, on the image quality results was investigated. The Doppler protocol has been used to test the performance of a variety of systems, and the effect of frame rate, wall filters and other system controls on the quality of Doppler information has also been investigated. CONCLUSION: Improvements to the test protocols have made UEEP test methods more robust. Future work will include further developments of B-mode, colour and power Doppler test methods, collation of comparative data on the performance of state-of-the-art medical ultrasound scanners, and the introduction of user evaluations.

### **Work in Progress**

#### **Evidence of steady-state free precession effects in long TR EPI used for functional MRI**

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Unexpected partial saturation of the water magnetization can be introduced into functional MRI time series that use long TR ( $\text{TR}=6\text{ s}$ ) EPI from the imperfect application of fat suppression. In a phantom, it is shown that additional relaxation effects occur in multislice EPI scans as a function of the number of slices when conventional binomial

fat saturation is employed. Additionally, there is evidence of steady-state free precession signal formation. EPI acquisitions in human volunteers with and without fat saturation using standard non-selective binomial pulses confirm this additional relaxation effect, with a mean reduction in grey and white matter signal to  $0.94 \pm 2\%$ , whilst this signal reduction was not observed for CSF. From simple sensorimotor activation experiments, we consistently observed for all subjects that the omission of fat suppression resulted in fewer voxels (less than 50%) being identified as active and a more focal activation region when global normalization was utilized. Changes in absolute level of BOLD contrast and global signal contrast were marginally smaller (3.1% vs 4.2%) with the omission of fat saturation. Additionally, the relative degree of activation and deactivation were modified by the fat saturation conditions applied. Possible causes for the contrast modulation are discussed. A method of spatio-spectral suppression maybe required to achieve the most accurate location of neuronal activation sites.

### **Work in Progress**

#### **Use of a new test object for image quality in a quality assurance programme for dental radiography**

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PURPOSE: A report by the Royal College of Radiologists and the National Radiological Protection Board (1994) recommends that fully comprehensive quality assurance (QA) programmes should be in place at all establishments where dental radiography is undertaken, and that these QA programmes should include an assessment of image quality. MATERIAL AND METHOD: The suitability of a test object (Leeds dental test object, DEN.TO) for measuring threshold contrast detail detectability (TCDD) has been assessed in a QA survey of 30 community dental clinics located throughout north Wales. RESULTS: The test object was found to possess suitable sensitivity for detecting variations in image quality attributable to differences in film, processing and operating kilovoltage. The TCDD results were combined with resolution and radiation output to derive a Figure of Merit for dental radiography. CONCLUSION: The results suggest that a QA programme that does not include an assessment of image quality may be failing to prevent the production of poor radiographs.

### **Work in Progress**

#### **Assessment of image display monitor performance**

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PURPOSE: With the proliferation of PACS, computer monitors are replacing conventional light boxes as the primary display device for radiographic images. Setting up and maintaining video display monitors properly will help to reduce display variation and to improve overall presentation of the radiological image. With the introduction of a PACS system in the hospital, a quality control protocol was introduced to assess monitor performance and to ensure that each monitor matched the intended application. MATERIAL AND METHOD: A test protocol was drawn up that required a photometer and the ability to display the SMPTE test pattern and a low contrast test image. Tests included measuring a range of luminance (brightness) levels and determination of monitor grey scale gamma characteristic, monitor spatial uniformity, ambient lighting (illuminance levels) and low contrast detectability. RESULTS: Results are presented for 15 monitors (both CRT and flat panel) of four different types located in Radiology, Accident and Emergency, Fracture Clinic and ITU departments. CONCLUSION: Monitors show a wide variation in response, with the CRT monitors generally performing better than the flat panel monitors. However, the flat panel monitors, with their low reflectance screens, performed well in areas where the ambient lighting was difficult to control, such as Accident and Emergency.

