

Radiology and Oncology '94 Work in Progress

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MONDAY 23 MAY

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- 12.31 Development of optimization algorithms for conformation therapy**
O C L Haas, Coventry
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- 12.51 A stereotactic technique that is machine transferable
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- 1.11 Immunoscintigraphy of bladder cancer following intravesical administration of indium-111 labelled monoclonal antibody NCRC 48**
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- 4.31 What is a normal aorta in the older male?**
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- 5.11 Treatment of synthetic graft-related anastomotic stenoses with directional atherectomy: technique and preliminary results
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- 1.23 End of session

Monday 23 May

12.15 – 1.15 pm

Work in Progress: Oncology

Bramham Suite

The technological revolution advances radiotherapy techniques? Is technology an expensive commodity with no real pay-off? [Paper]

M E Welch

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With relatively cheap high power computer systems being made readily available there is a tendency to rely more than ever on the analytical and managerial qualities of the control software. Nearly all major pieces of diagnostic and radiotherapy equipment now have either a small computer or a powerful microcomputer attached. Is this complexity really required? What are its advantages if any? It is a well known fact that that it is easy to design a piece of equipment with minimal hardware and maintain a flexible approach by modifying the software when faults are discovered or control changes are required, but does this type of design regime lead to flaws in the system that would not occur with a more basic but established design? The simultaneous control of a number of machine movements synchronized to dose rate as would be used for dynamic therapy is a good use of a computer controlled system, as is equipment such as multileaf collimators where as many as 40 pairs of blades are being moved simultaneously to a predesignated position using software with all the built-in safeguards as a control device. The checking of basic safety interlocks and the control of a machine's parameters is probably still best accomplished by the use of dedicated systems with a simple overseeing device. Complex equipment needs either total system backup with experts at hand to resolve problems, or to be used in a department where possible long down times can be tolerated. Is technology its own worst enemy or is the purchaser to blame for not specifying exact requirements, including serviceability and minimum down time?

Developing the clinical use of the multileaf collimator to achieve conformal radiotherapy to tumours of the head and neck [Paper]

R G Newberry

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Following much technical work preparing and proving the Philips multileaf collimator (MLC), clinical work has started to establish the techniques and routines required for treatment of tumours of the head and neck, where irregular treatment volumes are needed. The aim is a demonstration of problems incurred and solutions found, during the transitional period between a situation where individual leaf positions are hand planned to one where the CADPLAN computer planning system is developed to create and plot irregular treatment volumes. It is anticipated for the machine operators that with experience of these new procedures, the use of the MLC will aid the simulation process and that it will help to improve both set-up reproducibility and the machine time required for these patients.

Development of optimization algorithms for conformation therapy [Paper]

¹O C L Haas, ¹K J Burnham and ²J A Mills

¹Control Theory and Applications Centre, Coventry University, and ²Department of Clinical Physics and Bioengineering, Walsgrave Hospital, Coventry CV1 5FB, UK

A megavoltage photon beam model which fully incorporates scatter is used with a control algorithm to produce optimized dose distributions for conformation therapy using stationary beams. The profiles of the beam modifiers

are determined by the algorithm. At present the algorithm deals with a two-dimensional irradiated area which, along with the applied beams, is represented by a matrix formulation. In the beam model the primary component is expressed as an exponent with all matrix elements contributing scattered radiation to other elements. In order to speed up the algorithm only elemental scatter above a chosen threshold is considered. The control algorithm uses the least squares approach. It minimizes two functions: an objective function which describes a dose distribution over a target area and a penalty function which emphasizes the importance of reducing the dose over critical structures below a tolerable value. The control algorithm has been evaluated against standard test cases such as a hinged pair and a three field brick. This work has provided the basis to proceed with two further tasks. Firstly, to extend the algorithm to a three-dimensional irradiated volume and, secondly, to evaluate experimentally the distributions produced by predicted beam modifiers.

Is high resolution obtainable on both the blade tip and edge on the Philips multileaf collimator? What techniques are required to achieve this? [Poster]

M E Welch and T J Davy

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

The Philips computer controlled multileaf collimator (MLC) is able to create shapes used for radiotherapy quickly and with a greater degree of daily accuracy when compared with standard blocking techniques and the resultant set-up methods employed. It is true that for simple shapes involving straight lines no real problem exists; however, as soon as we look at complex shapes the problem becomes more involved. It is possible to create crude lung shielding with single fields but the isodose contours will be inferior to standard blocking techniques. The resolution at the blade tip is equal to a standard collimator but the resolution of the blade edge is limited by the physical blade width. A simple approach to improve blade edge resolution is time sharing the blades to achieve the required isodose contour and position. A simple interrupt is all that is required. Measurements have shown that fields are easily created by one of two methods. Method one involves superimposing two or more fields to create an acceptable complex shape accompanied by beam weighting to improve the resolution of the blade edge. Method two involves an oscillating edge which makes the creation of complex shapes much easier and simplifies patient set-up. Both methods produce a good isodose contour comparable to blocks. Measurements have shown these methods to be very acceptable for clinical use. Direct comparisons have been made between the MLC and blocks for an upper

mantle, including penumbra, matching of the delivered isodose to that required, leakage and transmission, and daily reproducibility.

Development of a large-volume megavoltage computed tomography scanner for radiotherapy verification [Paper]

M A Mosleh-Shirazi, W Swindell and P M Evans

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Conformal radiotherapy requires the delivery of radiation beams shaped to encompass planned target volumes (PTVs). The PTVs may have smaller than standard safety margins for movement. This necessitates the position of the PTV within the patient to be determined on every treatment fraction. A large-volume megavoltage CT (MVCT) scanner, which uses the X-ray beam of a linear accelerator and cone-beam tomographic reconstruction, is under development. We shall investigate its potential for supplying the required 3D soft-tissue anatomy. The scanner consists of a CsI (Tl) crystal array, a 45° planar mirror, a lens and a digital CCD camera. The array offers a 40 × 30 cm² field-of-view at the isocentre. A joint Monte Carlo and experimental study to optimize the detector (selecting the best scintillation material, thickness and crystal coating for this application) is presented. The image-acquisition hardware is also described. Finally, results on the influence on image noise of frame averaging before or after digitization and the effect of X-ray and electron scattering on image resolution are discussed. The scanner being developed here has the potential to acquire clinically useful multislice MVCT as well as large-area portal images.

