

Scientific Programme Abstracts

Monday 17 May

9.00 – 10.15

Clinical MRI I: The Brain

Argyll I

Current clinical developments in cranial MRI

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Over the last year several research developments have been incorporated into routine clinical imaging protocols. This has extended the range of applications for MRI. I shall consider these under three main groups: (1) Those relating to patients and the way they are positioned within the magnet. This includes a consideration of the ergonomics of the magnet bore and coils, the use of MRI in stereotaxis and radiotherapy planning and the problems of noise and claustrophobia. (2) Sequences. These include fast spin-echo which provides similar but not identical contrast to conventional spin-echo, angiography, magnetization transfer, diffusion imaging and the various methods of imaging the long T_2 components within the brain. (3) A consideration of how this information from MRI can be integrated with images and data from other modalities. This includes developments in data segmentation, fitting data and combining functional with anatomical information. This must provide the clinician with easily assimilated and clinically relevant diagnostic information if it is to influence clinical practice. These technical developments will be illustrated and their applications in both paediatric and adult radiology practice will be presented.

Unusual clinical and radiological presentations of multiple sclerosis (MS)

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The diagnosis of multiple sclerosis (MS) is often difficult. Clinical and radiological investigations may be unhelpful or even misleading. The authors have reviewed the literature for the more unusual clinical and radiological presentations of MS and illustrated the paper with their own experiences.

Case 1 presented with a space-occupying lesion (SOL) on CT with plaques seen on MR imaging. Case 2 had a SOL with ring enhancement on CT with clinical features of a tumour, shown by MR and subsequent tests to be MS; Case 3 a patient with hemiplegia with MR features of MS; Case 4 a patient with cord symptoms shown to have a normal cord on MR but plaques within the brain. Case 5 had massive diffuse white matter disease affecting almost the entire white matter due to widespread MS plaques. (MR imaging and post-mortem correlation shown). The authors conclude that all patients with an unusual neurological history, or CT findings not entirely compatible with the history, should have MR imaging of the brain even if MS is not initially suspected. This may avoid wrong diagnosis or other unnecessary investigations, including brain biopsy.

Cerebral proton spectroscopy in HIV infection: clinical, immunological and MRI correlation

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The purpose of this prospective investigation was to determine the extent of changes seen in the proton spectra of the brain in HIV infection, correlating the results with clinical, immunological and MRI findings. Spin echo localized (TE = 135) proton spectroscopy of the brain was performed on 103 patients and 23 controls. The patients were classified into early and late stage disease groups using the clinical Centers for Disease Control classification system and also the CD4 lymphocyte count. Diagnostic MRI was performed on all patients. Three radiologists reported the images independently, scoring for the presence or absence of focal and diffuse HIV-related abnormalities. The mean N-acetyl-aspartate (NAA)/choline(Cho) and NAA/creatinine(Cr) values in those in late stage HIV infection were significantly lower than those in the early stages. A signifi-

cant rise in Cho/Cr was seen in those with low CD4 counts. A proportion with late stage disease demonstrated severe spectroscopic abnormalities. Abnormalities correlated with diffuse but not focal MRI abnormalities. Spectroscopy provided a closer relationship to neurological signs than imaging, but the closest relationship was provided by combining the results of imaging and spectroscopy. The results support the use of NAA as a putative *in-vivo* neuronal marker. Spectroscopy provides information complementary to MRI and augments the value of a combined magnetic resonance study.

Prognostic value of CT and MRI in patients with AIDS and neurological deficits

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The purpose of the investigation was to determine the prognostic value of CT and MRI in AIDS patients with neurological symptoms, in relation to the initial and follow-up imaging results. Initial and follow-up CT and MRI examinations (53 CT and 52 MRI) of 51 patients were evaluated for the presence of cerebral atrophy and/or focal lesions. Survival time (Kaplan-Meier plots) and relative hazard (stepwise Cox regression model) of patients were calculated. The mean survival time of patients with initially normal findings was longer (688 ± 91 days) than that of patients with isolated cerebral atrophy (324 ± 64 days) or isolated focal lesions (201 ± 99 days). The shortest survival time (76 ± 43 days) was found in patients with both cerebral atrophy and focal lesions. Compared to patients with normal imaging results, patients with atrophy alone had a relative hazard of *3.6, those with only focal lesions *6.4, and those with both changes *19.3. It was concluded that cerebral imaging with CT and/or MRI allows identification of AIDS-related cerebral changes and may contribute to assessment of prognosis.

Cranial MRI in lymphoma

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In a retrospective review of 27 patients with lymphoma imaged by cranial MRI, we have analysed the indications for referral and the abnormalities detected. Clinical indications for referral were: (a) non-specific features (headache, nausea, lethargy) (six patients); (b) specific neurological signs (motor dysfunction, visual field disturbance, seizures)

(nine patients); and (c) clarification of CT findings (12 patients). The MR scans were normal in 12 patients. Of the abnormal scans, cerebral lesions were seen in 11 patients; five of these were post-operative changes, and four were posterior fossa lesions. Characteristic MR features of intracranial lymphoma are illustrated. In the 12 patients referred following CT, MRI demonstrated more extensive abnormality in only two, and in neither patient was management altered as a result of MRI. While MRI is an effective method of demonstrating intracranial pathology it does not appear to add significantly to CT, which remains a satisfactory investigation where MRI is unavailable.

MR imaging in cranial nerve involvement by CNS sarcoid

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Neurological involvement in sarcoid occurs clinically in about 5% of cases, and in a larger proportion at post-mortem. It is initially a granulomatous leptomeningitis but the disease may spread along perivascular spaces into the parenchyma. Parenchymal granulomata coalesce to produce masses and vascular involvement may produce infarction. Clinical cranial nerve involvement may be produced by direct invasion around the skull base, infarction, compression by parenchymal masses or as a result of obstructive hydrocephalus. This presentation discusses clinical and radiological features and the differential diagnosis in four examples of neurosarcoid in patients with cranial nerve abnormalities. MR before and after gadolinium-DTPA enhancement is the best available technique for the demonstration of the leptomeningeal and parenchymal involvement in sarcoidosis, but the findings are not specific and still underestimate the extent of disease, as is shown by comparison with clinical, operative and post-mortem findings.

Demonstration of epileptogenic lesions by magnetic resonance imaging at 0.5T.

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Epileptic fits are increasingly regarded as an indication for cross-sectional imaging to exclude a potentially treatable abnormality. In most patients, CT is the initial imaging investigation, but with increasing availability of MRI, CT

may no longer be the most appropriate technique. In this study the ability of MRI to detect focal abnormality in epilepsy was assessed and compared with the results of previous CT. 100 consecutive patients (44M, 56F, age range 4 months to 66 years) undergoing MRI for investigation of epilepsy were reviewed. T_1 - and T_2 -weighted spin echo sequences were obtained on a 0.26T Picker or 0.5T GE Vectra system using a head coil. Of 42 patients aged less than 16 years, 12 required sedation. Intravenous gadolinium-DTPA was given in 25 patients. MRI was normal in 44% and of these, CT was normal in 42. In the two patients with abnormal CT, no lesion was identified on MRI. In the 56 abnormal MRI scans, the diagnosis was malignant cerebral neoplasm in 19, benign tumour in eight, changes secondary to ischaemia, trauma or demyelination in 22, mesial temporal sclerosis in four, congenital abnormality in two and infection in one. CT scans were falsely negative in 17 patients with the following diagnoses: one hamartoma, two gliomas, two mesial temporal sclerosis, two multiple sclerosis, nine ischaemic/degenerative changes and one abscess. Although MRI was more sensitive than CT in identifying a structural abnormality in these highly selected patients with epilepsy, surgical cure by removal of the lesion has been attempted in fewer than 5% of patients. Nevertheless, demonstration of an epileptogenic structural lesion is desirable in order to assess prognosis and identify patients for whom surgery is an option.

Colloid cysts: comparison of pre- and post-operative MRI and CT findings

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Colloid cysts are rare tumours of the third ventricle in the area of the foramina Monroi fixing on the velum interpositum or the plexus choroideus. The clinical manifestation is a consecutive hydrocephalus and raised intracranial pressure. Colloid cysts are characterized on native CT and on T_1 - and T_2 -weighted MRI by primary hyperdense and hyperintense representation, respectively. Sometimes a hyperintense margin can delimit a central hypodense or hypointense content of the cyst. This imaging depends on the residue of leukocytes and cholesterol. Only a few cases comparing CT and MRI findings have been published yet and therefore, we intended to analyse both methods. Nine patients with CT and MRI were examined pre- and post-operatively. On MRI we considered the various sequences with special regard to differential diagnosis, eg low-grade glioma. In order to plan the access to the tumour we evaluated the multiplanar scanning direc-

tion. The size of colloid cyst varied from 8×8 to 26×48 mm; in the latter case 17 ml of a glutinous fluid was aspirated intra-operatively. In conclusion, because of some false negative CT findings, MRI is the method of choice in the delineation of colloid cysts.

Imaging of primary progressive aphasia—a comparison of CT, MRI and cerebral perfusion SPECT findings

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Primary progressive aphasia (PPA) is defined as progressive failure of language for two or more years, with preservation of activities of daily living, in patients in whom neuropsychological testing confirms sparing of non-verbal cognitive function. The clinical features of this syndrome have been well documented, but its neuroradiological aspects have not. We studied 12 patients with PPA; nine underwent cranial CT, 10 underwent MRI and 11 had cerebral perfusion studies using ^{99m}Tc^m-HMPAO single photon emission computed tomography (SPECT). CT was relatively insensitive at detecting abnormalities, images being within normal limits for age in six patients (66%). MRI revealed abnormalities in eight (80%), seven of whom had focal atrophy of the left temporal region: in two patients this was the sole abnormality. Quantitative analysis of SPECT imaging revealed significant perfusion deficits in the left temporoparietal region in 10 patients (91%). These deficits corresponded with atrophy seen on MRI in six patients. MRI and SPECT are, therefore, more sensitive than CT in detecting focal abnormalities in PPA. They are also complementary, demonstrating abnormalities of structure and function, respectively. However, SPECT may reveal a decrease in perfusion before structural changes become apparent.

The MRI appearances of lymphocytic adenohypophysitis of the pituitary

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Lymphocytic adenohypophysitis is a rare non-neoplastic cause of a pituitary mass. The anterior pituitary is infiltrated with small lymphocytes and plasma cells, occasionally arranged in follicles with a variable amount of fibrosis.

An autoimmune aetiology is postulated in view of the lymphocytes. The clinical history is often suggestive, with the majority of patients developing symptoms of an enlarging gland or hypopituitarism towards the end of a normal pregnancy or early in the post-partum period. We present the MRI appearances of this condition in two female patients, one presenting in late pregnancy and the other in the early post-partum period. Both patients

complained of headache and visual field loss. This diagnosis should be considered in the differential diagnosis of any mass lesion arising in the sella turcica, particularly in the clinical setting described. In this situation biopsy may be useful to avoid completely resecting the anterior pituitary, and a trial of steroids should be considered in view of the possible autoimmune aetiology.

9.00 – 10.15

The Chest I

Argyll II

Just how useful is HRCT of the chest?

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The adept investigation of patients with suspected diffuse lung disease remains a challenge: the traditional yardsticks of clinical examination, lung function tests and chest radiography are imperfect both individually and collectively in terms of sensitivity, specificity and observer variation. Experience with high resolution computed tomography (HRCT) in the assessment of diffuse lung disease has accumulated rapidly over the last few years and its role is now clearly defined in particular situations. Not only does HRCT improve the detection, specific diagnosis and assessment of disease activity of many diffuse lung conditions, it also allows the confident exclusion of significant interstitial lung disease. The performance of HRCT is critically discussed and compared with other methods of investigating patients with diffuse lung disease. While HRCT of the lungs is one of the most exciting developments in thoracic imaging, the radiation burden to the patient should not be forgotten. Furthermore, it should not be overlooked that in some instances HRCT may provide more questions than answers. The imaging of asbestos-exposed individuals is taken as a model to explore some of the potential disadvantages of HRCT.

The natural history of the adult respiratory distress syndrome assessed with serial High Resolution Computed Tomography

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In order to determine the natural history of adult respiratory distress syndrome (ARDS), the high resolution lung CT scans performed on eight patients in the acute and convalescent periods were analysed. Eight patients who

fulfilled the conventional diagnostic criteria for the diagnosis of ARDS were scanned on an Imatron Ultrafast scanner on at least two occasions, between 2 and 22 weeks apart (mean 10.5 weeks). The disease pattern, distribution and extent were documented by two observers. In the acute phase the predominant morphological abnormality was ground-glass opacification (8/8); other patterns included multifocal consolidation (5/8), reticular opacification (6/8), linear opacification (5/8), and parenchymal distortion (8/8). There was no zonal predilection, in particular no concentration of disease in the dependent parts of the lungs. In the convalescent phase the majority of these abnormalities resolved, except for the reticular pattern, denoting interstitial fibrosis, and parenchymal distortion, shown by bronchial dilatation. Two patients developed unequivocal CT features of emphysema on follow-up scans. We conclude that in ARDS the predominant CT abnormality of ground-glass opacification is reversible, but serial HRCT reveals the development of interstitial fibrosis, emphysema, and bronchial dilatation in some patients, explaining the clinical features reported in long-term survivors.

Bronchiectasis in late HIV-disease

B Trotman-Dickenson, G Luzzi, A Holmes and T Peto
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In HIV infection there is an increased frequency of bacterial pneumonia but the development of bronchiectasis is not well recognized. Over a 2½-year period, six patients with HIV infection with chronic symptomatic lung disease were examined by HRCT of the lung to determine the presence and severity of bronchiectasis. The chest radiographs were normal, or showed bronchial wall thickening. All subjects were male (mean age 29 years) with chronic cough. At the time of HRCT examination there was no evidence of acute infection. Bronchiectasis was demonstrated in five patients and bronchial wall thickening in only one further patient (a non-smoker). Patients had been HIV-seropositive for a mean period of 7.2 years (range 5–

10 years) before the development of bronchiectasis. Four patients had previous PCP infection, the mean interval between PCP and presentation of chronic lung symptoms was 21 months (range 4 months – 4 years). As life expectancy in HIV-infection increases with improved therapy, bronchiectasis may become an increasing problem. HRCT examination provides a method of early recognition of this HIV-related complication.