### **Work in Progress**

#### **The diagnostic efficacy of JPEG image compression in CT, RNI and ultrasound imaging**

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PURPOSE: To establish, in a series of pilot studies, appropriate image processing methods and to establish visually significant JPEG

controllable quality factor (CQF) values to be used in a main study. **MATERIALS AND METHODS:** PC-based open platform software was used. Several popular JPEG compressors were compared and evaluated, including Corel Photopaint™ and Adobe Photoshop™. Interpolation and image editing were used to minimize the visual impact of the JPEG blocking artefact and to eliminate distracting binary artefacts. The test sequences were prepared using Corel Photopaint 8.0™ and MS Powerpoint™, and were reviewed by 65 radiographers and student radiographers. **RESULTS:** This pilot study has provided an estimation of the visually significant JPEG CQF threshold (for the sample images and modalities in the study), to be established prior to the main study (now underway). **CONCLUSIONS:** (1) Modest use of up-sampled bicubic interpolation and the elimination of binary artefact prior to compression are important in reducing the impact of JPEG image compression upon the visually significant threshold, for most observers. (2) The visually significant threshold varies for each modality. (3) The compression ratio is not a true measure of the JPEG effect upon image quality at a given CQF and the compression effect varies with image content. (4) Different JPEG compressors found in common graphics software do not produce similar compression results at similar CQF values.

#### **Evaluation of the sensitivity of a range of Doppler ultrasound scanners**

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**AIMS:** The ability to detect flow is the most critical aspect of a Doppler system. If flow cannot be detected, no other aspect of performance matters. In addition, the distinction between slow flow and no flow is of great clinical importance. To evaluate the sensitivity of a number of ultrasound scanners of differing complexity, a Doppler sensitivity phantom was built. The objective of this study was to determine whether the Doppler sensitivity phantom could differentiate Doppler ultrasound performance in scanners of varying complexity. **MATERIALS AND METHODS:** The Doppler sensitivity phantom consisted of tissue-mimicking material (0.5 dB cm<sup>-1</sup> MHz<sup>-1</sup>) surrounding four vessels (4.8 mm, 3.2 mm, 1.6 mm) at varying depths from 3–15 cm. Three Doppler ultrasound scanners of varying complexity with a number of different transducer combinations were evaluated.

**RESULTS:** The Doppler sensitivity phantom was used to test the performance of different ultrasound scanners and transducer combinations and it was found that there were differences between the different scanners. The effect of vessel size, vessel depth and velocity on the Doppler ultrasound scanners' sensitivity was also investigated. **CONCLUSIONS:** The Doppler sensitivity phantom presented here was able to identify detectable differences in sensitivity performance between Doppler ultrasound scanners and was also found to be challenging to state-of-the-art top-of-the-range Doppler ultrasound equipment. Thus, it provided a robust Doppler sensitivity phantom and test protocol for measuring the sensitivity of Doppler ultrasound scanners.

## Computerized Poster

### **Work in Progress**

#### **A demonstration of image display monitors**

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Departments of <sup>1</sup>Medical Physics, <sup>2</sup>Diagnostic Radiology, <sup>3</sup>Orthopaedic Surgery and <sup>4</sup>Chest Medicine, St George's Hospital, London, UK and <sup>5</sup>The University of Chicago, Chicago IL, USA

The display monitors in a PACS system are an important element for diagnosis and clinical review, as well as a significant capital cost and ongoing maintenance cost. The required quality of monitors is a function of the task, from diagnostic reporting to clinical review, and also a function of the type of image, *e.g.* from ultrasound to a digital chest radiograph. Many wards and outpatient departments are equipped with standard personal computers with colour cathode ray tube (CRT) monitors, and with flat panel liquid crystal displays (LCDs) also beginning to be used in such areas. This demonstration gives the viewer the opportunity to decide what image information can be satisfactorily displayed on these monitors, allowing the viewer to make side-by-side comparisons of the same image on different monitors. The monitors will range from high brightness high resolution black and white CRT (2048 × 2560 pixels at 600 cd m<sup>-2</sup> brightness) to a personal computer LCD screen (1024 × 768 pixels at 200 cd m<sup>-2</sup> brightness). Evaluation sheets will be available for the viewers to record their assessments.