A stereotactic technique that is machine transferable [Paper]

M E Welch

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The most expensive item in radiotherapy is machine time. Stereotactic techniques on linear accelerators involve a great deal of dedicated quality assurance prior to treating. A one shot treatment may not be of much concern as patient numbers per year are small, but fractionated treatments make this an expensive practice. A main concern is that the beam projected from the applicator is always hitting the same point in space. Fields opposed by 180° gantry angle should match with an error of less than 0.5 mm. Sources of error are alignment of the applicator to the linac head, and movement at the isocentre when the gantry is rotated. The isocentre should remain constant but

applicator error may vary on a daily basis. A method of aligning the applicator accurately on a daily basis is required. One method used is to drill into the existing head and screw mount the applicator, via locating pins, directly to the head. Even this method requires periodic adjustments, and does not allow the technique to be transferable unless the recipient machine has also been modified. We looked for a less invasive method that would allow the technique to be transferred to any machine of the same type without modifications. We resolved the problem by developing an applicator mount involving two customized clamps. To date the only error discovered is 0.25 mm displacement during a 360° collimator rotation. Measurements indicate the collimator rotation bearing as we are unable to adjust this error to zero. An option is to create a window and move a field defining device in this space to maintain an accurate position. To perform this manually would be time consuming. A computer controlled stereotactic applicator which allows continuous monitoring of the beam would be a solution to the problem, and would also allow the user to modify the shape of the projected beam in order to perform conformation therapy.

Variable thickness compensating filters [Poster]

H Kobayashi, Y Sakurai, S Abe, S Kondou, Y Obata and T Ishigaki

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In radiotherapy it is important to ensure a high dose area coincides with a planned target area. We have developed and reported a variable thickness multileaf filter system with a multileaf collimator. This system could compensate for the inhomogeneity of absorbed dose which arises from the differences of width of multileaf collimators. In our system we did not change the parameters which control the thickness of each filter. We developed a new system of wedge shaped compensating filters, in which the thickness of the compensating filter is variable in each filter, the thickness of which is therefore controlled without altering the parameters. Attenuation of absorbed dose by coupled compensating filters is approximately $A = e^{-0.82Y}$ (A , relative absorbed dose; Y , filter position; 0.82, constant in our experiment). We measured the relationship between field width (length is 20 cm constant) and relative absorbed dose at 5 cm depth along the centre of the field. From our measurement, Y and X (filter width) are shown as follows: $X = (1/3)Y^2 - 5Y + 23$. Relative absorbed doses of field widths range from 0.93 to 1.03. By using compensating filters, the doses vary between 1.00 and 1.005. A new system of compensating filters could compensate for inhomogeneous

dose distribution occurring as a result of field width difference.

Titanium implant in head and neck cancer patients: the Swansea experience [Paper]

A El-Sharkawi, A Ali and D W Patton

Department of Clinical Oncology, Singleton Hospital, Swansea SA2 8QA, UK

Large numbers of patients with head and neck tumours will require metal plates or screws to be implanted in the bone for reconstruction of the mandibular defect or for rehabilitation. Although titanium implants have been highly successful in patients with acquired surgical defects, their usage in patients with cancer of the head and neck has been of concern as the introduction of titanium metals in the radiation field may lead to inhomogeneities of radiation dosage in the target volume. To avoid such inhomogeneity, we set up a small pilot study in which a titanium implant is performed a few weeks to a few months after completion of radiotherapy. To date, seven patients with head and neck tumours had a titanium implant 1–24 months after their radiotherapy treatment. The absorbed doses of radiotherapy to areas implanted varied from 2 000 r to 4 800 r. Of 25 fixtures placed none has been lost after an implantation period of 6–42 months. Our initial results are very encouraging. In the light of our limited experience and results so far, we suggest the following: (1) radiotherapy treatment should precede a titanium implant placement; (2) a titanium implant placement should be performed only at centres with significant experience in oncology and osseointegrated dental implants; and (3) team work is paramount.

Immunoscintigraphy of bladder cancer following intravesical administration of indium-111 labelled monoclonal antibody (Mab) NCRC 48 [Poster]

¹R B Kunkler, ¹M C Bishop, ²D J Green, ³M V Pimm and ³M R Price

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In an ongoing trial, six patients with known or suspected bladder cancer were given 300–500 µg of Mab NCRC 48 radiolabelled with approximately 15 MBq of ¹¹¹In diluted in 50 ml of saline and administered intravesically for 1 h. Caudal scintigrams were taken before and after saline washout of the antibody from the bladder. Five of the six patients had bladder tumours (Grades 1–3 transitional cell carcinoma, Stages pTa–pT2). Areas of increased activity on the scintigrams appeared to correlate with the position of the tumours at cystoscopy. Biodistribution studies

comparing antibody uptake between normal and tumour tissues confirmed differential uptake to bladder cancer. These results suggest that immunoscintigraphy of bladder cancer, including those of low grade, may be possible using radiolabelled monoclonal antibodies administered intrave-

sically. Immunoscintigraphy may have a role in the diagnosis and follow-up of superficial bladder cancer. Intravesical administration of monoclonal antibodies is unlikely to be complicated by problems associated with their systemic use.