Acute pneumonitis associated with low dose methotrexate treatment for rheumatoid arthritis

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Acute pneumonitis is an uncommon but serious complication of low dose methotrexate therapy for refractory rheumatoid arthritis (RA). Severe reactions may progress to respiratory failure. Early recognition of the toxicity is important as cessation of therapy and steroid treatment usually leads to dramatic improvement. Since 1984, 43 patients with RA have been established on low dose methotrexate in the Oxford Health District. Five patients have subsequently developed methotrexate pneumonitis. The radiological features, including HRCT appearance, are described. Three men and two women (mean age 64 years) developed a sub-acute illness with fever, cough, and increasing dyspnoea following on average 6 months (range 3–8 months) of methotrexate therapy. An infection screen was negative in all patients. The chest radiographs, at presentation, revealed a diffuse mixed pattern of airspace and reticular shadowing in four patients and airspace shadowing alone in one patient. In two patients there was an upper zone predominance. HRCT was performed in three patients and demonstrated a ground-glass appearance of the airspace shadowing with a patchy distribution. Lymphadenopathy and pleural effusions were not present. Follow-up scans (within one week) demonstrated partial or complete resolution. At one month all the chest X rays were normal. Acute pneumonitis is uncommon and the clinical presentation is non-specific. A high index of suspicion in combination with the typical radiographic appearance allows a prompt and life-saving diagnosis.

Mediastinal CT in a British Asian population

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We describe a retrospective review of 39 consecutive thoracic CT scans in British Asian patients. Of 15 cases with

active tuberculosis, 14 had mediastinal lymphadenopathy; in nine patients, this was the only positive imaging finding, as neither lung parenchymal nor pleural abnormalities were detected on CT or plain chest radiograph (CXR). The patterns of node distribution and enhancement with intravenous contrast are described. We conclude that thoracic CT is useful in Asian or other high risk patients with pyrexia of unknown origin, in patients with an equivocally abnormal CXR, or where there is florid abnormality on the CXR and the differential diagnosis lies between sarcoid and tuberculosis.

Pattern of pulmonary infections in renal transplant patients

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The incidence of pneumonia in renal transplant patients is 10–20%. We studied the chest radiographs of renal transplant patients who presented between August 1991 and September 1992 with respiratory infections, comprising 37 episodes of pneumonia in 27 patients (17 males, 10 females), age range 23 to 68 years (mean 45.5 years). 19 patients were on cyclosporine-prednisolone immunosuppression and eight patients on additional adjunctive anti-rejection therapy. Pulmonary infections in these patients were analysed with regard to the organisms involved, time of occurrence after transplantation, clinical course and radiographic findings. There were 28 episodes of segmental/lobar consolidation and nine episodes of diffuse airspace/fine nodular shadowing. In 22 episodes, nine types of organism were documented, including opportunistic pathogens such as *Pneumocystis carinii*, *Herpes simplex*, Cytomegalovirus and *Candida albicans* besides routine bacterial pathogens. No organisms were isolated in 15 episodes. All multiple-organism infections involved cytomegalovirus, with 50% mortality. The overall mortality was 25.9%. Eight patients (29.6%) required transplant nephrectomy. These findings emphasize the importance of early and specific diagnosis of pulmonary infections in patients with renal transplants, enabling the institution of effective treatment in an attempt to salvage the transplant.

Experience of computed chest radiography in the sick patient

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The study reviews the benefits and disadvantages of a computed radiography system in the acutely ill patient. A Fuji computed radiography AC1 system was used to

provide images of the chest in patients requiring portable radiography on the wards. The system uses a normal X-ray machine, but replaces a film-screen cassette with a special imaging plate that is later read by the computed radiography machine to produce an image on conventional film. Benefits include a wide exposure latitude (allowing a decrease in repeat film rate), a decreased radiation dose, ease of use and a decrease in radiographer time. It is also possible to produce an edge-enhanced image as well as a conventional image from the one exposure, which allows better delineation of tube tips. Disadvantages are the capital cost of the system, poorer line pair resolution than conventional film screen combinations, and the relatively small size of the chest films. Diagnostic accuracy is not impaired. These points are illustrated and evaluated from the experience of the machine's first year of use in a District General Hospital. We conclude that a computed radiography system is a valuable contribution to radiography of the sick patient.

CT in the pre-operative assessment of patients with advanced lung cancer

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Surgical treatment of lung cancer has recently been extended to include patients with advanced but resectable local disease (Stage IIIA). In this study the reliability of pre-operative CT in staging of locally extensive lung cancer is assessed. The CT scans of 44 patients with surgically proven Stage IIIA or IIIB disease, and of a control group of 50 patients with conventionally resectable disease (Stage I and Stage II) were reviewed by an experienced radiologist. CT, surgical and histological findings were compared for each case. The results were divided into 4 groups. (1) In 54 patients, CT was interpreted as showing operable disease. At operation, 49 had resectable disease (22 Stage IIIA) and five were inoperable. (2) In 19 patients CT indicated disease of uncertain resectability. Of these, 14 had resectable disease (3 Stage IIIA) and five were inoperable. In this group, mediastinal invasion was suspected in 16 patients but confirmed in only four. (3) In 11 patients, CT was interpreted as showing probable inoperable disease; seven had resectable disease (3 Stage IIIA) and four were inoperable. (4) CT scans were retrospectively judged not to be of diagnostic quality in 10 patients, three of whom were inoperable. The causes of inaccuracy in CT assessment of lung cancer are discussed. Early studies reporting high levels of reliability were biased by inclusion of large numbers of patients with Stage I and II disease. This study shows that CT is of limited reliability in pre-operative assessment of Stage III disease.

Double blind comparison of iomeprol 350 and iopamidol 340 in CP scanning of the chest

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We present the results of a double-blind randomized study of a new non-ionic contrast agent, iomeprol 350, to compare the diagnostic quality of contrast enhancement in CT scanning of the chest compared to a standard agent, iopamidol. All patients who were undergoing CT scanning of the chest and who gave informed consent were included in the study. 91 patients were studied with 47 (34M, 13F) receiving iomeprol and 44 (32M, 12F) iopamidol. CT scans of the chest were performed dynamically with an 8 mm slice thickness. The 15 scans per study were radiographically assessed on a 4-point scale (0 = no enhancement, non-diagnostic, to 4 = excellent enhancement, excellent quality). Adverse reactions were noted during and following the procedure. The quality score per case showed a median of 45 with iomeprol (range 23-58) and 42.5 with iopamidol (range 22-55) with no statistically significant difference (Wilcoxon Rank Sum test) seen. Mild adverse reactions recorded included pain at injection site (6 cases iomeprol, 1 iopamidol), heart sensation (17 iomeprol, 16 iopamidol), nausea (2 iomeprol, 4 iopamidol), vomiting (1 iomeprol, 0 iopamidol), dizziness (6 iomeprol, 6 iopamidol), taste disturbance (8 iomeprol, 6 iopamidol) and headache (2 iomeprol, 1 iopamidol). Statistical analysis using a chi-squared test showed no significant difference in adverse reactions between the two groups. The results show that iomeprol 350 and iopamidol 370 are similar both in imaging quality and incidence of side effects.

Pre-employment chest radiography: The effectiveness of current guidelines

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Widespread chest radiography (CXR) for routine pre-employment purposes has largely been abandoned. In guidelines from the Royal College of Radiologists, employment CXR is not recommended except on clinical grounds. The British Thoracic Society (BTS) recommends CXR in those with a Grade 3 or 4 Heaf Test or in symptomatic individuals. Our health board changed its policy in accordance with the BTS guidelines, and we have performed an audit of the first 18 months of the new policy. A total of 129 CXRs (42 male, 87 female, age range 18-54, mean age 35 years) were performed because of a positive tuberculin test, and two cases of active pulmonary tuberculosis (TB) were detected. Both occurred in visiting staff from countries

where TB is endemic. Results suggest that in asymptomatic staff only those with a history of a recent stay in a country where TB is endemic require a tuberculin test and if positive should proceed to CXR. A much larger study however is required before guidelines can be changed.

The role of computed tomographic imaging in cardiac malignancies — a demonstration with two rare cases

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Primary tumours of the heart and pericardium are extremely rare, with published incidences of between 1 in 60 000 cases (0.00017%) and 1 in 1000 cases (0.1%).

However, when they do occur, sectional imaging plays an important role in their management. Complete resection is the only hope of cure and imaging is necessary not only to characterize their nature but also to delineate their extent prior to surgery. A patient with an undifferentiated sarcoma of the pericardium and another patient with an embryonal rhabdomyosarcoma of the right atrium are presented. The ultrasonographic and computed tomographic appearances of both tumours are demonstrated. To the best of our knowledge, the computed tomographic appearance of undifferentiated primary pericardial sarcoma has not been previously described. The roles of ultrasonography, computed tomography, magnetic resonance imaging and positron emission tomography in the assessment of primary and recurrent cardiac tumours are discussed.

9.00 – 10.15

Radiation Protection I

Argyll III

Dose reduction — the cost and the consequences

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Cost-benefit analysis is a popular tool that can readily be applied to many industrial processes. It is much more difficult to use in medicine and especially when ionizing radiation is concerned. Whereas radiation can be measured or estimated, the application to an individual is not necessarily a single arithmetical feat. For instance, radon might affect very differently a husband and wife, where one goes out to work in the open air and the other stays at home in an unventilated room in an area of high radon levels. Similarly, in the absence of an area dose-product meter, the dose absorbed during a barium meal examination will vary from radiologist to radiologist and will vary with the body mass screened, so that extrapolating from the mAs and kV meter readings is misleading — especially if the actual screening time is not recorded for each patient. Similarly, the benefits of dose reduction can be difficult to quantify. We can replace oral cholecystography with an abdominal ultrasound examination and can estimate the dose of ionizing radiation thus saved and then extrapolate to quality added life years or whatever parameter we choose to measure, but life is not always that simple. The advent of CT scanning has given us much more clinical information, but at the cost of an increased radiation burden. Few would argue that this cost outweighs those benefits. An attempt is made to indicate how some of these difficulties might be overcome, to obtain a consensus as to the best approach to convince an often sceptical management team that the additional costs of a proposed programme will result in a positive benefit to the patient.

Trends in patient dose (1981–1991) in a District General Hospital imaging department

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Diagnostic imaging makes an important contribution to the total radiation dose to the population. This study has

assessed the impact of the Ionizing Radiation Regulations 1985 on the population dose in a District General Hospital. Information relating to the number and type of radiographic examinations was gathered from departmental statistics. Patient doses were derived from departmental skin entrance measurements and standard dose allocation as supplied by the National Radiation Protection Board. The results demonstrate that despite a vigorous departmental policy of dose reduction, the population dose associated with diagnostic imaging is still increasing in this department. Audit and clinical education are seen as a means of maximizing the diagnostic potential of the X-ray department whilst simultaneously limiting patient dose through inappropriate or unnecessary X-ray requests.

Radiation safety and quality assurance measurements in the radiological university clinics in Tartu, Estonia

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The Finnish Centre for Radiation and Nuclear Safety (STUK) has made performance and quality assurance (QA) measurements at three diagnostic radiology departments at Tartu University Hospital. Performance measurements of the diagnostic X-ray units were concentrated on X-ray output, accuracy of the tube voltage, exposure time, image quality, patient dose, film processing and radiation scatter in the examination room. The measurements were performed with equipment used by STUK. The exposure values routinely used in Tartu were applied in these tests. The measured exposure parameters were in reasonably good agreement with the set-up values. The spatial resolution was as good as but the contrast resolution worse than the mean values measured in Finland. Patient doses were generally 2–5 times higher than the corresponding values recommended by the EC. Films were processed manually and the quality varied, resulting in uneven density and artefacts. Leakage radiation in the operator's room was negligible. In future, teaching of the personnel to carry out

QA measurements should be arranged and a QA organization for Estonia established. Also routine control of personal doses should be obligatory. An Estonian-Finnish pilot project has been started and film and TL dosimeters have been in use for 1 year.

Radiographic skin doses: investigation of dose levels

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In this paper we present the results of our patient dose assessment programme. Routine surveys of entrance skin dose for patients undergoing certain radiographic procedures, namely chest (PA), pelvis (AP) and lumbar spine (AP, lat and LSA), were started in December 1989. The first 29 studies are reviewed in this paper. These have comprised 107 assessments of skin dose for the specified projections in 28 X-ray rooms and have involved over 900 individual measurements. For each assessment the skin dose for an average-sized patient was interpolated from the measured data. The NRPB reference doses were exceeded in 22 out of the 107 assessments. Of these, 13 were in a single hospital which, as a consequence of these measurements, has successfully implemented a programme for dose reduction. As a result of this review, it has been concluded that the NRPB reference doses do not represent a dose which is as low as reasonably achievable, and revised investigation doses have been introduced based on the third quartile doses from our own survey which are approximately equal to the median value from the NRPB survey. The factors giving rise to higher values are discussed.

The impact of regular performance checks on X-ray equipment on patient dose reduction in diagnostic radiology

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Part of Recommendation 16 of the NRPB publication on Patient Dose Reduction in Diagnostic Radiology (NRPB 1990) states that "all X-ray imaging equipment should be subject to regular performance checks which, if necessary, should lead to appropriate corrective action or replacement". We start by presenting the results of a national survey designed to determine the level and frequency of

regular performance checks, the types of equipment tested and the mechanism available for taking corrective action when faults are identified. Such a programme of regular performance tests has been in place in the East Anglian Region for the past eight years and the second part of the presentation will review the major problems identified during that time and the progress made to rectify them. Finally, the Regional Service now has more than two years' experience of direct patient dose measurements. Over 1100 entrance skin doses have been measured for common radiographic views and nearly 2000 fluoroscopy procedures have been monitored. Data from this survey will be used to illustrate the impact of regular performance checks on equipment on patient dose reduction.

Reference

NRPB, 1990. Patient Dose Reduction in Diagnostic Radiology. *Documents of the NRPB, 1 (3)* (National Radiation Protection Board, Didcot, Oxon).