# College of Radiographers Student Radiographer Conference

## **An investigation into the occupational radiation dose to the eye during diagnostic neuroradiographic procedures**

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**PURPOSE:** Cerebral angiography procedures present a high radiation dose from scattered radiation owing to extended fluoroscopy time and high number of images, however they also provide valuable information. The lens of the eye is one of the most radiosensitive organs in the body and has been the subject of many studies. This study investigated the incident dose to the eyes of two neuroradiologists during diagnostic cerebral angiography. **METHODS AND RESULTS:** The incident dose was recorded using lithium fluoride dosimeters (TLD-100) (TLDs) taped onto the outside of the rim of spectacle frames containing no protective lenses. This arrangement was worn by one radiologist. TLDs were also taped onto the inside of protective lenses worn by another radiologist. An average dose of 12.21  $\mu\text{Gy}$  per examination was measured by the unprotected TLDs. An experimental method was undertaken to measure the effectiveness of the spectacles against both primary and scattered radiation by placing TLDs above and below the spectacles. No transmitted dose was measured in either case. **DISCUSSION:** The results of the study indicated that 0.4 mm lead equivalent spectacles reduce the dose to the eyes by 98%. It was also found that the amount of dose transmitted in real clinical settings was higher than found in the phantom measurements. However, all doses were found to be below the set limit of 150 mGy for the eyes.

## **The issue of consent when discussing non-accidental injury in paediatric radiography**

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The issue of consent and the diagnostic imaging of non-accidental injury (NAI) for forensic purposes in paediatric patients is an issue highlighted by recent publicity concerning consent for the retention of pathological specimens. Research was performed to investigate current practices employed when obtaining consent. This was facilitated by the use of interview techniques as well as analysis of secondary data obtained from relevant current literature. Themes to be discussed include definition and differentiation between recognized forms of consent, the various ways NAI episodes present themselves and the types of consent appropriate in each situation. Also to be highlighted are the potential ethical considerations faced by those who are required to obtain consent, as well as the medicolegal aspects relevant to the topic, with particular reference to the Childrens Act 1989, and the importance of compliance with departmental protocols. The key issues for radiographers when dealing with the sensitive issue of consent concerning NAI have been summarized to promote best practice and appropriate care.

## **Infection control: everyone's business?**

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Nosocomial infection has been recognized for centuries as a significant complication in hospital care. It has been estimated by the National Audit Office that infections contracted in Britain's hospitals could be killing 5000 people each year and costing the NHS 1 billion pounds. It has long been known that the number of deaths, additional costs of treatment and longer hospital stays could be decreased by better management and compliance with infection control policies. The simplest methods, such as keeping rooms free from dust and hand hygiene, are the most effective means of preventing infections. There are, however, many other means that need to be adhered to. The majority of healthcare workers are aware of nosocomial infection control guidelines, but how many actually comply with them? The radiography department is susceptible to the spread of infection, as radiographers often find themselves on the wards dealing with the "at-risk" patient, as well as the inpatient and outpatient who may come to the department.

To determine radiographers' compliance with these guidelines, it was decided to conduct an observational audit. The audit was carried out in the radiography department of a teaching hospital. The West Midland audit tool takes into consideration all the basic infection control practices and provides set criteria of observations to be observed relating to standard statements, which are simply answered yes, no or not applicable. This enabled percentages to be calculated related to each particular standard, and recommendations were made to improve the compliance with infection control. It was found that basic infection control practices were lacking, not only because staff lacked motivation or resources, but also because there was confusion as to whose job it was to clean. This study proved that not only is there a need for a management strategy to be drawn up to make infection control everyone's responsibility, but radiographers need to examine their role in preventing nosocomial infection, as their effort will not only benefit themselves, but also colleagues and patients in the future.

## **Decontamination of equipment in a general radiographic room**

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**PURPOSE:** To reduce the risk of cross infection in a trauma and orthopaedic radiography department by evaluation and modification of current infection control policies. This was owing to the identification of hospital-acquired infections as a major problem by the National Audit Office report into management and control of hospital-acquired infections. **METHODS:** Possible fomites were identified by swabbing many items of equipment taken from two general radiography rooms. This equipment included positioning pads, sandbags, easy slides, cassettes, lead aprons and the X-ray tube handles. From the results of this bacterial culturing, the effectiveness of current decontamination procedures and protocols was also evaluated. Improvements in the infection control policies were then investigated, suggested to the department and implemented. After 5 weeks, swabbing and culturing were repeated to evaluate the effectiveness of the new infection control protocols. **RESULTS:** The initial study showed extensive colonization of almost every piece of equipment by coagulase-negative staphylococci. Many items were also colonized to varying degrees by coliforms, bacillus and/or diphtheroids. The second study showed a much lesser degree of colonization by coagulase-negative staphylococci. Colonization by coliforms and bacillus also occurred, but this colonization was minimal. No colonization from diphtheroids was present in the second study. **CONCLUSION:** Owing to the modified infection control protocols, the risk of cross infection occurring in the trauma and orthopaedic radiography department studied has decreased.