Recommendations for Brachytherapy Dosimetry

Report of a joint BIR/IPSM Working Party

E G A Aird, C H Jones, C A F Joslin, S C Klevenhagen, M J Rossiter, A D Welsh,
J M Wilkinson, M J Woods, S J Wright

The aim of this report is to encourage those who are working in the field of brachytherapy to adopt, where possible, common definitions, common conventions and common approaches to measurements and dose calculations. Areas covered include:

- Historical perspective
- Advantages and disadvantages of the system approach
- Source specification
- Reference standards and traceability
- Quantities and units for dose prescription and dose calculations
- Dose rate calculations from reference air kerma rate
- Correction for attenuation and scattering in water
- Recommendations for localisation procedures
- Dose measurement in water and *in vivo*
- Recommendations for dose recording

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Monday 23 May

4.15 – 5.19 pm

Work in Progress: Clinical Projects

Harewood Suite II

A study of women attending for obstetric ultrasound: their expectations, preferences and levels of satisfaction [Paper]
V Aitken

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University of Hertfordshire, Hatfield AL10 9AB, UK*

Women attending for obstetric ultrasound at 18–20 weeks do so as well women with wants and needs. Yet, to date, there are no studies which have looked at the expectations of these women and their levels of satisfaction. Furthermore whether the sonographers can perceive these expectations and judge how satisfied the women are has not been examined. There is work to suggest that social support plays a role in maternal and fetal well being. However, this has not been considered with respect to expectations of and satisfaction with an ultrasound scan. The present study investigates the preferences and expectations of 130 women in North West Hertfordshire attending their first antenatal booking clinic, and examines their levels of satisfaction after the ultrasound examination. In addition, their levels of social support were investigated. This was done via the administration of a set of self-report questionnaires. Seven sonographers' perceptions of the women's expectations and levels of satisfaction were explored using a structured interview. The results show the women were a homogeneous group who were very satisfied overall and had had the majority of their expectations met. This was accurately perceived by the sonographers. The role of social support remains unclear. In the light of these findings the implications for the ultrasound service are discussed.

Evacuation proctography combined with peritoneography: a new technique to identify pelvic floor defects [Paper]

S Halligan and C I Bartram

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Evacuation proctography (EP) images structural rectal changes during voiding of barium paste. Only rectal contrast is routinely used and therefore standard EP fails to

demonstrate extrarectal pelvic floor defects. However, defecatory disorders may be due to rectogenital pouches which are only visualized on EP if opacified small/large bowel enters during evacuation, to form an enterocele. The pelvic peritoneal recesses are most precisely demonstrated by positive-contrast peritoneography (PCP) where contrast is introduced directly into the peritoneal cavity. We have therefore combined EP with PCP to investigate the relationship of the peritoneal recesses with rectal configuration and emptying. 16 constipated patients (6 M, 10 F) were examined. A site 2 cm inferior to the umbilicus was cleaned and anaesthetized. Injection of 30 ml water-soluble, non-ionic contrast, via a 22 G lumbar-puncture needle, was made into the peritoneal cavity under fluoroscopic guidance and the needle withdrawn. EP was then performed with 120 cc intrarectal contrast and lateral videofluoroscopy with computerized video capture for image analysis. The technique was well tolerated. Technical failure due to anterior abdominal adhesions occurred in one patient. Rectogenital pouch was demonstrated in six cases examined (40%), without contained bowel in five (33%). The dynamic nature of the investigation permits visualization of pelvic floor configuration during rectal emptying and suggests rectogenital pouches, not identified by a standard EP technique, may occur in 33% of constipated patients.

What is a normal aorta in the older male? [Paper]

¹G M Grimshaw, ²J M Thompson and ¹J D Hamer

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It has been argued that early detection of abdominal aortic aneurysm can reduce the high mortality of this condition. However, it is essential to know which patients are at risk. Many different criteria are currently used to differentiate the normal from the abnormal aorta. This study invited 13 000 males aged between 60 and 75 years, within the Birmingham conurbation, to their own GP's surgery for an ultrasound scan of the abdominal aorta. 10 061 scans have

been performed (77.4% attendance) using a portable ultrasound scanner to measure the maximum A/P diameter. Exploratory data analysis has been used to describe the distribution of aortic diameters and define thresholds for abnormality based on the known prevalence of large aneurysms. Preliminary analysis of the distributions of aortic diameters for patients aged 60, 65, 70 and 75 years shows marked changes in diameter between the seventh and eighth decade for up to 25% of the population studied. This analysis shows that many of the changes in the eighth decade, previously attributed to the growth of small aneurysms, are much more common than has been reported previously. Thresholds of abnormality are defined by this analysis in a statistically rigorous manner and can be shown to change from 26 mm at 60 years to 37 mm at 75 years.

A rapid, simple and accurate method of estimating gall bladder volume using ultrasound [Paper]

R Ballantyne and R Valance

Department of Radiology, Gartnavel General Hospital, Glasgow, UK

A simple non-invasive method of accurately measuring gall bladder volume is of value in assessing biliary tract function. To date, satisfactory information has been derived from real-time ultrasound images using the single cylinder method, sum of cylinders method and ellipsoid method. However, the single cylinder method, the least accurate of the three, and the ellipsoid method both require longitudinal and axial cross-sectional images of the gall bladder which may be difficult to obtain accurately. The sum of cylinders method is cumbersome and time-consuming. Using the Acuson 128XP machine and rubber balloon models, we compared the single cylinder and ellipsoid methods of gall bladder volume estimation with the Simpson formula, a computerized method conventionally used for assessing left ventricular volumes on echocardiography. Measurements required only a longitudinal scan of gall bladder and took only a few minutes to obtain. Our results show that the Simpson formula provides accurate quantification of gall bladder volume, comparable to the information provided by the sum of cylinders method and ellipsoid method yet obtained much more quickly.