Organ dose assessment for bronchiectasis and interstitial lung patients imaged with an Imatron CT scanner

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The Imatron is a high-speed CT scanner that uses a 210° beam rotation rather than the 360° rotation normally employed. Organ doses will therefore differ for scans with the patient prone or supine. Patients with lung disease may need to be scanned in either or both of these positions, depending on their clinical diagnosis. Measurements and calculations have therefore been made of the organ and effective doses to compare the risks for these two configurations. The measurements were made using TLDs on nine female patients (four prone, five supine) and an anthropomorphic phantom. The patient measurements provided an assessment of the variation of breast dose. For the phantom measurements, the TLDs were distributed to facilitate estimates of appropriate organ doses and effective dose. The calculations used organ dose conversion factors from published Monte Carlo calculations. The results show that for both scanning geometries, the breasts, lungs and oesophagus receive significant absorbed doses and that the patient orientation has an important influence on effective dose. Comparison of measurements with calculations shows good agreement provided care is taken to allow for the asymmetric geometry of the Imatron.

Evaluation of a new lead shield used for radiation protection during hepatobiliary interventional radiology

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Departments of Diagnostic Radiology and Medical Physics, Hammersmith Hospital, W12 0HS and Department of Biotechnology, South Bank University, London, UK

Interventional work in the hepatobiliary system involves the radiologists' hands being close to the primary beam and therefore by implication close to the scatter radiation produced. A lead shield specifically for right-sided liver punctures to protect the radiologists' hands against secondary ionizing radiation during interventional hepatobiliary procedures was designed and assessed both for radiation dose and ergonomics. Thermoluminescent dosimetry was used to measure the dose to the hands during 40 procedures, the majority done by two radiologists using an undercouch screening system. These were divided into 20 readings with protection using the new shield and 20 without the shield. Dose readings were also taken using an anthropomorphic phantom. The results obtained during the actual procedures showed that the dose to the hands was reduced by 54% when the shield was in use. The phantom readings, incorporating fewer variables which may affect the amount of secondary radiation produced, indicated a theoretical dose reduction by a factor of 3 at 5 cm displacement and an area of exposure of 7×7 cm. The dose reduction achieved was significant but the new lead shield proved awkward to use, although it was far more acceptable for some procedures than others. A newer modified lead shield is to be designed based on the comments received and with a view to maintaining the dose reduction.

Radiation dose and risk to patients during diagnostic and therapeutic ERCP

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Endoscopic Retrograde Cholangio-Pancreatography (ERCP) is used to image the biliary and pancreatic ducts. There has been a rapid growth in the number of procedures involving intervention. This results in extended fluoroscopy times and potentially high radiation doses to patients and staff. As a first step in the process of attempting to minimize radiation dose it is important to examine present practices. We surveyed 67 consecutive ERCP examinations in one centre to establish a typical set of parameters including radiation dose. Diametric measurements were recorded for each patient. Using the concept of effective dose, this allowed a prediction to be made of the lifetime

fatal cancer risk from a routine examination. The examinations were divided into categories according to standard Office of Population Censuses and Surveys (OPCS) classifications. 35 (52%) of examinations involved either stone removal, stent insertion or stent exchange. The remaining 32 (48%) were diagnostic procedures. The average age of patients was 68 years and weight 67.4 kg. For all examinations the mean fatal cancer risk was estimated at 1 in 10 500. Further steps to evaluate and reduce staff and patient dose are being undertaken.

Radiation risk to neonates in a special care baby unit

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Babies in a special care nursery may receive a large number of X-ray examinations during their first few months of life. In addition, the radiation risk factors for children are considered to be higher than those for adults, making paediatric dosimetry of special importance. A study has been carried out to assess the level of radiation dose received by neonates in a special care baby unit. Details of all radiographic examinations were recorded over a period of 18 months. These data were then used, together with measurements of tube output, to calculate entrance dose for each exposure. Monte Carlo simulation was carried out to calculate factors relating energy imparted to entrance dose, and these were applied to the calculated doses. The total energy imparted to each child was determined, and the associated radiation risks assessed. The mean number of X-ray examinations received by a neonate was 5.3, and the mean value of total entrance dose was 0.29 mGy. The maximum energy imparted to one child was 0.36 mJ, with a mean value of 0.04 mJ. The study has established an effective method of radiation risk assessment in the neonatal nursery, and typical dose levels for one particular unit.

Absorbed dose to children at X-ray investigations of the lung

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X-ray examinations of the lungs are comparatively frequent and the same child can be examined several times. Because young people are more sensitive to radiation than adults, it is very important to optimize the imaging procedures in paediatric radiology. The purpose of this work was to improve methods for rapid calculations of energy imparted,

of organ doses and effective dose to children and to quantify the dose values. Measurements were performed on 126 children. A transmission ionization chamber was mounted on the tube. For two-thirds of the patients TL-dosimeters were positioned on the patients' skin, central in the beam. The entrance doses were used to calculate the mean absorbed doses in different organs by the use of measured depth dose data. We found that the energy imparted

increases with the size of the patient, and results in a rather constant absorbed dose, 23 μGy (range 2–103 μGy) per investigation, for children of various ages. The mean absorbed dose to the lung was calculated to be 96 μGy (range 20–216 μGy). We conclude that lung radiography of children gives a low absorbed dose contribution even at repeated investigations. There is, however, still a potential for dose reduction.

9.00 – 10.15

Breast Imaging

Seminar Suite I

MONDAY

Screen-detected colloid and medullary carcinomas

G Long, J Blethyn, 'I J Monypenny, 'K Horgan and K Lyons

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Colloid and medullary carcinomas represent a small proportion of screen-detected carcinomas and are classically described as well circumscribed mass lesions mimicking fibroadenomas on mammography. 50 000 women were screened in a 44-month period and a total of 481 carcinomas were detected. Of these six were colloid and one was medullary. We reviewed the clinical, mammographic, sonographic and histological features of these cases. In only two did the lesion mimic a fibroadenoma on either mammography or ultrasound. Three presented mammographically as areas of asymmetrical density and three had associated microcalcification. Traditional teaching has also suggested that these carcinomas have a good prognosis; however, we found vascular invasion in two, and two patients were node-positive. Many features of these carcinomas differ from conventional teaching.

Poland's syndrome and breast screening: a source of confusion?

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Poland's syndrome encompasses a variety of congenital anomalies including absence or hypoplasia of the pectoral muscles, deformities of the ribs, breast hypoplasia and abnormalities of the ipsilateral upper limb. The prevalence is poorly documented but 1 : 20 000 is cited in the literature. During the prevalent round in the North-East of Scotland (February, 1990 to October, 1992) 35 229 women have been screened. Of these, six have been found to have unilateral absence of pectoral musculature as demonstrated by a single medio-lateral oblique view of each breast. This observation represents an unexpectedly high prevalence of

1 : 5870. These women have been examined for associated abnormalities and we present the results. The high quality mammography demanded by the screening service requires the inclusion of pectoral muscle to the level of the nipple. Absence of this muscle is a potential source of misinterpretation of a mammograph with subsequent recall on "technical" grounds. Recognition of this congenital anomaly is therefore important in order to avoid repeat mammography with its attendant anxiety and radiation dose.

The negative mammogram

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The causes of negative mammography in the presence of breast carcinoma were investigated to determine its clinical, pathological and radiological associations. A retrospective review of the clinical records, mammographic reports and original mammograms of all cases of newly diagnosed breast carcinoma passing through a combined breast clinic over a 2-year period was conducted. 175 patients presented with breast cancer, and mammography reports were negative in 29 (16.6%). This rate was higher in women aged under 50 and pre-menopausal women, and in those with Paget's disease or invasive lobular carcinoma. In addition smaller (under 10 mm) carcinomas were more difficult to detect. The negative mammograms were categorized into true negative (normal on review) or falsely negative (benign-appearing lesions or those with evidence of malignancy on review). 62% were falsely negative, and the reasons for these were analysed. There was delay between the patient's first attendance and treatment in 17 cases; 12 of these had negative mammograms. Any change in clinical staging with delay was studied. Clinical progression occurred in eight patients. We conclude that the pre-menopausal and under 50 age groups, and those with Paget's disease and invasive lobular carcinoma, are at greatest risk of negative mammography.

An audit of the mammographic needle localization service in Glasgow Royal Infirmary

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An audit was carried out to assess the mammographic needle localization (MNL) service for impalpable breast lesions in this institution. Over the last five years, 95 MNL procedures were performed, of which 25 were malignant (positive predictive value (PPV) of 26%). The "accepted standard" for this PPV is 20–30%. Current performance was assessed by independent "blind" review of 100 mammograms by two consultant general radiologists with an interest in mammography. Fifty of these had previously undergone MNL and subsequently biopsy (of which 13 were malignant). The other 50 were a random selection of benign (42) and malignant (8) cases. Malignancy was estimated on a percentage scale (benign 0%, suspicious 1–99%, malignant 100%). If the threshold for biopsy was 30%, with review of cases 1–30%, the PPV for Radiologist 1 was 44% (missing one intraduct carcinoma and detecting one recurrence on review) and for Radiologist 2 was 38% (missing one recurrence and detecting one intraduct carcinoma on review). However, if the two radiologists' reports were combined, assuming appropriate action for the higher percentage, then the PPV was 31%, with one recurrence and one intraduct carcinoma being detected on review, and no cases of malignancy being missed.

A national database for assessment of imaging features of interval cancers in the NHS Breast Screening Programme

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Breast cancers arising in the interval between screening examinations are inevitable in any screening programme. An analysis of these interval cancers is fundamental to the continued quality assurance process of the NHS screening programme. A number of distinct factors influence the proportions of interval and screen detected breast cancers, including the screening interval, technical quality of the mammography, biology of the different types of breast cancers and skill of the film readers. Interval cancers may be divided into four main groups: true intervals, occult on mammography, false negatives and miscellaneous. Analysis of the proportion of these interval subgroups provides an insight into the dominant influencing factors. Analysis of false negative examinations is of particular interest to radiologists as this factor can be influenced. As the numbers of interval cancers occurring in individual units

per annum are too small to allow for meaningful analysis, a national database has been set up to provide data and results from a large number of cases over a short period. The structure of this database, mechanisms of data collection and analysis, and the methods of result distribution are discussed.

Breast screening in Chinese women: Comparison of parenchymal patterns in Chinese and caucasian women

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Withington Hospital, Manchester M20 8LR, ²Breast
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UK*

Breast cancer incidence has been related to the presence of particular mammographic glandular patterns. This disease has a known lower incidence in Chinese than in caucasian women. This study set out to determine whether differences exist between the distribution of mammographic parenchymal patterns in Chinese and caucasian women which could explain this lower incidence. A retrospective analysis was performed, in Nottingham and Manchester, of women (ages 50–64) who had already attended for breast screening and who had been classified as normal. Strict criteria were applied to the identification of Chinese women by their names. Data were available for 160 Chinese women in these two centres and 540 caucasians. Two experienced radiologists in each centre read the respective mammograms from each city and identified parenchymal appearance using the Royal College of Radiologists Breast Group classification scheme. Results in this sample demonstrated no significant differences between the two groups of women in terms of any of the seven possible parenchymal pattern appearances. In conclusion, the finding of no difference in the distribution of parenchymal patterns between the two groups, despite the Chinese population having a known lower cancer incidence rate, suggests that it is dubious whether such patterns can be employed as a useful predictor of breast cancer risk.

Ergonomic requirements of multiviewers in breast screening

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Nottingham, and ¹Department of Academic Radiology,
Queen's Medical Centre, Nottingham, UK*

The purpose of this research was to investigate the design of the dedicated mammographic multiviewers employed in breast screening in relation both to established ergonomic

principles and to official guidelines. The objective was to determine whether radiological screening performance could be improved by modification of existing multi-viewers. Design recommendations for such multi-viewers have been produced by the DoH and the NHS and these criteria were first compared to established ergonomic data which yielded some discrepancies. Two types of alternator were then selected for further detailed investigation and experienced radiologists were videotaped as they used them. This yielded information on the inspection process itself as well as on the postures and movements of the radiologists whilst inspecting mammograms. These data were analysed using standard ergonomic techniques. Additionally, structured interviews were carried out with other screening radiologists concerning both the desired, and the required, features which should be included in the multiviewer design. It is concluded that existing guidelines could be improved, and specific design recommendations are proposed which would aid the radiologists in their task, so improving screening efficiency.

Axillary staging in breast cancer by colour Doppler ultrasound

S M Allan, R P Kedar, D O Cosgrove and N P M Sacks
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Lymph node status remains the single most important prognostic factor in breast cancer. Axillary surgery is currently the only reliable means of providing this essential information. This study evaluates using colour Doppler ultrasound to provide equivalent information by a non-interventional means. Patients with primary operable breast cancer were recruited from the staging clinics and written consent obtained. Each patient underwent colour Doppler ultrasound examination of their axillae with an Acuson 128 prior to the planned axillary surgery. These scans were performed and reported blind by two radiologists and then compared to the information provided from the histopathological examination of the resected axillary specimens. Twelve patients have been studied, with 6/12 cases containing metastatic cancer within the axillary nodes and six being uninvolved. Enlarged lymph nodes were correctly identified in all six cases of involved nodes and correct assessment of the disease state was possible in all these cases by Doppler assessment of the vascularity of the identified lymph node. The initial results would suggest that the combination of ultrasound and colour Doppler provides an accurate means of assessing the axilla in breast cancer and could possibly replace surgery for providing staging information.

Multicoil (phased array) MR imaging of the breast

¹R Kerslake, ²J Fox, ^{2,4}P Carleton, ^{3,4}M Imrie, ^{3,4}A Cook and ¹A Horsman

¹YCRC Centre for Magnetic Resonance Investigations, Departments of ²Surgery and ³Radiology, Hull and East Yorkshire Health Districts, Hull Royal Infirmary and ⁴Humberside Breast Screening Service, Kingston General Hospital, Hull HU3 2JZ, UK

The advantages of phased-array multicoil techniques for MR imaging include the ability to obtain large field-of-view images with preserved signal-to-noise and in-plane spatial resolution. We report on early experience with a prototype breast multicoil array (IGE Medical Systems) operating at 1.5 Tesla. 12 patients underwent unilateral and/or bilateral breast MR studies using the prototype coil. Conventional spin echo, fast spin echo and dynamic gradient echo and chemical shift selective fat saturation techniques following intravenous gadopentetate dimeglumine were used. Bilateral examinations were obtained with a large field of view and matrices of 256 × 512 to 512 × 512. Section thickness was typically 4–5 mm. The coil provided adequate coverage of the breast, internal mammary region and axillary contents though assessment of the axilla was occasionally hindered by flow artefacts (worse for left-sided examinations and post-contrast). Modification of pre-scanning procedures was essential for optimal fat suppression. Both benign and malignant lesions could be identified and characterized. Use of a dedicated phased array breast imaging multicoil enables high quality bilateral breast MR examinations to be performed in acceptable scan times and reasonable comfort for the majority of patients. The relative importance of dynamic and static post-contrast images will be discussed.