## **Role of ureteric compression in intravenous urography**

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**AIM:** Intravenous urography (IVU) is considered by many to be the gold standard in imaging of the urinary tract, and for over 70 years ureteric compression has been employed as part of the technique. However, it has been suggested that compression could actually disguise an obstruction and that the increased resistance of urine flow due to an obstruction could be confused with the compression effect. Urinary obstructions have the potential to cause irreversible renal damage and so it is important to evaluate clinical investigations to ensure that they are an effective method of diagnosing obstructions. It was therefore decided to carry out a study to investigate the role of compression in IVU in identifying urinary obstructions. The aim was to assess whether compression helps with the diagnostic detection of obstructions or in fact causes unnecessary discomfort and distress to the patient. **METHODS:** The study population involved patients undergoing IVU at the study hospital. Half of the examinations involved ureteric compression, whilst the other half did not. The radiologists' reports of these examinations were then obtained and analysed to identify any correlation between the examinations where obstructions were detected and the use of compression. Analysis was carried out using SPSS. **RESULTS:** The principal finding of this investigation was that 91% of obstructions detected involved examinations without ureteric compression. **CONCLUSION:** The results suggest that compression in IVU could be a hindrance rather than a help in identifying urinary tract obstructions. Further research into the use of compression in identifying obstructions is recommended.

# Bracco Satellite Symposia

## Monday 21 May

### Future Perspectives for Contrast Enhancement in MRI

#### MRI of the liver

D Sheppard  
Ninewells Hospital, Dundee, UK

#### MRI of the CNS

M Knopp  
National Institute of Health, Clinical Center/Diagnostic Radiology Department (CC/DRD), 10 Center Drive MSC 1182, Bethesda, MD 20892-1182, USA

#### MR angiography

G Schneider  
Department of Diagnostic Radiology, University Hospital, Oscar Orth Strasse, 66421 Homburg/Saar, Germany

## Wednesday 23 May

### The Changing Role of Ultrasound

#### The role of contrast enhanced ultrasound in the detection and monitoring of treatment of primary liver tumours

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All around the world, ultrasound represents the first line imaging modality in the follow-up of patients with known tumours (e.g. colon, breast or lung cancer) or liver cirrhosis to detect, respectively, metastases or primary liver tumours (e.g. hepatocellular carcinoma). Furthermore, the therapeutic approach to both primary and secondary focal liver malignancies has dramatically changed in the last few years. New modalities such as percutaneous ablative therapies (ethanol injection, PEI; radiofrequency, RF; laser; microwaves) and liver transplantation (OLT) have been introduced, in addition to or in competition with pre-existing modalities, e.g. surgical resection, systemic chemotherapy, segmental chemoembolisation, hypoxic perfusion. Thus, to decide on the appropriate therapeutic choice, accurate detection and intrahepatic staging (*i.e.* high sensitivity) by imaging is mandatory. In most cases, ultrasound is the first imaging modality in the diagnostic work-up of these patients, but, owing to patient limitations (e.g. obesity, gas, poor collaboration) and technical limitations (e.g. small lesion size, poor contrast resolution), the sensitivity of unenhanced ultrasound is generally lower than that of triphasic contrast enhanced helical CT, dynamic contrast enhanced MR and intraoperative ultrasound. For HCCs, the reported detection rate of ultrasound varies widely, from 46–95% for lesions measuring less than 2 cm in diameter to 82–93% for HCCs between 2 cm and 3 cm, going down to 59–68% for infiltrative and atypical HCCs. Biphasic or triphasic contrast enhanced helical CT is reported to achieve a detection rate of 89–92%, slightly inferior to that of intraoperative ultrasound (94–96%). For the most frequent type of liver metastases (hypovascular lesions), sensitivity rates of 57–92% (as low as 20% for lesions smaller than 1 cm) for ultrasound, 65–87% for conventional contrast enhanced CT, 85–90% for MR with liver-specific contrast agents and 90–95% (50% for lesions smaller than 1 cm) for intraoperative ultrasound have been reported. We are presently performing a clinical study comparing the sensitivity of contrast enhanced ultrasound (CEUS) with that of contrast enhanced biphasic or triphasic helical CT. CEUS is performed following intravenous administration of a second generation