A study to establish the feasibility of a community based ultrasound service [Paper]

V Aitken

Radiography Department, Division of Clinical Sciences, University of Hertfordshire, Hatfield AL10 9AB, UK

Recent Government strategy has been to move patient care away from hospitals and into the community. In 1989 the

Government White Paper *Working for Patients* had among its objectives the provision of health care on the basis of need in a more cost-effective manner. Ultrasound is a service which may prove suitable for transfer into the primary and community sector. As a diagnostic tool ultrasound has properties which make it a viable proposition for transfer into the community. Ultrasound is versatile and flexible, requires a low initial capital expenditure, is easily transported from one site to another, and can be operated by a qualified practitioner. The study commenced with interviews. These took the form of guided discovery sessions, where focused discussion on relevant issues generated areas of interest and concern. The following issues were considered in all the interviews: (i) estimated demand; (ii) perceived problems to be overcome; (iii) personal concerns about changes in roles; (iv) possible models of community service that would be viable; and (v) choice of criteria for successful transfer of ultrasound services. There were seven provider/user groups consulted: radiologists; general practitioners; obstetricians; sonographers; ultrasound managers; midwives and users of the service including a subgroup of obstetric women. This paper explores the findings of the interviews with healthcare practitioners and patients as to the feasibility of the provision of ultrasound as a community service.

The nature and extent of musculoskeletal discomfort experienced by breast screening radiographers [Paper]

J L May, A G Gale, J Castledine, C Haslegrave and A R M Wilson

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This research aimed to establish whether breast screening radiographers in the UK suffer from musculoskeletal disorders, and if so the nature and extent of these problems. The study set out to determine whether the frequency of musculoskeletal problems suffered by breast screening radiographers was higher than in other areas of radiology. Comparisons were also made with other non-radiographic staff working at the same breast screening units. A questionnaire was distributed to all 800 radiographers who are currently working within the breast screening programme. This investigated both the possible existence and the extent of musculoskeletal problems within this group, as well as job design, anthropometry and equipment usability. In addition similar surveys were undertaken of radiographers who had no connection with breast screening and also of clerical staff from the same breast screening units. The preliminary results indicate that a subset of breast screening radiographers do experience musculoskeletal problems. Particular areas of the body are the lower back, both wrists and the neck. The incidence of these problems differed from

that found in other radiographic areas and from the problems found in clerical staff working at the same breast screening units.

Intraduct biliary biopsies — results in 10 patients [Paper]

R A J Mannion and A A Nicholson

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Patients presenting with obstructive jaundice caused by a bile duct stricture present a difficult management problem. The most appropriate treatment depends on the clinical state of the patient and on the nature of the stricture. The presence of a mass lesion or lymph node metastases may allow percutaneous fine needle aspiration biopsy, but these findings are frequently absent and cholangiography is often not diagnostic. In these circumstances biopsies are required and we present a technique whereby 6 F paediatric biopsy forceps are introduced into the biliary tree via an 8 F vascular sheath allowing samples to be obtained for histology and cytology. The technique involves placement of a stiff wire across the stricture over which is placed the 8 F sheath. The biopsy forceps are then advanced through the sheath and alongside the wire and biopsies are then obtained under fluoroscopic guidance. We present the results obtained so far in 10 patients. Successful biopsies have been obtained in eight patients and there have been no complications. The technique is quick and easy to perform and allows biopsies to be obtained from multiple sites.

Treatment of synthetic graft-related anastomotic stenoses with directional atherectomy: technique and preliminary results [Paper]

S J Vinnicombe, S Heenan, A M Belli and T M Buckenham

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Our purpose was to assess the use of the Simpson atherectomy catheter in the treatment of stenoses secondary to anastomotic neointimal hyperplasia (NIH). To date, seven lesions have been treated in six patients (four male, two female, mean age 67 years). All had diagnostic arteriography because of deteriorating symptoms or signs while under surveillance. There were three femoropopliteal, one aortoiliac and two aortofemoral synthetic grafts. All had severe anastomotic stenoses typical of NIH. Suprainguinal lesions were accessed via a retrograde transfemoral approach; infrainguinal lesions via an antegrade approach. Three patients required initial hydrodynamic thrombectomy; four required thrombolysis. All received 5000 iu heparin peri-procedurally. Directional intimal resection was performed with an appropriately sized Simpson atherectomy catheter. Passes were made till the stenoses were less than 30% angiographically. Patients were fully heparinized following the procedure. Technical and clinical success was achieved in all six patients, with a rise in the ABPI. The only complication was one minor groin haematoma, treated conservatively. One aortofemoral graft reoccluded after 1 week. The other five grafts remain patent (follow-up 4–12 months). We conclude that NIH is a common and problematic cause of late synthetic graft failure. Our early results suggest that further long-term evaluation of this mode of treatment is indicated.

Tuesday 24 May

12.15 – 1.11 pm

Work in Progress: Technical Projects

Harewood Suite II

Contributions to contrast enhancement in computed tomography and magnetic resonance imaging: a novel analysis [Paper]

P Dawson

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Our aim was to obtain a better understanding of the contributions to image enhancement of blood pool and interstitial contrast agent components. A novel simple theoretical analysis has been developed. This analysis clarifies the relationship between the two components and its time evolution; demonstrates that the literature definition of "equilibrium phase" of enhancement is wrong and based on a misunderstanding of the anatomy and physiology; and indicates how a number of parameters of physiological and anatomical significance, such as capillary permeability and the proportion of tissue volume which is vascular and that which is interstitium, may be obtained from CT or MRI data. This new analysis contributes both to the understanding of contrast enhancement mechanisms and to the field of functional and physiological imaging.