Prospects for axillary staging in breast cancer by magnetic resonance imaging

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Lymph node status is still the single most important prognostic factor in breast cancer. Axillary surgery remains the only reliable means of providing this information. This study evaluates the use of MRI to provide equivalent information. Patients with primary operable breast cancer were recruited from the staging clinics and consent obtained. T_1 -W and T_2 -W images were obtained of the axilla in coronal and axial planes respectively. To avoid observer bias, scans were reviewed without clinical details by a single radiologist experienced in MRI. The MRI interpretation was then compared to the information

provided from the histopathological examination of the resected axillary specimen. 25 patients have been studied, with lymph nodes being correctly identified in 86% of cases. A threshold size of 5 mm was found to be necessary for identification of axillary nodes. Correct assessment of the disease status was possible in 52% of cases by virtue of

signal change. These figures were improved by providing clinical information prior to MRI interpretation rather than the unrealistic situation of "blind" reporting. We feel that with the benefit of clinical information, MRI will be useful as a staging technique for both new cases and those where restaging of the axilla becomes necessary.

9.00 – 10.15

Cancer Treatment and Patient Care

Seminar Suite II

Psychosexual aspects of cancer and its treatment

A Cull

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Sexual relationships are important to the quality of life for many people and may be compromised by cancer and its treatment. The nature and frequency of sexual problems may be expected to vary with disease site and treatment arising from physical damage to genital structures and/or their neurological, vascular or hormonal control. Non-specific effects such as fatigue and the psychological impact of disease and treatment on the individual and on the relationship with a partner are also relevant. Patients may be reticent about volunteering sexual concerns and doctors are often reluctant to ask, thus clinical estimates often under-represent the problem. Systematic enquiry shows significant sexual morbidity across all disease sites and following all therapeutic modalities. In clinical trials such data are useful not only as an outcome measure but to inform patient choice. Recent research has shown conditions under which some men are willing to trade survival time for the chance of maintaining sexual potency. In clinical practice an early opportunity to discuss such concerns may avert some problems while simple interventions delivered early may be effective in reducing the incidence and severity of others. For a minority of patients specialist referral may be indicated. The case for more systematic assessment of sexual concerns among cancer patients will be illuminated with data from local research on patients with cervical cancer.

Sexual morbidity following radiotherapy for germ cell tumours of the testis

S D Tinkler, G C W Howard and G Kerr

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Hospital, Edinburgh EH4 2XU, UK*

The purpose was to assess sexual function following orchidectomy and abdominal radiotherapy in testicular cancer patients. Anonymous questionnaires were sent to: 237

patients treated with orchidectomy and abdominal radiotherapy in Edinburgh between 1974 and 1988; 32 patients under "surveillance" following orchidectomy alone; and 402 "normal" age matched controls. Sexual function over the preceding 6 months in all men, and the first 6 months after treatment in the patients, was assessed. Completed questionnaires were returned from 137 (62%) radiotherapy patients, 18 (56%) surveillance patients and 121 (35%) controls. The radiotherapy-treated patients performed significantly less well than the controls in almost all the parameters looked at, including erection, ejaculation and libido. In addition, almost 24% of the radiotherapy group felt disabled or disfigured by the treatment, most commonly because of the presence of only one testicle. There was no difference in responses between the two time periods or in any of the treatment variables. A deterioration in sexual function was observed with increasing age in the treated and control groups. The clinical significance of these observations is unclear but, together with increasing information on other toxicities following this therapy, the role of radiation for early stage seminoma is being brought into question. The wider use of testicular implants may reduce morbidity from orchidectomy.

Cost effectiveness of strontium-89 in patients with carcinoma of the prostate: an interim analysis

A J McEwan, D G McGowan, G Amyotte and J MacGillivray

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The TransCanada Strontium Study studied the effectiveness of strontium-89 as an adjunct to palliative radiation in hormone-refractory carcinoma of the prostate. Patients were randomized to receive strontium-89 in a dosage of 400 MBq or a placebo at the conclusion of a course of palliative radiation. A total of 133 patients were entered, 126 receiving the study medication. An endpoint in this study was a cost analysis. Because of provincial variations in costing, this was proven to be difficult. At the Cross Cancer Institute in Edmonton, 29 patients were entered and the cost analysis will be presented. The overall costs were

approximately equal for the two groups. However, the direct therapy costs, per patient, were 30% greater in the placebo group than in the strontium group, and the patient management costs were about equal (medical imaging and laboratory). In contrast, the hospital stay costs were some 30% less for the placebo group. The reasons for these differences will be discussed.

Surveillance after treatment for well differentiated thyroid cancer: is chest radiography of any value?

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Well differentiated thyroid carcinoma has an excellent prognosis, with many patients achieving a cure. The incidence of pulmonary metastasis is about 11%. Where thyroid ablation has been used in the initial treatment, thyroglobulin (Tg) levels are a sensitive marker of disease. Data regarding the usefulness of chest X ray (CXR) in monitoring relapse in these patients does not exist and regular CXRs as well as Tg levels continue to be performed as routine surveillance. To assess the efficacy of this approach we have reviewed all serial CXRs and corresponding Tg levels on every patient with well differentiated thyroid carcinoma treated and followed up at The Royal Marsden Hospital between 1984 and 1987. A total of 364 CXRs were performed on 49 patients with a mean follow-up of 6.5 years. Of these only 14% were undertaken for clinical reasons, with 86% being requested as routine. Seven patients developed lung deposits, six of whom had CXR performed because of elevated Tg levels, abnormal iodine uptake scans or abnormal chest CT scan. In no case were lung metastases diagnosed by routine CXR in an asymptomatic patient. We conclude that, apart from an initial staging CXR at diagnosis, routine chest radiography is neither a cost effective nor a sensitive method of screening for relapse in asymptomatic well differentiated thyroid carcinoma. It should be reserved either for patients with chest symptoms or for cases where Tg is not a useful marker of disease.

CHART outside the trial

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During the last three years we have treated 91 patients by a CHART-type protocol outside the randomized trial. 16 out of 21 patients with carcinoma of the head and neck showed complete early regression, and only three had to be re-admitted because of the severity of mucosal reaction. We

observed no serious late damage. In 18 patients treated for lung neoplasms, four responded fully. The only side-effect was transitory dysphagia, and fibrotic changes in the treated volume were observed in five patients. We have also treated six patients with urinary bladder tumours, four with anorectal carcinomas, two with carcinomas of the prostate, one with cancer of the urethra, and one metastatic pelvic tumour of unknown primary site. In 10 of them the tumour dose was 50–54 Gy in 36/12 days, in one 40 Gy in 33/11 days, and two patients received 47 Gy in 36/12 days. Nine of these involved large pelvic volumes. We observed complete response in five and a useful partial response in another five patients. Diarrhoea, dysuria, frequency or painful spasm was observed in eight patients. These symptoms eventually settled. No serious treatment-related morbidity was observed. The tolerance and results will be described in detail, as well as in another 20 patients with various diagnoses and localizations. We have also treated the whole breast and axilla in 17 patients, nine of them after local excision of the primary tumour, eight with inoperable primary tumours, and one after mastectomy. Two large tangential 5 MV fields were used to treat the whole breast and axilla in 30 sessions, delivering 40–54 Gy TD, and 140–250 kV direct field boost to 6–11 Gy incident dose in five sessions. Complete response was observed in 5/8 primary tumours. So far, none of the prophylactic or the full responders have recurred (mean follow-up time 14 months). Acute tolerance was excellent. Only one patient suffered from deforming breast fibrosis (5184 cGy TD in 36/12).

Care of elderly patients receiving radiotherapy treatment

C Lark and C Jacobs

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Since the mid 1980s the demographic trends in the United Kingdom have been changing. We are faced with an ever-increasing elderly population, whose numbers exceed the numbers of people in subsequent generations. This means that the elderly are becoming a major group in this country, with many associated health care and social implications. The retired population may be divided into two categories, with the "young" elderly (65–80) and the over 80s having very different needs. The aged group represents the greatest challenge to health care. They may not have a spouse or family support network and may need to be cared for by the state. Talking and observing in the Radiotherapy Department, clinics and wards and appraising the literature on the care of the elderly made us aware of the importance of meeting the needs of these patients. We concluded that there was a place for a fresh look at our communication skills and support services for these patients.

Computer assisted teaching programme for laryngeal cancer

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Computer-assisted learning has been shown to be a useful adjunct to conventional clinical teaching. A computer programme has been written using the Macintosh multimedia software Hypercard to teach the principles of treatment of laryngeal cancer by radical radiotherapy. The programme is available on 3½" floppy disc and incorporates text, sound and both static and animated graphics. It covers the relevant clinical anatomy, pathology, typical target volumes, field arrangements and distributions for supraglottic, glottic and subglottic tumours and the results of treatment. Using the mouse to click on appropriate "buttons" and icons, the postgraduate student can move forward or backward in the programme. The self study programme is user-friendly, enabling the student to follow the programme with minimal or no supervision. Delegates will be enabled to assess the programme for themselves.

The effect of head and neck irradiation on taste dysfunction — a prospective study

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Taste dysfunction is one of the major causes of morbidity for patients having irradiation to the head and neck. In a prospective study on 26 patients we have evaluated objective and subjective taste loss both before, during and after a course of irradiation to the head and neck region. Patients were divided into four groups depending on the volume of tongue or parotid contained within the irradiation field: Group A (predominantly parotid), Group B (predominantly tongue), Group C (both tongue and parotid) and Group D (control group—neither tongue nor parotid). Taste was tested objectively using a series of solutions at different molar concentrations in order to determine the sensitivity to sweetness (sucrose), saltiness (NaCl), bitterness (urea) and sourness (HCl). Patients also

completed a subjective taste questionnaire including details of the dryness of their mouth following irradiation. The results of the study show that only 4/17 (24%) patients in Groups A (parotid) and D (control) had any significant objective taste loss. However 6/9 patients in Group A did complain of marked dryness of the mouth. All patients in Groups B and C, in both of which over 30% tongue was within the treatment field (nine patients), had some degree of both objective and subjective taste loss. We conclude that some degree of tongue irradiation is crucial to the development of radiation-induced taste loss, while parotid irradiation by itself has less of an effect on taste even after causing mouth dryness.

Glioblastoma: Analysis of progression following the extent of neurosurgical resection and two different radiotherapeutic concepts

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Departments of ¹Radiotherapy and ²Neurosurgery, University of Göttingen, 3400 Göttingen, Germany

The therapy of glioblastomas is still unsatisfying, although different neurosurgical and radiotherapeutic concepts exist. The success of the medical treatment depends on the time of diagnosis, tumour localization, extent of resection and the post-operative radiotherapy. This study intends to demonstrate the effects of a new accelerated regime with a whole brain irradiation of 40 Gy (5 × 2 Gy weekly) and additionally 1.8 Gy three times a week up to 21.6 Gy in the tumour area in comparison to conventional radiotherapy. Special interest is focused on the extent of operation and early signs of recurrence visualized by MRI. 128 patients with an average age of 56.5 years underwent surgical intervention. MRI or CT controls with contrast media were performed within 48 hours after neurosurgery and led to the classification of the operative therapy in biopsy, extended biopsy, subtotal and radical (> 95%) resection. Postoperatively, 30 patients were treated by the new regime whilst the majority were irradiated conventionally. An important predictor for survival rate was early signs of tumour progress during radiotherapy, confirmed by closely following MRI investigations. Therefore 16.8% of our patients were reoperated. To summarize, the new accelerated radiation regime facilitates short-term stay in hospital without further complications. The efficacy of both radiotherapeutic concepts are nearly equal. According to our preliminary data the extent of surgical therapy is a more important factor in the survival rate than different regimes of radiotherapy.

Atypical and malignant meningiomas: comparison of CT and MRI during neurosurgical and radiotherapeutical treatment

¹S Schlen, ²R Verheggen, ¹D Matthaei, ²E Markakis and ¹E Dühmke

Departments of ¹Radiotherapy and ²Neurosurgery, University of Göttingen, 3400 Göttingen, Germany

The meningiomas are predominantly benign tumours which constitute approximately 15% of the primary brain tumours. Atypical and malignant meningiomas are rare and characterized by focal necrosis, mitosis, cell and nuclear pleomorphism of different degree. The aim of our study was to evaluate the benefit of CT in comparison to MRI during the surgical and radiotherapeutical course and follow-up examinations. The value of post-operative radiotherapy will be discussed in patients with atypical and malignant meningiomas with regard to the degree of the

surgical resection. Between October 1986 and 1992, 21 patients in all — 12 women and nine men — with the pathological diagnosis of atypical ($n = 11$) or malignant ($n = 10$) meningiomas underwent neurosurgical intervention. In 8/3 cases the diagnosis was primary atypical respectively malignant meningioma. In 10 patients up to five neurosurgical operations preceded the final histological event of an atypical or malignant variant. As typical signs of atypical or malignant meningiomas we consider the following CT and MRI findings: inhomogenous enhancement, signs of focal or extensive necrosis and irregularity of the tumour surface. In order to delineate the radiation treatment fields we labelled the skin in this areas for MRI with newly developed marker on an adhesive foil fitted with a matrix of polyurethane. Routinely performed follow-up investigations revealed clear advantages of MRI in the evaluation of relapsing tumours, strategy of neurosurgical intervention and radiotherapy treatment planning.