ultrasound contrast agent (SonoVue, Bracco, Milan, Italy), using contrast specific software, either Coherent Contrast Imaging (Acuson, Mountain View, USA) or Phase Inversion (Siemens, Erlangen, Germany), or C 3 (Technos, Esaote) in continuous real-time scanning mode with very low MI (0.1–0.2) to avoid microbubble disruption and to study dynamically the vascular phase. This consists of an arterial phase (15–25 s), an early portal phase (45–60 s) and a complete portal phase (90–120 s). In the group of 28 patients with known liver cirrhosis, elevated serum levels of AFP, SGOT and SGPT, and with at least one questionable nodule found with B-mode ultrasound, the sensitivity of CEUS and CT are almost equivalent: in 25/28 cases the detection rate showed no differences (58 vs 58 lesions), whilst in 3 patients conspicuity on CT has been superior (3 vs 11 lesions), mostly owing to the typical limitations of ultrasound (e.g. obesity, technical difficulty to perform panoramic scans of the entire liver). The typical vascular pattern of HCCs (high and rapid peak of enhancement in the arterial phase followed by a relatively quick “wash out” in the portal phase) has been visualized in 54/61 HCCs, while in the remaining 7, inhomogeneous enhancement with CEUS has been related to necrotic changes. A similar enhancement modality has been found in 3 patients with hypervascular liver metastases from neuroendocrine tumours, with a detection rate equivalent to that of helical CT (9 of 9 lesions). Vascular phase and continuous mode are likely to be of crucial importance for the detection of multifocal hypervascular liver lesions. In a group of 14 patients with known history of colorectal, gastric or breast cancer, CEUS showed the same kind of enhancement as CT (minor signs of vascularity in the arterial phase, enhancement equivalent to that of normal liver in the early portal phase and hypovascularity in full portal phase). The detection rate was much higher than that of helical CT: in 8/14 patients, 20–100% more numerous metastatic foci have been detected by CEUS than by CT, with size ranging from 5–15 mm. Using this technique, the detection of hypovascular lesions during the early and full portal phases is also achievable with high accuracy, likely comparable with that previously reported in the late phase of air-based contrast agents, while this triphasic dynamic contrast study using second generation ultrasound contrast agents at the same time provides information useful to the correct characterization of the lesions. In addition, preliminary results obtained during the same clinical study using SonoVue to assess the sensitivity of CEUS for the detection of residual viable tumour following RF ablation of HCCs, in comparison with biphasic contrast enhanced helical CT, showed that the specificity of CEUS is equivalent to that of contrast enhanced helical CT for the diagnosis of residual viable tumour following percutaneous ablation.

#### The role of contrast ultrasound in the characterization of focal liver lesions

##### E Leen

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There are still fundamental difficulties in the ultrasound imaging of pathological tissues with acoustic properties similar to those of the surrounding liver parenchyma. Doppler ultrasound has sometimes been used as an adjunct to depict any associated altered vascularity with the hope that it may betray its presence or help to characterize the pathology. However, Doppler assessment of low velocity blood flows and small volume flow rates in the macrovasculature and microvasculature, respectively, is inherently limited, as the Doppler effect from solid tissue motion is stronger than that of flowing blood and the echoes from small blood volume are far too weak. Clearly, there is a need for echo enhancers. Basic understanding of the behaviour of microbubbles under various sound fields has been fundamental to the recent development of improved methods of visualizing and displaying contrast agents. The simplest method of displaying the signals from microbubbles in the microcirculation over those of tissue is to destroy the microbubbles at high ultrasound output using fundamental colour/power Doppler modes (stimulated acoustic emission/loss of correlation imaging), as they will emit the strongest signals in the process, and Doppler modes are ideal as they are very sensitive. A mosaic of colour Doppler signals and colour enhancement are displayed on colour or power Doppler mode, respectively. Greyscale enhancement can now be achieved effectively using second/pulse/phase harmonic imaging mode as a result of the same destructive process. However, destruction of the microbubbles results in transience of the effect unless there is replenishment of new microbubbles in the scan plane. So only microbubbles that can perfuse the imaging space between frames may be visible. In clinical practice, contrast enhancement is seen only on one frame (first) because scanning is performed