Contrast dose reduction in peripheral intravenous digital subtraction angiography with a new stepping table technique [Paper]

A C Downie, R Dourado, A K Banerjee, K G Burnand and A T Irvine

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Intravenous digital subtraction angiography (iv DSA) is an accepted technique in the initial investigation of peripheral vascular disease, being less invasive than intraarterial techniques. However, the large contrast medium dose required is a major disadvantage. We present our initial experience in 22 patients (mean age 65 years) in a randomized comparative trial of conventional iv DSA and a new stepping table technique with reduced contrast dose. All studies were performed using a Siemens Polytron Angiostar unit,

imaging from upper abdominal aorta to calf trifurcation. Conventional studies used 50 ml contrast injections at five static table positions (total dose 250 ml). The new technique utilized the perivision DSA stepping table feature, and two contrast injections (total dose 110 ml). Subtracted images were acquired from two or three positions during each contrast injection. Further conventional images were obtained when necessary. In the perivision group contrast dose was reduced by a mean of 33%, and diagnostic studies often used only 110 ml of contrast. Radiation dose was reduced and there was no difference in image quality between the two groups when scored blindly by two independent observers. We conclude that the perivision DSA technique is a useful refinement of iv DSA resulting in a beneficial contrast dose reduction without loss of image quality.

A digitized radiological atlas of anatomy [Poster]

D Tennant, S Morris, J Szucikiewicz, D Proffit and M Preston

Diagnostic Imaging and Computer Services Departments, St Bartholomew's Hospital, London EC1A 7BE, UK

Anatomy has, in the past, often used text-based learning methods which many medical students find tedious and time-consuming. Contemporary computer-based self-directed learning methods have been shown to be extremely effective in allied disciplines. Current radiological techniques generate images of outstanding clarity which in many instances are entirely normal. We believe that these represent a much under-used educational resource. Our project aims to provide a disc-based teaching library of normal radiological anatomy. To this end we have, to date, digitized approximately 1000 images from various modalities and have incorporated some of these into tutorials, demonstrating key anatomical features. The software for a computerized atlas has been written and we are currently writing labels and accompanying text. When our project is completed it will form a library of approximately 1500 labelled images. A comprehensive index will link labelled

structures; detailed cross-referenced information about any labelled structure will be available at the click of a mouse and sets of MCQs will be provided to aid self-directed learning. In addition, the digitized images, which are in an industry-standard format, will be available to tutors as a basis for further educational tools.

An image quality evaluation of computed radiography in the paediatric X-ray department [Paper]

J S Price and A R Cowen

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The introduction of computed radiography technology has brought about new possibilities in the field of paediatric radiology. This presentation will describe work being carried out to maximize image quality and to express the potential advantages of the technology in specialized paediatric examinations. The paediatric department produces images at lower exposure and beam energy than many adult examinations. Additional X-ray beam filtration may be used in an attempt to reduce dose to the patient. Antiscatter grids are often avoided for the same reason. The result is that the X-ray detector system can be presented with low signal-to-noise, low contrast images. Young infants whose small bones are less attenuating than those of older patients are radiographically demanding and produce highly collimated examination views, also with low subject contrast. Potentially, the computed radiography system has many advantages in the paediatric department. The wide exposure latitude, automatic exposure control and the ability to image process will help to optimize the image contrast and examination detail whilst keeping patient dose to a minimum. At FAXIL we are developing a theoretical model to maximize image quality whilst maintaining low patient doses. This can be applied to the clinical department. (This work is supported by the Medical Devices Directorate of the UK Department of Health.)

Assumptions, inaccuracies and comparability of whole-body bone and soft tissue determination by dual energy X-ray absorptiometry [Paper]

P Tothill

Department of Medical Physics, Western General Hospital, Edinburgh EH4 2XU, UK

All methods of measuring body composition involve assumptions. Comparisons between results from dual energy X-ray absorptiometers (DXA) from three manufacturers, underwater weighing (UWW) and three bioimpedance analysis (BIA) systems give an indication of their limitations. DXA measurements on volunteers showed that

whole-body bone mineral and fat results from Hologic, Lunar and Norland instruments at three centres in Scotland were not sufficiently similar for comparability and suggest that the manufacturers use different fat distribution models. Regional variations were bigger and show that bone recognition is an important factor. Measurements of an anthropomorphic phantom gave an indication of calibration differences, but show that a more complicated, realistic and variable model is required. UWW assumes that the density of lean tissue is constant, but DXA measurements demonstrated that the variable proportion of bone renders this assumption invalid. BIA has many assumptions, and poor agreement with the other techniques suggests that these are not sufficiently valid.

Effective dose calculations in dental radiology [Paper]

A R Lecomber and K Faulkner

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The likelihood of cancer induction carried by an exposure to ionizing radiation can be quantified using the concept of effective dose. Its calculation employs a mathematical model using tissue weighting factors to combine absorbed dose data for a number of organs into a single value representing the risk of carcinogenesis. The concept of effective dose was originally introduced to help in the assessment of workers' occupational exposures, but has also been applied to patient dosimetry for the comparison of risks associated with radiological examinations. For most procedures this technique is satisfactory, but for a number involving highly uneven dose distributions or localized irradiation, such as dental radiography, the correlation of the effective dose with risk becomes more uncertain. The values of tissue weighting factors are based on radiological data from a number of sources, and as the understanding of the biological effects of radiation have been refined, so these weighting factors have been changed. The last revision to the weighting factors was in 1990, and although previous workers have modified recommended tissue weighting factors in order to represent better the risk associated with dental dosimetry, their work was based on the earlier, unrevised dose-response data. The purpose of the present work, therefore, was to review the current state of knowledge of the biological effects of radiation, with particular emphasis on those tissues and organs found in the head and neck. From this basis, various methods of effective dose calculation for dental radiology were compared. In addition, an attempt has been made to produce a set of weighting factors for the calculation of effective dose which accurately reflects the known risks associated with dental radiographic examinations.