10.45 – 12.00

Clinical MRI II: Musculoskeletal

Argyll I

Clinical role of MRI of the knee

D Wilson

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In specialized orthopaedic institutions MRI of the knee has made a radical impact on clinical practice. Three of the UK's major orthopaedic hospitals have their own MRI system and the others have all arranged regular access either at nearby hospitals or by a mobile system. At the Nuffield Orthopaedic Centre in Oxford around half of the MRI studies are for internal derangement of the knee. This totals over 1500 examinations per year and routine MRI of the knee for NHS patients is a reality. It is likely that this trend will spread to district general hospitals by the end of the decade. The primary reason for this rapid change in medical practice is the now excellent precision of MRI for meniscal and ligament injuries. There are now many studies that confirm accuracy in excess of 90% for the diagnoses of these disorders compared to arthroscopy. Indeed, the most recent work suggests that arthroscopic diagnosis is probably not an adequate gold standard as it seems likely that MRI is a more precise tool. Certainly arthrography has ceased to be a useful test and it is unlikely that radiologists will be able to obtain training in this technique. How does the introduction of ready access to routine knee MRI affect everyday practice? It rather depends on the local surgical referral pattern. First question your surgical colleagues for an honest opinion on what proportion of arthroscopies are therapeutic and what proportion are diagnostic. If the majority are therapeutic it is likely that the local services are overwhelmed and the only cases arthroscoped are those very likely to have treatable injuries. In these circumstances MRI is an expensive luxury and the money would be better spent on more surgeons and theatre time. More typically around 40–50% of arthroscopies will be purely diagnostic. A normal MRI is highly predictive that arthroscopy will be of no value and the routine preoperative examination by MRI will safely reduce this rate by well over half. A 30–40% reduction in surgery is likely. At £500–600 per arthroscopy and £170–200 per MR study the economics indi-

cate a break-even or small gain. However there are obvious advantages in reduced morbidity and the release of surgical and theatre time to other procedures with a higher likelihood of therapeutic success. With a well organized internal market these cases more than offset the provision of an MRI unit. To put it simply, with a busy knee practice MRI saves money, improves the quality of care and reduces morbidity.

Magnetic Resonance Imaging for the problem knee: a randomized clinical trial

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A prospective randomized trial was performed to assess the effect of MRI in patients likely to undergo arthroscopy of the knee. 52 patients were studied. 27 patients were randomized to MRI; no imaging was performed in the 25 control patients. We assessed the following outcomes: the leading clinical diagnoses at referral and follow-up, the numbers and types of arthroscopies in the two groups and the outcome as judged by health-related quality of life (QOL) scores. Fewer arthroscopies occurred after MRI (8/23) than amongst the controls (12/20, $p < 0.10$, not all patients reattended). There were also fewer purely diagnostic arthroscopies amongst those who had MRI (2/23 compared with 8/20, $p < 0.05$). There were no significant differences in the number of changes in diagnosis between the groups. The QOL scores improved over six months in both groups; this improvement reached statistical significance amongst the MRI patients ($p < 0.05$) but not in the controls. It was concluded that MRI offers an acceptable alternative to purely diagnostic arthroscopy. This cheaper and less invasive approach may even contribute to improved quality of life in these patients.

Magnetic Resonance Imaging in pigmented villonodular synovitis

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Pigmented villonodular synovitis is an uncommon cause of monoarticular joint pain characterized by hyperplasia of synovial villi. The knee and hips are commonly involved and show plain film changes characterized by periarticular osseous pressure erosions and an increase in periarticular soft tissue radiodensity. In the past diagnosis necessitated review of plain films and arthrograms and ultimately required definitive biopsy. This study highlights the clinical and pathological features of the disease and reviews the magnetic resonance features in three patients who presented to the Mater Misericordiae Hospital between June 1991 and June 1992 with a biopsy proven diagnosis; correlation is made between gross signal changes and corresponding histological sections. As a result of improved soft tissue resolution and characteristic signal changes of haemosiderin deposited in synovium, MRI enables a diagnosis without recourse to an invasive biopsy.

Meniscal cysts of the knee detected by Magnetic Resonance Imaging

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Meniscal cysts are a complication of meniscal tears that extend to the capsular attachment, and are reported to be three times more common on the lateral than on the medial side. We present 50 patients with meniscal cysts detected by MRI. Patients had at least two sequences, usually a gradient echo volume acquisition (FISP) and a T_2 -weighted gradient echo sagittal image (FLASH). On review of the scans, 50 patients met the criteria for meniscal cyst. 29 cysts involved the medial meniscus and 22 the lateral meniscus. The most common sites were the posterior third of the medial meniscus and the mid-third of the lateral meniscus. Of the associated meniscal tears, 29 were classified as horizontal, eight as oblique and 14 as complex. Thirty cysts were small ($< 1 \text{ cm}^3$), 16 were of medium size ($1-5 \text{ cm}^3$) and five were large ($> 5 \text{ cm}^3$). According to the request card, 13 cysts were suspected clinically, five being on the medial side and eight on the lateral side. Small cysts were only detected on the lateral side. This study indicates that medial cysts are more common than previously thought and are more difficult than lateral cysts to detect clinically.

Rotator cuff Magnetic Resonance Imaging with operative correlation

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MRI is increasingly used for evaluating lesions of the supraspinatus tendon. The present study was undertaken, firstly, to evaluate the accuracy of MRI in comparison with operative findings in a large group of patients with shoulder pain of sufficient severity to warrant operative intervention. Secondly, the study was performed to determine the value of different spin echo sequences in assessing the supraspinatus tendon. Recommended pulse sequences include T_1 , T_2 and proton density images. T_2 weighted images are required to visualize supraspinatus tendon tears, but imaging time could be reduced if it were shown that T_1 -weighted images were not essential. Of 60 patients examined to date, 15 had normal tendons at surgery and 20 had full thickness tears, all but three of which were detected by MRI. There were no false positive MRI diagnoses of full thickness tears. The remaining 25 patients had varying degrees of tendonitis and partial thickness tears. In this group, there was generally good correlation between the MR and operative findings, but in four patients MR suggested tendonitis only when a partial tear was also present. In two patients tendonitis only was found at surgery, when MR had suggested a partial tear. The significance of these findings and the value of different pulse sequences is discussed in detail.

MRI of the temporomandibular joint: Quantum leap in cost effective imaging or pricey technological overkill?

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TMJ dysfunction is a diagnostic imaging challenge that is currently being revolutionized by the application of MR as a non-invasive method for demonstrating the joint, particularly disc displacements. In our institution MR (with dedicated TMJ coils) has now wholly supplanted arthrography. Initially the extra expense of this was felt justified because of increased patient acceptability and lack of radiation dose. However, we have recently introduced a volume acquisition pulse sequence that has reduced imaging time significantly. This has allowed increased patient throughput and hence lowered costs. We present our current MR imaging protocol for TMJ dysfunction together with a detailed analysis of costs as compared to arthrography. We have found comparative prices of £109 for arthrography (single joint) and £100 for MRI (bilateral examination). Taken together with patient preference for MRI over arthrography, we conclude that MR is both highly cost effective and well tolerated in evaluating TMJ dysfunction.

Magnetic Resonance Imaging in hyperparathyroidism

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We planned to evaluate MRI in the assessment of hyperparathyroidism. Records of patients referred for MRI of the parathyroid glands between 1986 and 1992 were reviewed. 69 patients underwent both MRI and surgery. The interpretation of the MRI was compared to the findings at surgery. 61 patients had no history of parathyroid surgery, and the results of MRI in this group were: true positive 44; false negative 10; true negative 2; false positive 5; sensitivity 81%; specificity 29%; accuracy 75%. MRI was more accurate in the diagnosis of adenoma (82%) than hyperplasia (50%). Eight patients had previously undergone parathyroid surgery. The results of MRI in these cases were: true positive 6; false negative 1; true negative 1; false negative 0; accuracy 87.5%. Four patients had ectopic parathyroids. All four were successfully located. Two cases of parathyroid carcinoma did not show any distinctive radiological features. Four of the five false positive diagnoses were due to enlarged lymph nodes. MRI was found to be an accurate modality for investigation of hyperparathyroidism, particularly following previous parathyroid surgery. Pitfalls which may occur include: (1) Low sensitivity for the identification of hyperplasia; (2) Misinterpretation due to enlarged lymph nodes or adjacent thyroid disease.

Biplanar MRI of herniated lumbar discs: Value of axial images

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The aim of this study is to determine if transaxial images add further information to sagittal projections in the evaluation of lumbar disc herniation. The biplanar MR images of 40 patients with sciatica were separately reviewed by two independent radiologists. Discs were classified into four categories, from 1 = normal to 4 = rupture through posterior longitudinal ligament. Site of herniations were

noted. Of 140 discs imaged in both planes, 62 herniations were identified; 97% in the sagittal and 89% in the axial plane. 53/62 herniations were seen in both planes; 31 with matched sites of herniation. 16 posterior herniations on sagittal projections were seen to have a lateral component on the axial plane with 15 nerve root compressions. Transaxial images missed seven disc herniations but identified another two. Thirty discs were treated with discolysis. Four far lateral herniations were identified only on axial projections. We conclude that a transaxial view is required for lumbar disc evaluation as it allows clearer visualization of thecal distortion, nerve root compression and epidural foraminal fat attenuation, and identifies far lateral herniations.

Correlation of far lateral disc herniation and presenting symptomatology

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Far lateral disc herniation whether foraminal or extraforaminal in position is a rare finding on X-ray examination. This study was carried out prospectively to investigate the correlation of presenting signs and symptoms with far lateral disc herniation and to research the incidence of asymptomatic lesions. One hundred patients presenting with lumbar radiculopathy are being prospectively investigated on a 0.2 Tesla permanent magnet MRI. The examinations were carried out according to a set protocol using T_1 and T_2 sagittal and T_1 axial sequences and when necessary a T_1 coronal sequence. The images are being interpreted independently by two neuroradiologists who were satisfied as to the quality of the studies. The radiological findings are graded and recorded using a standard protocol. We found the incidence of far lateral disc herniation to be 11.5%. The presenting symptomatology corresponds to the level of disc herniation. To date there are no cases of asymptomatic herniation. Far lateral disc herniation is a less well recognized cause of back and lower limb symptomatology. This condition needs to be accurately diagnosed to enable the surgeon to plan the correct surgical approach.

10.45 – 12.00

Angiography

Argyll II

Use of a directional needle for anterograde guide wire placement in the superficial femoral artery

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Cannulating the superficial femoral artery (SFA) for anterograde femoropopliteal angioplasty or thrombolysis can sometimes be difficult and time-consuming, particularly in obese patients, those with disease at the origin of the SFA, and those with a high bifurcation of the common femoral artery (CFA). We describe the use of a cannula (PERICAN[®], B Braun Ltd, Aylesbury, Bucks, UK) with a pencil point tip and a bevelled distal side hole to direct a guide wire into the SFA. We have used this successfully in 20 patients without requiring additional catheters or guide wires. There have been no significant complications. We have performed a randomized prospective pilot study in 16 patients undergoing femoropopliteal angioplasty, comparing the directional needle with our standard cannula. The number of passes required and the time taken to puncture the CFA was the same in both groups. The mean time taken to cannulate the SFA with the guide wire was 72 s using the directional cannula and 329 s using our standard cannula and further catheters were required in two patients in this group. This directional needle is an effective and cheap alternative to the use of multiple catheters, sheaths or guide wires sometimes required in these patients.

Vascular problems related to haemodialysis

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The vascular problems directly related to haemodialysis in a patient population of 150 over a three-year period have been reviewed. Significant complications were encountered in eight patients and these included subclavian vein occlusion/stenosis following prior central line insertion and stenosis of the fistula itself. Six patients had subclavian vein occlusion/stenosis and presented with limb oedema

following arteriovenous fistula formation. Treatments included insertion of a subclavian stent, surgical ligation of the fistulae and embolization of a fistula. Two patients with fistula stenosis were treated with angioplasty. Examples of these complications and therapeutic interventions will be presented and our experience with colour-flow Doppler considered. The majority of vascular access complications were related to previous central line insertions and we recommend that venography be performed in patients due to have arteriovenous fistula construction if they have had previous central vein cannulation.

The incidence of conjunctival contamination by blood during angiography

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In view of the well documented conjunctival route of viral transmission and intended introduction of universal precautions at our institution, we have assessed the incidence of conjunctival contamination by blood during angiography. Operators wore either their own or clear plastic safety spectacles during angiography. At the end of the procedure these were checked for droplet contamination. Technical details thought likely to influence the incidence of contamination were recorded. 121 spectacles from 100 cases were examined. Contamination with clear fluid was found in two cases (1.6%). Blood droplets were found in three cases (2.5%), all involving different operators and types of procedure. In no case was the operator aware of contamination. The actual incidence of conjunctival contamination will be less than 2.5% owing to the smaller surface area of the conjunctiva than of the spectacle lens. Although much lower than the incidence reported by surgeons and histopathologists, it should not be ignored in view of the consequences of HIV and viral hepatitis infection. Given the frequency of angiographic procedures, radiologists should acknowledge the usefulness of eye protection encompassed within a universal precautions policy.

Vascular intervention in young patients — A case controlled study

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Previous studies have suggested that atheromatous vascular disease behaves more aggressively in young patients. We have followed a case controlled group of young patients to assess outcome following radiological intervention as a primary treatment for vascular occlusive disease. The study group of 23 patients (one female), median age 43 (range 33–45) were case matched with a group of median age 67 (60–85). Re-intervention was required in 10 (8) of the study (control) patients, with a mean time interval to re-intervention being 0.74 years in the study group and 2.88 years in the control group. In 8 (4) cases first re-intervention involved treatment of the same lesion, and in 7 (1) of these this treatment was radiological. Where a different lesion was treated this was by radiological means in all cases. In the 10 study patients who came to re-intervention a total of 14 further radiological procedures were required. This contrasts with the older group in whom five radiological re-interventions were required in eight patients. These data suggest that occlusive vascular lesions behave more aggressively in young patients. As treatment in this group is biased towards continued radiological intervention rather than surgery, the treatment of young arteriopathies carries clear financial implications for interventional radiology units.