at a frame rate at which the interval between frames far exceeds the time for new microbubbles to perfuse the scanning plane. In the liver microcirculation, it takes approximately 5–8 s for the contrast agent to fill this scan plane. This forms the basis for “interval delay imaging”, or intermittent imaging. Short or long delay times can be used to emphasize either vascular or tissue contrast, respectively. More importantly, this technique can accentuate the differential perfusion kinetics between normal tissue and focal liver lesions, which may improve characterization. In addition, understanding the kinetic profiles (arterial, portal, arterioportal equilibrium, late phases) of these contrast agents (following a bolus injection in peripheral vein) in abnormal tissues relative to the normal surrounding liver parenchyma has also been key to improved differentiation between benign and malignant lesions. In that respect, the kinetic profiles of echo enhancers are not dissimilar to those obtained when using CT or MR.

**IMPROVED CHARACTERIZATION WITH CONTRAST ENHANCED ULTRASOUND:** Based on relative differential reperfusion of the tumour tissue with contrast agent compared with that of normal liver parenchyma, Wilson and colleagues demonstrated how this simple method of “interval delay imaging” improved the differentiation between metastases and hepatocellular carcinomas from benign haemangiomas using enhanced harmonic or pulse inversion mode. In the case of colorectal liver metastases, which are known to be hypovascular, the lesions appeared as focal filling defects smaller than their original size. In a background of bright liver, following interval delay imaging. In contrast, hypervascular hepatomas appeared as a “white ball”, being as bright as/brighter than the surrounding liver, reflecting the same degree of perfusion. In haemangiomas, peripheral nodular enhancement as seen on CT and MR could be demonstrated in the early vascular phase. Reversal of the haemangioma echogenicity from hyperechoic to hypoechoic following contrast agent administration was also a feature. A white “veil”, corresponding to wave of contrast agent destruction, can be seen descending through the scan plane. Haemangiomas did not participate in this “veil”; hepatomas always participated in the “veil”, whilst only the margin of colorectal metastases did. These findings reflected the amount and distribution of contrast agent that has perfused the scan plane during

the interval delay. In our own experience, this technique is simple, effective and reproducible with agents such as SonoVue (Bracco). However, in routine clinical practice, continuous real-time scanning is the norm. Scanning intermittently at specific arterial, portal and late phases (based on exact times following injection) may be problematic given the wide variations in transit times that exist between different patients. Although destruction of microbubbles is an effective method of displaying the contrast (using high mechanical index), the effect, as discussed above, is transient and requires interval scanning. Therefore, the challenge is to limit contrast destruction and yet obtain enough contrast differentiation between normal and pathological tissues. This limitation is solved by scanning at very low MI, thereby suppressing mainly the tissue echoes to display enough of those from the contrast agents. This method, called “conservative imaging”, allows continuous scanning of the focal lesion to be characterized, showing the dynamic representation of the blood supply of the lesion in the different vascular phases. In limiting bubble destruction, this method also has the advantage of allowing the use of repeated smaller doses of contrast agent. Contrast and penetration are evidently compromised and fortunately these have been resolved by the more recent refinements from the equipment manufacturers, such as Power Pulse Inversion or Contrast Coherent Imaging, with overlay displays and improved phase inversion harmonics enabling real-time perfusion display even of small and deep lesions.

**CONCLUSION:** The application of contrast enhanced ultrasound has been extended beyond simply displaying the macrocirculation of focal liver lesions. The microcirculatory kinetic characteristics of these tumours can now be displayed in real-time, which is superior to CT or MR. In that respect, contrast enhanced ultrasound is ideally suited for characterization of focal liver lesions in clinical practice. Of particular relevance here is the fact that use of contrast agents would defer referral to more costly and/or invasive procedures and any delay in patient management.

#### **Developments in ultrasound contrast agents**

D Bokor

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