Update on the recommended protocol for FAXIL threshold contrast detail detectability test objects used in television fluoroscopy [Paper]

J H Launders, S McArdle, A Workman and A R Cowen
FAXIL, D Floor the Wellcome Wing, The General Infirmary, Great George Street, Leeds LS1 3EX, UK

The threshold detection index gives an overall measure of image quality and can be determined subjectively using FAXIL threshold contrast detail detection (TCDD) X-ray test objects. The present standard protocol for serial quality assurance is adequate; however, the system is not suitable for the comparison of large diameter X-ray television fluoroscopy systems nor for the comparison of performance on an absolute basis. The aim of this investigation, therefore, was to find a reliable viewing protocol which can encompass these applications by investigating further the viewing conditions with which to perform TCDD tests. Factors which may affect the perceived threshold contrast include the ambient room lighting and the viewing distance. The FAXIL TCDD test object TO.12 was viewed by four experienced observers to assess various combinations of three ambient room illumination levels and four viewing distances, including a fully flexible distance viewing technique. The results showed that the illumination level made no significant difference; however the choice of viewing distance is critical, and the flexible distance technique consistently returned the highest perceived threshold contrast. It is now recommended that for comparative testing a flexible viewing distance is used and the results normalized to allow for both the relative dose rates and magnifications of the individual systems. This protocol is found to produce self consistent results independent of field size. (This work was funded by the UK Department of Health, Medical Devices Directorate.)

Application of infrared in stomach examination [Poster]

A M Ambartsoumian

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The physical nature of infrared radiation caused us to investigate its possible clinical application. Examinations of 136 patients were held by using a source of infrared radiation, with a wavelength of 1.2 mkm, and a fibroscope connected to the eyepiece of an electrooptic transformer of infrared radiation which has a wavelength in a range including 1.2 mkm. In the first experimental series (10 observations) examinations of stomach mucosa under infrared instead of usual light were conducted. For this purpose the filter, which only admitted radiation of 1.2 mkm was set in front of the lamp acting as the light source. In the second experimental series (126 patients) the whole thickness of stomach walls was held. The effect of transillumination had been applied. The effect on skin of an infrared examination was taken into consideration. The examination was carried out with the infrared source outside, in front of the stomach, with the endoscope light source turned off. The results of the first group showed the definite significance of using infrared radiation in revealing a source of bleeding. In the second group the examinations were a success in revealing submucose tumours (two) and the process of cancer spread (six). Thus, the use of infrared radiation has potential in stomach examinations.

Wednesday 25 May

12.15 – 1.23 pm

Work in Progress: Magnetic Resonance

Ripley Suite

Small vessel enhancement on phase contrast magnetic resonance angiography by varying velocity encoding with spatial frequency [Paper]

¹D J Lomas, ²R Grimm, ³R K Butts and ³R L Ehman
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The selection of correct velocity encoding (*Venc*) is important in phase contrast magnetic resonance angiography (PC MRA) in order to avoid aliasing and to maximize sensitivity for lower velocity flow. This work investigates enhancing the visibility of small vessels on qualitative PC MRA by varying *Venc* with spatial frequency. The concept exploits the *in vivo* relationship between vessel diameter and flow velocity by applying a lower *Venc* to the higher spatial frequencies which represent predominantly smaller diameter vessels. The concept was simulated mathematically, and implemented by modifying the 2D and 3D phase contrast sequences on a clinical whole body 1.5T MR imager (Signa, GE). The sequences were evaluated using a dual tube steady state flow phantom. Preliminary clinical evaluation has been performed in volunteers. Both the mathematical simulation and the flow phantom evaluation confirm the validity of the concept. The preliminary clinical examinations demonstrate *in vivo* enhancement of small vessels when compared with the standard phase contrast technique. Varying *Venc* with spatial frequency is a novel technique that enhances the visibility of small vessels on qualitative phase contrast MRA examinations.

An evaluation of magnetic resonance angiography [Paper]

¹S C Davies, ^{1,2}P C Jackson, ¹F V Zananiri, ²K Murphy, ^{1,3}M Halliwell, ²A J Jones and ^{1,2}P N T Wells
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Magnetic resonance angiography (MRA) is emerging as an attractive technique for characterizing and quantifying

blood flow in cardiovascular systems. As MRA capabilities continue to advance it becomes increasingly important to develop suitable methods for verifying and assessing both angiographic and flow quantification techniques. The purpose of this study is to design and construct test objects which will form part of a comprehensive protocol to assess the various MR techniques offered by manufacturers. The evaluation will be carried out by MAGNET (Magnetic Resonance Evaluation Team) on behalf of the Department of Health. An appraisal of MRA was prerequisite to the design and construction of the test objects. The key areas identified in the appraisal study were: (1) the specification of the clinical and radiological requirements of any angiographic technique, including flow quantification; (2) the identification of the imaging parameters and the possible limitations of an MRI system and pulse sequences with respect to the radiological and surgical requirements; and (3) the review of test objects developed by other authors. We report on the initial findings of the appraisal and design parameters for test objects and flow rigs.

Preliminary results with a torso multicoil array for breath-hold cardiac cine magnetic resonance imaging [Paper]

¹R A Coulden, ¹D J Lomas, ¹C Sims and ²J P Felmlee
¹Department of Radiology, Addenbrooke's Hospital, Cambridge CB2 2QQ, UK, and ²MR Research Laboratory, Mayo Clinic, Rochester, USA

Our purpose was to evaluate a prototype two part multicoil torso array for breath-hold cine MR imaging of the heart. Five volunteers underwent breath-hold cine MRI of the heart on a clinical 1.5 T magnet system (Signa, GE). Cine images were obtained in standard cardiac long and short axes using an ECG gated fast gradient echo sequence with segmented k-space acquisition (FASTCARD, TR 9.8 ms, TE 2.5 ms, 20° flip, matrix 256 × 128, 16 kHz bandwidth). Each image set was acquired with the standard body coil and the prototype torso array. Breath-hold cine MRI demonstrated cardiac chambers, myocardial borders and systolic wall thickening using both coils, but superior signal

to noise ratio with the torso coil produced notable improvements in border definition and in the depiction of intracardiac structures, *i.e.* papillary muscles and RV moderator band. This gain in SNR, however, was partly offset by image heterogeneity. The prototype multicoil torso array, by increasing SNR, facilitates breath-hold cardiac cine imaging. It has yet to be seen whether this improves the reproducibility of quantitative measurements of ventricular function.