Contrast bolus quality studied with ultrafast CT

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We studied the aortic bolus quality after intravenous contrast using ultrafast CT (Imatron C-100) (UFCT). With its subsecond scan speed, UFCT can reliably quantify the passage of an aortic contrast bolus. In two healthy dogs (35 and 36 kg), 15 ml diatrizoate and iohexol (both rendered 292 mg ml⁻¹ of iodine) were given at 5, 10 and 20 ml s⁻¹ via a 9 French central venous line. The order was alternated. In a further 36 kg dog, 25 ml iohexol 300 mg ml⁻¹ and diatrizoate 370 mg ml⁻¹ were given at 10 and 20 ml s⁻¹. 20 sequential 0.1 s scans were performed at the level of the mid-abdominal aorta over 30 s. Time density curves were analysed, and gamma-variate fits performed to exclude the effect of recirculation. Curve fits were found to be highly

reproducible. In 5/6 cases, the peak aortic density was lower at 20 ml s⁻¹ than at 10 ml s⁻¹. The area under the curves (which is representative of the amount of contrast in the bolus) was a mean 22% higher with non-ionic contrast. The observed peaks and rate rises were higher and sharper with 10 than 5 ml s⁻¹. We conclude that bolus quality may be adversely affected by very high rates. Non-ionic contrast appears to be better retained within the intravascular space.

Angiographic patterns in young patients with myocardial infarction

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This prospective study was undertaken to analyse the findings at left ventricular angiography and coronary angiography in patients presenting with myocardial infarction at an early age. 158 patients under the age of 45 were recruited to the study between 1976 and 1986, having been admitted to the Western Infirmary, Glasgow with an acute myocardial infarction. By 1991, 56 patients (35%) had died. 79 survivors were reviewed at this time. The distribution of risk factors at presentation and at follow-up was recorded. Mortality was found to relate to the number of diseased coronary arteries at the time of presentation and to the persistence of cigarette smoking, but not to the severity of left ventricular damage. Further analysis of the patterns of coronary artery disease was carried out and compared with the findings at left ventricular angiography in three groups of patients: firstly, those who died; secondly, survivors who suffered subsequent cardiac events; thirdly, survivors free of further cardiac events at follow-up. The findings of this analysis are presented.

Magnetic Resonance Imaging versus transoesophageal echocardiography in the diagnosis of thoracic aortic dissection

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We compared magnetic resonance imaging (MRI) and transoesophageal echocardiography (TEE) in the diagnosis and assessment of thoracic aortic dissection by carrying out a retrospective review of all TEEs and MRIs performed for thoracic aortic dissection over a 2-year period. Eight patients had both MRI and TEE. MRI was performed using spin echo and cine-Grass sequences. TEE was per-

formed using a 5 MHz ultrasound transducer mounted on an endoscope. Four cases were Type A aneurysms diagnosed on both TEE and MRI. Four cases were Type B aneurysms. One was diagnosed on TEE but not MRI because of motion artefact. One was identified by both studies; but two cases whose only initial imaging finding was a subintimal haematoma were diagnosed on MRI but missed by TEE. MRI identified the distal extent of the dissection in all cases, unlike TEE. In one case MRI demonstrated extension of the dissection into the right brachiocephalic artery, a finding not made on TEE. Clearly TEE and MRI are complementary investigations for the diagnosis of thoracic aortic dissection. MRI can show the full extent of a dissection if it involves the neck vessels or extends into the distal aorta.

Thoracic aortic dissection and penetrating atherosclerotic ulcer of the thoracic aorta: a CT study

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The purpose of this study was to critically review the CT signs of Type B thoracic aortic dissection (TAD). An assessment was also made of cases with penetrating atherosclerotic ulcers of the thoracic aorta. The CT scans of all patients in whom a diagnosis of TAD had been made over the last five years were reviewed. Images were assessed for CT signs of aortic dissection, in particular those described in standard texts. Several of the classical signs of TAD were seen in only a minority of cases; however, an enhancing aortic wall at the site of the dissection was a useful sign. Two patients showed an evolution of CT signs from a thrombosed false lumen to those of penetrating atherosclerotic ulcer. This is contrary to the previously described natural history of these lesions. In summary, compression of the true lumen by a thrombosed false lumen is the exception in Type B TAD. An enhancing aortic wall at the site of the dissection is a previously under-recognized sign. Penetrating atherosclerotic ulcer of the thoracic aorta is not a single entity. In our series these ulcers are shown by CT to develop after the demonstration of a Type B TAD.

A novel method for optimizing visualization of deep pelvic veins during lower limb venography

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We planned to evaluate the effect of abdominal compression in improving visualization of deep pelvic veins during lower limb contrast venography and to study the physio-

logical basis of this technique using Doppler wave form analysis. Abdominal compression was applied in preference to above-knee compression to reduce contrast clearance from the ileo-femoral veins in a group of 20 patients. Conventional protocol was followed in a similar sized group. Blind comparison, by two independent observers, of both groups was made. The effect of abdominal compression was further studied by Doppler wave form analysis in a separate normal group. We found that abdominal compression improved visualization of the ileo-femoral veins in the study group, as it had the effect of obliterating flow signal in the ileo-femoral veins. We conclude that it is a safe, reliable method of improving contrast in venographic study of the lower limbs. The physiological basis of this modification to a standard technique is discussed.

Venography: direction of injection affects the venous distribution of infused agent

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Peripherall targeting of a drug is essential for successful and safe intravenous regional blockade. We describe the venography findings of both antegrade and retrograde injections in Intravenous Regional Blockade (IVRB). Three patients with reflex sympathetic dystrophy of the upper limb scheduled for IVRB with guanethidine were studied. The cephalic vein of the forearm was cannulated at the wrist, one in the usual antegrade direction and the other in the reverse or retrograde direction. After exsanguination and application of a tourniquet to the upper arm 30 ml of iopamidol was injected over 60 s. A series of radiographs were taken at 10, 30, 60, 120, 300 and 600 s. Radiographic analysis demonstrated a significantly earlier and superior peripheral distribution with retrograde injection. This suggests that retrograde injection may improve success in Bier's block and IVRB.

Incidence and severity of extracranial carotid disease in patients with peripheral arterial disease

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Patients with peripheral arterial disease experience higher rates of stroke than the general population. Controversy continues about the role of endarterectomy in asymptomatic carotid disease; nonetheless it seems important to assess the incidence and severity of carotid disease in this high risk group. Colour-aided duplex carotid ultrasound examination was performed on 100 consecutive patients

undergoing arteriographic evaluation for symptoms of peripheral arterial disease. Measurements of flow parameters and of intimal thickness were made of the femoral and carotid arteries. Significant numbers of patients were demonstrated to have lesions greater than 70% stenosis. The results of carotid examination were correlated with angiographic scoring of the arteriograms. These results may have implications for screening high risk populations.

Complications of carotid arteriography: six years on

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The risk of carotid angiography contributes to the overall risk of intervening in carotid disease. An earlier study from our department in 1986 showed a neurological complication rate of 7.4%, with 3.0% permanent deficit and 0.7% mortality. We wanted to find out whether our current rates of neurological complication were still similar, or are closer to those reported from other centres. In our department, patients considered for carotid endarterectomy go to angiography if the preceding carotid ultrasound is equivocal, or indicates very high grade stenosis, to exclude occlusion. We have reviewed retrospectively the case notes of 213 patients undergoing carotid angiography over a 4-year period to December 1991. 189 had angiography because of transient ischaemic attacks, amaurosis fugax, or recovering stroke. 24 patients were examined for other reasons. Six patients (2.8%) were found to have neurological complication, of which four were transient. One had a severe right hemiplegia, and there was one death. The neurological complication rate of carotid angiography in our centre has dropped by more than 70% since the early 1980's. The only important differences in our practice have been the introduction of non-ionic contrast media and digital subtraction. Our rates are similar to those reported elsewhere.

Clinical evaluation of digital quantitative angiography (DQA) of carotid and vertebral arteries

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The use of DQA may now be explored in patients. We acquire data at angiography and analyse it at a different institution using pre-subtracted video of two small contrast

injections made into one artery, fully informed consent having been obtained from the patient. The procedure occupies 1.5–4 min of the angiogram time. The video is immediately available for analysis, 3D calibration having been achieved earlier. Video at 25 fps has less good spatial resolution than cine (which we used previously) and has other limitations, but is adaptable. Studies in progress suggest that the accuracy of video-derived flow measurements will make them clinically acceptable. By 22.11.1992 we had used the method for 15 patients. Results are presented as peak and mean blood-flow of common carotid and/or internal carotid (I.C.) or vertebral arteries in ml/min and flow curves through at least one cardiac cycle. "Normal" mean I.C. flows have lain within the range calculated from total brain weights and classical Xe¹³³ bloodflow studies (132–196 ml min⁻¹). Abnormalities associated with arteriovenous malformations, stenosis, intracranial space-occupying lesions and cerebrovascular disease will be illustrated.

Transcranial colour Doppler ultrasound: demonstration of intracranial vessels and structures in normal volunteers

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Transcranial Doppler (TCD) techniques have been developed over the last 10 years and provide useful information on the patterns of blood flow in the main intracranial arteries. Recent developments in equipment and software have enabled some imaging information to be obtained and, in addition, colour Doppler information to be displayed in conjunction with this. We report the results of imaging 20 normal subjects with transcranial colour Doppler ultrasound equipment using the temporal windows and suboccipital window. Using the temporal windows the intracranial internal carotid arteries were demonstrated in all subjects, as were the proximal middle cerebral arteries. The ipsilateral posterior cerebral arteries were not visualized in two subjects. The basilar, anterior and posterior communicating arteries were seen in only half or fewer of the subjects. Using the suboccipital window the right vertebral artery was seen in 17/20, the left vertebral artery in 15/20 and the basilar artery in 14/20. Components of the ventricular system and structures in the brain parenchyma were seen to a variable extent. The technique has several advantages over standard TCD; these include shorter examination time, more rapid localization and identification of vessels and the facility for angle correction, which produces more accurate velocity estimations.

10.45 – 12.00

Radiation Protection II

Argyll III

MONDAY

Does environmental alpha radioactivity cause cancer in the general population?

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Research in microdosimetry has shown that the spectrum of physical damage along high LET α -particle tracks is unique and fundamentally different from low LET radiation such as from γ rays. Recent experiments *in vitro* show, unexpectedly, that α -particle irradiation of a cell may induce a transmitted genetic instability that may well result in the generation of genetic abnormalities later in the same cell line. The effect does not occur for irradiation by X rays and the RBE for the process is effectively infinite. Risk factors for cancer induction derived from low LET exposures might therefore be presumed inapplicable to exposure to natural α -radiation such as from domestic radon exposure. Recent calculations of radon-derived dose to body organs yield values higher than previously realized. Accordingly, in Britain unusual correlations exist between domestic radon exposure and several cancers: various leukaemia subtypes, melanoma and prostatic cancer. Measurements of *hprt* mutation in peripheral lymphocytes of individuals show a correlation with radon level in their homes. Taken together these data provide a working hypothesis that α -radiation from natural sources may be an important initiator of some cancers in man.

Airborne radioactive contamination associated with routine nuclear medicine procedures

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Many nuclear medicine procedures have the potential to cause significant air contamination. We have investigated several procedures involving the radionuclides ^{125}I , ^{131}I , ^{32}P and $^{99\text{m}}\text{Tc}$ where levels exceeding the Derived Air Concentrations (DAC) could possibly occur. Measurements were done using a portable air sampler running at 2.21min^{-1} , with paper filter, water trap and charcoal filter. Where

appropriate, further measurements were done on surgical masks worn by staff, and on some staff urine samples. Negligible contamination was found in all cases except in lung ventilation imaging. In this procedure, patients breathe an aerosol of $^{99\text{m}}\text{Tc}$ produced by a nebulizer system, and air contamination was always detectable. Although this was generally below 1% of the DAC, with a half-time in room air of about 6 min, there were occasional much higher levels up to or even above the DAC. Most sources of these occasional high levels have been identified and minimized. Further reductions may require more complex measures, possibly not cost-effective. Calculating from these results, staff may receive $100\mu\text{S}$ per year from $^{99\text{m}}\text{Tc}$ aerosols. Reducing this requires a good leak-free production system, careful attention to setting-up procedures, and adequate instructions to patients.

Studies of the relationship between patient dose and size in paediatric radiology

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Reference level patient doses for radiographic examinations for adults have given X-ray departments a standard against which they can measure their own performance. Similar assessments for paediatric examinations are more difficult to make, because of the wide range of patient sizes. Studies have been carried out for limited age ranges, but an alternative method linking doses to patient size, through an equivalent patient diameter derived from the height and weight, could be more widely applicable. A study of patients examined in the Royal Aberdeen Children's Hospital has been carried out using TL dosimeters, dose area product meters and dose calculations. A linear relationship was found between the logarithm of entrance skin dose for radiographic examinations and equivalent patient diameter with variations of $\pm 20\%$ between individual results. A similar relationship was found between dose area product and

equivalent patient diameter for complex examinations involving both radiography and fluoroscopy, but with wider variations between individuals. The use of an equivalent patient diameter derived from data on patient height and weight enables comparisons to be made between doses for children of different ages and could provide the basis for comparisons of paediatric doses.

Radiation protection in the cardiology catheter lab — are we practising safe cath?

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Cardiologists and cardiac radiologists working in cardiac catheterization laboratories are exposed to some of the highest levels of scattered radiation experienced by workers using diagnostic radiation. These high levels of operator exposure are produced by a combination of the cineangiographic technique and the introduction of lengthy diagnostic and interventional cardiac radiological procedures. We present the results of a two-year audit of radiation exposures received by catheterization laboratory personnel at the Royal Infirmary of Edinburgh. These results are put in perspective of overall risk to staff. Means of reducing radiation exposure to cath. lab. personnel are discussed with particular reference to the advent of digital coronary angiography and barrier methods. We conclude that the single most important factor in reducing operator exposure is strict attention to radiation hygiene.

Patient dosimetry and image quality during chest radiography

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This study aims at quantifying the observed variations in patient entrance doses measured using lithium borate thermoluminescence dosimeters (TLD's). Data are presented for over 1500 patient doses measured during standard chest examinations on 50 X-ray tubes distributed throughout the West Midlands. Over 25 variables were collected; these included applied potential (kVp), current-time product (mAs), filtration (mm Al) and processor indices. Entrance surface doses were converted to effective doses in order to estimate the effect of the contribution of these independent variables on the variation in patient dose. Image quality of the radiographs were also assessed. Radiographs from each of the centres involved were assessed, with the aid of a questionnaire, by departmental radiologists and a sample of these by a control radiologist. The questionnaire evaluated patient positioning, respiration and radiographic quality. The films were then reviewed a second time by the control radiologist, where they were scored on an arbitrary scale in order to assess the immediate impression of the radiographic quality. Analysis has been carried out to compare the patient dose measurements with the image quality scores, and to compare the results between the departmental radiologists and control radiologist and between the detailed and simple analysis carried out by the control radiologist.

10.45 – 12.00

Radiological History

Seminar Suite I

The new photography: early pioneering work in Glasgow
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The City of Glasgow played a distinguished part in the early development of medical radiology. Lord Kelvin, Professor of Natural Philosophy at the University of Glasgow, was one of two scientists in Great Britain to whom Roentgen sent text and photographs illustrating his discovery. Kelvin rapidly passed the details to fellow members of the Philosophical Society of Glasgow for investigation. This resulted in the presentation at a special meeting of the Society held on 5 February 1896 of a discourse and demonstration entitled *On the Roentgen X-rays, or the New Photography*. Two of the joint presenters, Lord Blythswood and Dr John Macintyre, were to be founder members and future presidents of the Roentgen Society. Each made a major contribution, with continued support and inspiration from their co-worker Dr James Bottomley as well as from Lord Kelvin. In his presidential address to the British Association in 1896 Lord Lister was moved to refer to "the wonderful penetrating power which the rays had acquired" in the hands of Dr Macintyre of Glasgow. Macintyre and his collaborators recorded many notable achievements and it is appropriate to recall some of these as present members of his adopted profession meet in the city where he lived and worked.

The Aberdeen contribution to early radiology

A Gillanders

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This paper traces the initial application of X rays in medicine from 1896 onwards on the part of a number of distinguished medical graduates of the University of Aberdeen, and their subsequent individual careers in radiology in London, in the Aberdeen Royal Infirmary at Woolmanhill, and within the Royal Army Medical Corps. Coverage of the Radiology Department in Aberdeen extends to the 1930s to record the sterling work of the Australian radiolo-

gist in charge during World War II, and his role in the planning of a new Department for the Royal Infirmary on the Foresterhill site.

Dawson Turner 1857–1928: Pioneer of Edinburgh radiology
J J K Best*Department of Medical Radiology, University of
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Dawson Turner was born in 1857. He studied medicine at Edinburgh, graduating in 1888. Following house jobs he studied abroad, returning to Edinburgh to lecture in physics at the Surgeons' Hall. He took up his appointment shortly before the announcement of Roentgen's discovery of X rays. Recognizing the importance of the discovery, he set up a primitive apparatus in his house and demonstrated photographs taken by the "Roentgen Process" to a meeting of the Edinburgh Medico-Chirurgical Society on 5 February 1896. In November 1896 he was appointed by the Managers of the Royal Infirmary as Assistant Medical Electrician and succeeded to the post of Electrician in 1901, a post he held until his retirement in 1911. He suffered severe radiation burns which eventually caused the loss of three fingers and an eye. He died on Christmas Day 1928 and his name is recorded on the Martyrs' Memorial at St. George's Hospital, Hamburg. His pioneering work is recognized by a plaque in the Radiology Department of the Royal Infirmary. Dr Dawson Turner was the author of *A Manual of Practical Medical Electricity* and provided illustrations for *The Roentgen Rays in Medical Work* by Dr David Walsh, one of the earliest radiological text books.

An Irish lady, two English colleges, and a Scottish hospital in France and Serbia

J M Guy

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Miss Edith Stoney, a mathematics graduate of Newnham College, Cambridge, acted as a radiographer during the

First World War. She joined the Scottish Women's Hospitals, an organization founded by the suffragists, serving first in their base hospital at Royaumont and then briefly in Villers-Cotterets. Later she joined the Girton and Newnham Unit of the SWH, serving in Serbia and Macedonia. This paper describes the contribution of one of the many non-medical personnel to the radiological services in wartime and outlines some of the difficulties experienced in setting up static and mobile radiological units.

Sir Humphrey Davy Rolleston (1862–1944): A physician's contribution to the development of radiology

A K Banerjee

Radiology Department, St. Thomas's Hospital, London SE17EH, UK

Humphrey Davy Rolleston was born in 1862 and qualified in medicine from St Bartholomew's Hospital in 1888. He became a physician at St George's Hospital in London in 1898 and succeeded Sir Clifford Albutt as Regius Professor of Physic in Cambridge from 1925–1932. Although much has been written about Rolleston's contributions to clinical medicine and medical history, his important role in the development of early British radiology remains largely forgotten. Rolleston chaired the British X-ray and Radium Protection Committee from its inception in 1921 to 1943 when he retired due to ill health. Among those on the committee were Robert Knox, Sir Archibald Reid, Sir Sidney Russ and Stanley Melville. Rolleston was President of the Roentgen Society in 1922/23 and played an important role in the amalgamation of the Roentgen Society and the British Institute of Radiology in 1927. He was the inaugural President of the new society in 1927/28. His contribution to the radiology literature included his 1922 Presidential Address entitled *Acute Constitutional Symptoms due to Radiation*, a subject he returned to in his 1930 article, *The Harmful Effects of Irradiation*. Rolleston gave the Mackenzie Davidson Lecture in 1927 and became an Honorary Member of the BIR in 1933 and of the Faculty of Radiologists in 1944, the year in which he died.

Albert Renaud's historico-radiological collection

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Albert Renaud, a French engineer who passed away in February 1990, accumulated during 40 years an impressive collection of more than 1500 items in the field of radiological technology. His collection includes many splendid pieces from the 18th and 19th centuries recalling the discovery of electricity, the history of tubes, batteries,

condensers, Ruhmkorff coils, and electrostatic generators, so as to reveal the conditions which led to Professor W. K. Röntgen's great discovery in 1895. Very well preserved wooden radiological installations from the early years illustrate the evolution from physical research technology towards medical radiology, e.g. not less than five "cabineets" from 1896, and other more and more specialized installations from 1897, 1898, 1900, 1902, 1905, 1908, etc. Examples of all important achievements and developments of tubes, generators, and complete installations in medical and dental radiology during the first half of the 20th century are presented, as well as examples of technological "dead ends". The educational consistency of this collection explains why it has recently been designated to become a museum which may be of interest for radiologists, engineers and technicians. This museum is to be opened for the centenary in the Beaujolais region near Lyon.

History of tomography

H-J Maurer

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For the first time a moving X-ray beam was used by H. Meyer in 1913. In the early twenties tomography was done experimentally using different forms of movements: linear, circular, spiral, as well as hypocycloidal. But the technical problems, especially of X-ray tubes, could not be overcome. A clinically useable tomograph was first established in the mid-thirties. In 1938 G. B. Watson and I. Vallebona achieved transverse sections through the body; but this development was stopped by World War II. In 1949 A. Wachsmann and G. Gebauer presented another arrangement for horizontal sections. But picture quality was good enough. Later on hypocycloidal tomography (Philips) made very thin slices possible but in the usual axis. Hounsfield's development of CAT meant a big step forward, in particular spiral CAT. MRI allows, in addition, tomograms in three dimensions. CAT as well as MRI make spatial reconstruction possible.

Radiology in Malaya in the 1920s

M L Wastie

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The provision of radiology in the tropics has never been sufficient, now or in the past. The situation in Malaya in the 1920s presented great problems and a great challenge.

Before the second world war the Malay peninsula consisted of four federated states: Selangor, Negri Sembilan, Pahang and Perak; and five unfederated states; Penang and Malacca, together with Singapore, comprised the Straits Settlements which was a Crown Colony. X rays were in use in Malaya soon after their discovery. An X-ray unit was presented to the Government Hospital in Ipoh in 1897 and X rays were used in Kuala Lumpur in the early years of this century. In the 1920s the population of the Federated Malay States was 1 350 000 and there were 45 hospitals. The principal diseases were malaria, dysentery and diarrhoea, pulmonary tuberculosis and beri beri. One radiologist was appointed in 1920 and a second in 1927. In 1925, England, Wales and Scotland with a population of 43 780 000 had 172 radiologists. During the 1920s the number of radiographs taken increased. The problems besetting the radiologist are described in the annual medical reports for this period.

Albania: living radiological history

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The author was part of a small team consisting of the director of a charity, a radiologist, a radiographer and two radiography students, which visited Albania in 1992. The objects of the visit were to assess radiographic facilities, to advise on improvements and to help train staff. A description is given and some slides shown of the equipment still in use in Albania. Some of it is up to 50 years old. The lack of adequate radiological protection is emphasized. Mention is given to outdated film processing facilities. As outside agencies, including our own, are now involved in training staff and advising on and providing equipment, the opportunity to observe radiological history in action may not last for much longer.

10.45 – 12.00

Nuclear Medicine I

Seminar Suite II

The gastrointestinal system — from mouth to anus

L K Harding

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There are rumblings of change in the nuclear medicine assessment of the gastrointestinal tract. Unlike contrast radiology, ultrasound, CT and to some extent MR, function is assessed rather than changes in anatomy. Radionuclide investigations are particularly useful for assessing transit along the gastrointestinal tract from swallowing to defaecation. New techniques have been developed to evaluate the fundal and antral emptying of the stomach, and also its contractile activity. Transit within the small intestine and colon are providing useful data and isotope defaecography is challenging the place of conventional radiological tests. Nuclear medicine tests have been used in the diagnosis of acute cholecystitis for a number of years, but their place in chronic cholecystitis has only recently been recognized. Bleeding, inflammation, or infection of the gastrointestinal tract are readily localized, and recent data on antibodies for the detection of bowel malignancy suggest that progress has at last been made with detecting secondary deposits, particularly after surgery.

The value of the monoclonal antibody B72.3 (Oncoscint) in the diagnosis of recurrent colorectal tumours

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The diagnosis of recurrent colorectal tumour following surgery is a frequent problem, 50% of patients with Duke's C carcinoma will have a local recurrence within a year. Various techniques have been used to detect recurrence, including serum CEA levels, CT, MRI and monoclonal antibody imaging. 20 patients with suspected tumour recurrence following previous surgery were imaged using the monoclonal antibody B72.3 radiolabelled with ¹¹¹In (Oncoscint CR103) which reacts with a high molecular weight

tumour-associated glycoprotein. Ten patients were given a dose of 80 MBq and 10 a larger dose of 150 MBq to assess the effect of dose on image quality. Both planar and SPECT images were taken at 48 h. Each patient had a CT scan and selected patients a MRI scan as well. The diagnosis of recurrence was made by clinical examination, endoscopy or follow-up. Overall, using SPECT, the sensitivity and specificity of B72.3 for the diagnosis of recurrence tumour were 100% and 60% respectively. Planar imaging resulted in lower sensitivity. For CT the values were 80% and 100%. There was no difference in tumour detection using the high or low dose of radiolabel. Monoclonal antibody imaging is a useful adjunct to CT for detection of recurrent tumour, particularly when CT gives equivocal results.

Combined MR, CT and PET imaging in oncological patients

W L Wong, C Studholme, P Lewis, K S Raju, R P Beaney, K Tonge, T Nunnan, D J Hawkes and J Pemberton

Division of Radiological Sciences (St. Thomas' and Guy's Hospitals), Departments of Radiology, Radiotherapy and Gynaecology (St. Thomas' Hospital), and Clinical PET Centre (St. Thomas' Hospital) London SE1 7EH, UK

CT and MRI provide complementary information for the evaluation of patients with malignant tumours, showing detailed morphological changes and anatomy. However, neither offer much information on function. Positron emission tomography (PET), on the other hand, gives unique functional images with little anatomical detail. We demonstrate registration of CT, MR and PET data sets using a technique based on an anatomical landmark in the head and neck and pelvis. CT, MR and PET-FDG scan in three patients were obtained (head and neck cancer, one; cervical cancer, two). Fluoride scans were obtained for pelvic registration. Registration was performed by identifying eight or more homologous points in 3D from each modality and hence calculating the rigid body transformation relating the coordinates of the various scanners. In the

pelvis, 3D PET points were identified from fluoride scans, and for the neck, such points were identified from cerebral structures from the PET-FDG scans directly. Additional important information obtained from combined PET, CT and MR data sets of these regions in our three patients is illustrated. A video loop of the pseudo-rendered images obtained from PET and CT data sets in the patient with nasopharyngeal cancer is shown, part of work in progress to improve the accuracy of 3D external beam radiotherapy planning in patients with head and neck tumours.

The indeterminate lung scan; its clinical perception and effect on patient management

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We aimed at assessing how clinicians further investigate and manage patients in whom the isotope lung scan is reported as indeterminate. 650 consecutive lung scans performed at Edinburgh Royal Infirmary between 1.1.90 and 31.12.91 were reviewed. 102 patients with indeterminate scans were identified and clinical notes reviewed. Patients already on Warfarin for known DVT were excluded from this study. In the remainder, over 50% of patients with indeterminate scans were interpreted by clinicians as having definite evidence of pulmonary embolism and most were fully anticoagulated with Warfarin for 2-7 months. The majority were not referred for corroborating investigations. Radiologists recommended further investigation in 30% of cases, most frequently pulmonary angiograms. Clinicians requested further investigation in 20% of cases favouring venography. Indeterminate lung scan reports are open to misinterpretation by physicians. Interpretation is influenced by associated clinical factors but often appears haphazard, and some patients may not be receiving correct therapy. Physicians should be educated as to the meaning of an indeterminate lung scan. Radiologists should firmly suggest appropriate further investigation and pulmonary angiography should be employed more frequently.

Lung Ventilation and Perfusion imaging — does the postural influence on particle deposition influence ventilation perfusion mismatch?

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Comparison was initially made between perfusion images injected in the erect and supine positions. It was found that

there was a significant mean percentage shift of 17.3%. These images were then compared with erect ventilation images and the degree of ventilation perfusion mismatch assessed. 26 patients referred for V/Q imaging were examined. Equal amounts of the radiopharmaceutical (M.A.A., Amersham) were injected in the supine position and erect posterior views obtained. The second fraction was administered with the patient's position unchanged, and the view repeated. The true erect image obtained by subtraction, and the supine images, were normalized and compared by profile analysis. Erect posterior ventilation images were obtained using ^{81}Kr . The erect and supine perfusion profiles were then compared with the erect normalized ventilation profiles and the degree of mismatch assessed by division. Paradoxically the erect ventilation profile was mirrored more closely by the supine perfusion particle deposition. There was consequently less ventilation perfusion mismatch compared with the mismatch between the two erect profiles. This relationship was less well defined in the cases with concurrent pathology such as pulmonary emboli and COAD. Ventilation in the erect position is more uniformly distributed to the lung apices than erect perfusion. There is greater V/Q mismatch in the erect position than in the supine position.