Cine magnetic resonance imaging of the pharynx in snorers [Paper]

R A Coulden, C Sims and D J Lomas
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Our aim was to evaluate cine MRI of the palate and pharynx in volunteers and patients being considered for surgery for severe snoring. Five volunteers and six snorers underwent cine MRI of the pharynx on a 0.5 T magnet system (Signa, GE). Mid-line, sagittal images were obtained using a rapid gradient echo sequence (FAST GRASS, TR 9.8 ms, TE 2.5 ms, 30° flip, matrix 256 × 128) with 8 s cines (6 × 1.3 s frames) being acquired repeatedly during different manoeuvres: (i) inspiration and expiration mouth open and closed; (ii) sucking and blowing through a straw; and (iii) snoring mouth open and closed. Cine MR demonstrated changes in pharyngeal shape and palate position with each manoeuvre but frame rate was too slow to freeze snoring vibration. Instead, vibration was suggested by movement blur. No differences were seen between patients and volunteers but subjects able to snore with their mouth closed showed vibration blur of the posterior pharynx rather than soft palate. Refinements are needed to increase frame rate, but cine MR may prove useful in defining the site of obstruction in snorers and so guide the nature of possible intervention, *i.e.* palatal stiffening or uvulo-palato-pharyngoplasty.

Magnetic resonance imaging of orbital pseudotumour using fat saturation and Gd-DTPA [Poster]

J A Hardman and S F S Halpin
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Orbital pseudotumour is the most common cause of an intraorbital mass in the adult. The diagnosis is usually clinical with a rapid improvement with steroid therapy, although patients presenting with unusual features may require radiological evaluation. CT appearances are well described although may often be non-specific; surface coil MR imaging adds to the specificity of the diagnosis

compared with CT. However, with conventional spin echo sequences subtle lesions or enhancing tissue can be masked by the high signal intensity of orbital fat. Fat suppression techniques including frequency selective pulses (Chem.Sat.) and the hybrid method suppress the high signal from fat and still give a high signal from enhancing lesions and the normal ocular muscles following Gd-DTPA, unlike STIR sequences. Contrast enhanced fat suppression MR imaging also improves anatomical detail within the orbit, eliminates chemical misregistration artefact, and lesion contrast is increased by adjusting the dynamic grey scale of the image. We illustrate the value of contrast enhanced fat suppression MR imaging of orbital pseudotumour. We also present a hypothesis as to why the ocular muscles enhance intensely following Gd-DTPA as this appearance is not seen in other skeletal muscles.

Preliminary results with a torso multicoil array for abdominal magnetic resonance imaging [Paper]

¹D J Lomas, ¹C Sims, ¹R A Coulden and ²J P Felmlee
*¹Department of Radiology, Cambridge University,
Cambridge CB2 2QQ, UK, and ²MR Research Laboratory,
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We aimed to evaluate a prototype two part multicoil torso array for abdominal magnetic resonance imaging. The prototype torso array was compared with the standard body coil on a clinical whole body 1.5 T MR imager (Signa, GE). Measurements of signal-to-noise ratio (SNR) were made using phantoms and examinations were performed with both conventional and breath-holding imaging sequences on patients and volunteers. Substantial increases in overall SNR of up to 2.5 times that achievable with the standard body coil are possible with the prototype array. The improvement in SNR is demonstrable in conventional spin echo imaging and particularly in breath-holding imaging sequences. This gain in SNR is partly offset by image heterogeneity. The prototype multicoil torso array, by increasing the available SNR, facilitates breath-hold imaging and improved conventional magnetic resonance imaging of the abdomen.

Magnetic resonance scan segmentation and analysis to monitor brain swelling [Paper]

N Saeed
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Brain swelling is observed in the immediate post-operative period after coronary artery bypass surgery (CABS). Eye-balling the sulci in temporal scans gives an indication of the change in sulci size, but this method is very subjective and

provides a very coarse measure of brain swelling. An automated computer based procedure has been developed to identify the sulci and perform width measurements. This involves automated segmentation of the brain using knowledge based image processing; the isolated brain is edge enhanced to highlight the sulci boundaries. The brain contour is smoothed and then shrunk in four steps to provide various levels at which sulci width measurements can be performed. Six CABS patients (58–72 years) were scanned 1 week before the operation, 20–40 min after surgery and 1 week later. Also, three volunteers (50–73 years) were imaged twice over a period of 1 week to provide a measure of sulci width changes in a normal environment. Reduction in sulci width by about 20–71% was noted in the immediate post-operative state in comparison to the pre-operative conditions; in the case of the volunteers the variation was below 12%. Computer based sulci width measurement provides accurate delineation of the sulci and gives an objective measure of the degree of brain swelling after CABS.

Image co-registration for functional imaging studies [Paper]

J V Hajnal, I R Young and G M Bydder
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Functional neuroimaging studies rely on the detection of small stimulus correlated signal changes in serially acquired MR images. Subject motion between images can result in signal changes that correlate with the stimulus [1], so that the origin of any observed signal changes remains uncertain unless the effects of motion are adequately controlled. We have developed an image co-registration program that is designed to address this problem. Multiple image data sets were acquired by sequentially scanning individual subjects. Using a χ^2 optimization criterion, images were aligned with each other by rigid body translation and rotation in two or three dimensions. The statistical uncertainties of the transformation co-ordinates were calculated from the inverse of the Hessian matrix of second directions. Accurate image co-registration was achieved in all cases with positional uncertainties of less than 1% of a pixel. A computer program has been produced that allows sequentially acquired MR images to be co-registered with an uncertainty of less than 1% of a pixel. This enables genuine image differences to be more clearly distinguished against a greatly reduced level of misregistration artefact.

Reference

1. Hajnal, J V ET AL, *Magn. Reson. Med.* (in press).

Magnetic resonance imaging of the uterine cervix and parametrium: characterization of zonal anatomy and vascularity using an enveloping intravaginal coil [Paper]

¹N M deSouza, ²I C Hawley, ¹J E Schwieso,
³D J Gilderdale and ⁴W P Soutter
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Our purpose was to characterize the zonal anatomy and vascularity of the normal cervix and that following cone biopsy on magnetic resonance imaging using an intravaginal coil. 13 female subjects of reproductive age with clinically and cytologically normal cervixes and three patients who had undergone laser cone biopsy for cervical dysplasia were imaged. A ring design solenoid receiver coil was placed around the cervix. T_2W and T_1W axial images were obtained. Seven uterine specimens resected for menorrhagia were similarly studied and imaging appearances were correlated with histology. *In vivo* results showed two stromal zones surrounding the high signal central canal, and endocervical mucosa were identified. They were differentiated on T_1W as well as on T_2W where the inner ring has a low signal while the outer ring has an intermediate signal intensity. The outer zone was highly vascularized with inflow effects from large vessels visible on single slice scans. On administration of gadolinium-DTPA in the normal volunteers the endocervical mucosa enhanced rapidly. This rapid mucosal blush was absent in the post-cone biopsy subjects. The outer zone showed more gradual enhancement. The inner zone enhanced relatively slowly. *In vitro* results showed a high signal intensity central mucosa, and two stromal zones were identified. The inner low signal ring correlated with a region of tightly packed stroma (cell count 5900 ± 2376 nuclei mm^{-2}) and the outer zone corresponded to more loosely packed stroma (cell count 2199 ± 558 nuclei mm^{-2}). In conclusion, these detailed appearances and enhancement patterns of the normal and post-cone biopsy cervix need to be recognized in order to interpret subtle changes in locally invasive cervical neoplasia.

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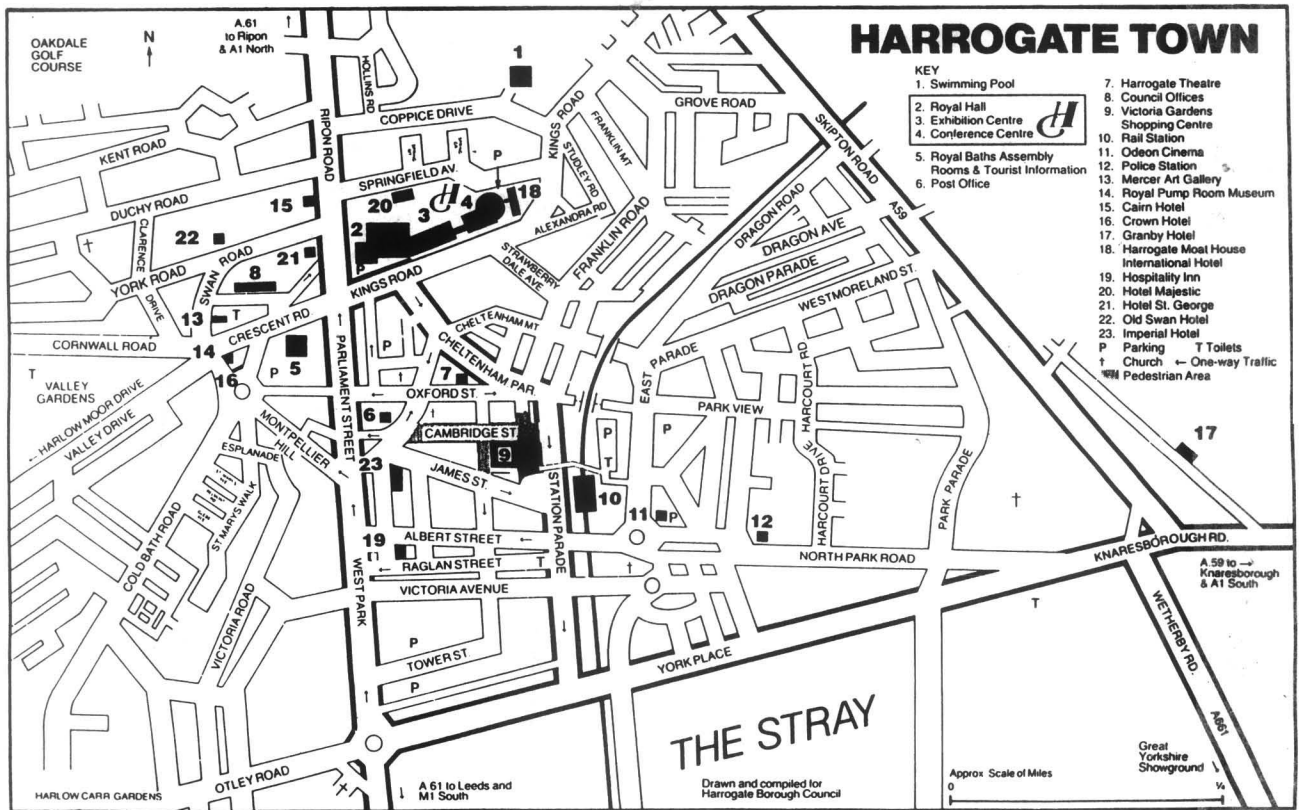
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