Early diagnosis of Alzheimer's disease using SPECT imaging

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Overlap between groups of moderately to severely demented Alzheimer's disease (AD) patients and age-matched elderly controls in most semiquantitative studies is such that single posterior cortical perfusion measures lack sensitivity. In the present study, the value of a combination of semiquantitative single photon emission computed tomography (SPECT) measures was examined. Initially supratentorial transaxial perfusion measures were obtained in frontal, anterior temporal, posterior temporal and occipital cortical areas in both hemispheres in 11 healthy elderly controls and 29 mild to moderately impaired AD patients. Highly significant hypoperfusion was noted in the AD group for each of the four temporal perfusion measures, but substantial overlap was noted between the groups. Using linear discriminant function formulae incorporating the four temporal perfusion measures, 10/11 (91%) controls and 25/29 (86%) AD patients were

correctly classified. The value of these discriminant formulae was tested prospectively in a further 15 cognitively impaired cases of very mild (CDR 0.5) or mild (CDR 1.0) severity, 11 patients with a diagnosis of "probable AD" and individual cases of cerebrovascular dementia, dementia (frontal type), primary aphasia and paranoid psychosis. With the discriminant formulae obtained at baseline, 10/11 "new" AD cases and none of the four non-AD cases were classified to the baseline AD group. These data support the use of a number of SPECT-derived perfusion measures from those areas which are predictably involved pathologically in the earlier phases of AD in a linear discriminant format as a useful adjunct to the clinical assessment of the patients with suspected mild AD.

Investigation of MPTP-induced Parkinsonism in non-human primate

^{1,2}R F Wang, ²C Loc'h and ²B Mazière
¹Department of Nuclear Medicine, Fujian Medical College, 350004 Fuzhou, PR China, and ²Service Hospitalier Frédéric Joliot, DRIPP-DSV-CEA, 91401 Orsay, France

In an attempt to clarify the relationship between nigrostriatal dopaminergic function and clinical symptomatology, two controls and 12 monkeys received intravenous injection of 1-methyl-4-phenyl-1,2,3,4 tetrahydropyridine (MPTP) 0.5–12.5 mg kg⁻¹. Without or with the development of extrapyramidal signs or symptoms from one day to 3 months, we performed under anaesthesia PET brain scans for 90 min following injection of 200 MBq 6-(18F)fluoro-L-dopa, collected simultaneously arterial blood samples at 5, 10, 20, 30, 45, and 60 min after radioligand injection for correcting arterial input function using radio-TLC analysis (¹⁴C, alumina plate) and solid phase extraction (SPE) (Sep-pak A1₂O₂). No significant difference was observed in two groups studied, but the rate (mean ± SD) of metabolism of F-18 fluoro-dopa was found by radio-TLC analysis and SPE to be slower in different times for MPTP-exposed subjects (82.0 ± 1.6, 63.0 ± 0.5, 45.0 ± 1.3, 34.0 ± 1.7, 25.0 ± 2.5 and 23.0 ± 3.0) (especially marked in MPTP-induced Parkinsonism) than in controls (72.0 ± 1.3, 52.0 ± 0.5, 32.0 ± 0.8, 24.0 ± 0.5, 18.0 ± 1.8, 14.0 ± 0.3). In MPTP-treated monkeys, the data obtained with PET (ECAT/950B) showed an evident diminution of 18F-dopa striatal accumulation compared to controls with normal subjects through those exposed to MPTP and subjects with MPTP-induced Parkinsonism, and caudate activity was apparently depressed. Our results appear to be consistent with the hypothesis that exposure to an environmental toxin may give rise to subclinical damage to the nigrostriatal pathways.

Estimation of combined radio-analytical technique with brain PET study in determining 18F-dopa metabolism in man

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Our purpose was to develop and validate the analytical methods for the *in-vivo* determination of metabolism of 18F-dopa using positron emission tomography (PET). We studied eight neurologically normal subjects and 11 patients with Parkinson's disease (PD, *n* = 8) and schizophrenia (*n* = 3), proven clinically and identified with CT and MRI, by PET scans in the resting state with eyes closed and ears unplugged for 90 min subsequent to intravenous injection of 200 MBq 6-(18F)fluoro-L-dopa. Arterial blood samples at 5, 10, 20, 30, 45, and 60 min were withdrawn in heparinized tubes and centrifuged for radio-TLC analysis and solid phase extraction (SPE). There was a good correlation between radio-TLC analysis and SPE ($r = 0.961$, $y = -5.2 \pm (1.12x)$). The data obtained from the determination of unchanged fraction of 18F-dopa in plasma using two analytical methods showed an aspect of patients with PD was much slower than in controls ($r = 0.98$, $p < 0.0001$). On brain PET image, we observed a slight symmetrical diminution on caudate activity and a more marked depression in putamenal radioactivity accumulation, with the putamenal reduction most marked contralateral to the major clinical motor deficit. No significant difference between controls and schizophrenia was found. The results demonstrate that the methods proposed appear useful for assessing and quantifying accurately the pre-synaptic dopaminergic function combined with correcting the input arterial function in routine clinical brain PET image.

Lymphoscintigraphy and duplex Doppler sonography in the investigations of unexplained limb oedema

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Oedema of the limbs may be due to a lymphatic abnormality such as hypoplasia or obstruction. Alternatively oedema may have a venous cause such as reflux or varicosities. It is only in this latter group that effective treatment options are available. It is the aim of this paper to show that a combination of duplex Doppler sonography and lymphoscintigraphy in patients with limb oedema will help determine the aetiology and thus identify patients for whom treatment is appropriate. 10 patients (three male and

seven female, age range 23–81 years) have been studied. All presented with unexplained oedema involving lower limb in nine cases and an upper limb in the tenth. Each patient underwent Doppler sonography (5 MHz linear array, Acuson 128) followed by lymphoscintigraphy (⁹⁹Tc-labelled sulphur microcolloid injected into the web spaces of both feet or hands). In five patients the lymphoscintigraphy was abnormal, showing absent or poorly visualized

lymphatics. In six patients the Doppler study was abnormal showing venous reflux and/or varicose veins. All patients in the latter group received treatment guided by the ultrasonic report. In two patients both studies were abnormal; but there were no cases where both investigations were normal. We conclude that the combination of lymphoscintigraphy and Doppler ultrasound is a satisfactory means of assessment of patients with chronic limb oedema.

12.15 – 1.15

Silvanus Thompson Memorial Lecture

Argyll I

High-speed and high-resolution MRI: Implications in clinical imaging

F W Wehrli

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It is now 20 years since Lauterbur's historic paper on NMR zeugmatography and over a decade since clinical implementation of what is now called magnetic resonance imaging (MRI). While MRI's extraordinary sensitivity to demonstrating diseased tissue had become apparent during early clinical evaluation, critics pointed out that the modality was likely to remain slower than CT, its closest tomographic counterpart. This limitation, it was contended, was inherent to the T_1 relaxation times of protons in biological tissue, thus dictating the pace of data acquisition. The present lecture attempts to address the remarkable progress made

during recent years, both as far as scan acquisition time and spatial resolution are concerned. Reduced flip angle excitation, described by Ernst over a quarter of a century ago, and the idea to fill data acquisition space more efficiently by encoding an array of echoes by Mansfield, were major milestones in the quest to enhance scan rate. One of the most significant applications of fast imaging is the ability to overcome image degradation from physiological motion such as breathing, cardiac pulsation and peristalsis. Of course, spatial resolution and signal-to-noise are the major trade-off parameters of scan time. Further, the exact requirements for scan time are dictated by the time scale of the physiological event and the clinical task at hand. MRI scan time is a continuum covering several orders of magnitude from about 10 ms for line scan projection imaging up to several hundred seconds for conventional spin-echo imaging.

12.15 – 1.15

Vascular and Interventional Radiology

Argyll II

Comparison of radiologically and surgically-placed Hickman catheters

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The percutaneous insertion of long-term central venous Hickman catheters is increasingly being performed under fluoroscopic control in radiology departments. This paper describes a retrospective comparative review of 84 radiological and 81 surgical procedures performed in the past two years. A total of 161 catheters were placed, 83 radiologically and 78 surgically, in 73 and 70 patients respectively. Local anaesthesia was used in the former, and general anaesthesia in 59 (73%) of the latter procedures. Operator experience was equivalent in both groups. There were three primary surgical failures of placement, with 14 (17%) cases requiring repeat attempts. Five surgical lines were misplaced on insertion. The only significant early radiological complication was pneumothorax in four cases (two requiring drainage). The later complications of catheter loss or displacement, blockage and venous thrombosis were similar for both techniques. Percutaneous insertion of Hickman catheters under radiological control offers rapid service, with more accurate placement and better patient acceptance in a lower cost environment.

Glove perforation during interventional procedures. Are we at risk?

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In the current climate of anxiety relating to needle stick injuries and the increased awareness of blood-borne cross infection, we have conducted a study to assess the perforation rate of gloves worn whilst undertaking routine and complex interventional procedures. Our aims are to assess the operator risks and ascertain any related factors. The gloves tested were standard Regent Dispo Surgeons' gloves.

The proven testing equipment (to be demonstrated) consists of an electronic circuit which is able to detect changes in resistance. If the gloves were perforated there would be a change in resistance activating a buzzer, thus alerting the operator. All operator grades were tested in general interventional cases that varied from TIPSS to routine angiography. The overall perforation rate was low (< 2%) and did not include the 1% that tested positive prior to the procedure. We found that the result was not influenced by the time, type of procedure or the equipment. With the increase in the numbers of patients undergoing invasive diagnostic and therapeutic imaging, we can be secure in the knowledge that the risk of perforation and thus of inoculation is significantly lower than for our surgical colleagues and is not enough to warrant additional protection.

Percutaneous closure of arterial puncture with a collagen vascular plug in patients requiring anticoagulation

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This was a retrospective study to determine if a collagen plug haemostasis device can achieve haemostasis in patients requiring continued anticoagulation. The collagen plug is delivered via an 11.5 French insertion sheath, down the puncture tract. The plug is sited on the exterior surface of the artery with no intra-arterial component. The maximum size of arterial puncture that can be treated is 8 French. We used this device in 58 patients (49 male, 9 female, age 36–80 years, mean 56 years) who underwent coronary angioplasty and required continued anticoagulation. 22 of these patients had coronary stents and were on high dose heparin and Warfarin (APPT 3–3.5/normal PT 3–3.5/normal). The remaining patients were on heparin infusions (15 000 IU bolus followed by 1000–2000 IU h⁻¹, APPT2–4/normal). The depth of plug placement was measured at the time of arterial puncture and manual compression applied after

placement. The time to control bleeding was 7–420 s (mean 138 s). Complications were seen in four patients: continued bleeding from the puncture and requiring external clamping (two), moderate haematoma (one), one patient developed delayed (12 h) arterial insufficiency due to incorrect placement of the collagen plug. A similar group of patients without plug usage had to undergo a temporary drop in their heparin levels following sheath removal to achieve haemostasis. We concluded that the use of a collagen plug haemostasis device is of considerable value in managing patients requiring continued anticoagulation following coronary angioplasty.

Intravascular catheter manipulation and foreign body retrieval using the Amplatz gooseneck snare

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The Amplatz “gooseneck” snare is a recently-developed right-angled snare constructed from nitinol wire. The right-angle configuration of the snare loop is designed to facilitate capture and manipulation of intravascular foreign bodies, while the nitinol alloy renders it densely radio-opaque and “kink-free”. We have used the gooseneck snare successfully to reposition multilumen subclavian catheters in several patients, and have performed retrieval of intravascular foreign bodies (Gianturco and Hilal embolization coils, angiographic guidewire, vascular catheter fragment) in four patients. We have found the device simple and quick to use, with procedures averaging less than 10 min and involving a minimum of discomfort and radiation dose to the patients. The technique of subclavian catheter manipulation and four cases of foreign body retrieval from the central veins and renal artery are described and illustrated. We believe the Amplatz gooseneck snare offers an effective means of manipulating central venous catheters and retrieving intravascular foreign bodies.

A new retrievable coil delivery system — experience in the first 20 patients

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The technique of transcatheter occlusion therapy using stainless steel coils has undergone little change since it was first described in 1975. The major disadvantage of coils is the potential for their misplacement and inadvertent embolization of a non-target area. The choice of correct coil size

and proper positioning are especially important in pulmonary arteriovenous malformations — too small a coil runs the risk of passage into the systemic or cerebral circulations, too large will result in occlusion of branches supplying normal lung. We describe a new coil delivery system which allows the operator to retrieve the coil after it has assumed its helical shape, if the position is felt to be unsatisfactory. The simple design, based on a thread-counterthread relationship between wire and coil, is a novel, effective and inexpensive way to permit the selection of that coil most suited to a given situation. This design eliminates the possibility of embolization of an undesired site. We report the results of the deployment of the new coil in our first 20 patients, the majority of whom had pulmonary arteriovenous malformations.

Cost effective foramen ovale electrodes

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New relatively inexpensive foramen ovale guidewires have been developed with Cooks for 48 h continuous monitoring of temporal lobe EEG activity. These guidewires are introduced percutaneously under screen control under general anaesthesia. The method of introduction, low cost and quality of EEG information are discussed.

Image-guided tumour destruction by interstitial laser photocoagulation: optimization of laser parameters

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Interstitial laser photocoagulation (ILP) is a new percutaneous image-guided technique of thermal destruction (necrosis) of deep-seated tumours, using low power laser light energy. Our purpose was to investigate: (a) the effects of different laser wavelengths on the size of thermal damage produced, and (b) the role of charring in ILP. 45 Wistar rats (250–300 g) had ILP to their liver (exposed at laparotomy), by inserting a 400 µm optical fibre into the liver, and activating the laser at 1W, 2W, or 3W. This was performed at three laser wavelengths (1064 nm Nd:YAG, 1320 nm Nd:YAG, 805 nm diode) using a clean fibre, and at two wavelengths (1064 nm and 1320 nm Nd:YAG) using a fibre with its tip pre-charred. The 805 nm and 1320 nm laser wavelengths produced significantly greater necrosis than

the 1064 nm, using a clean fibre-tip (mean diameters at 2W were 21.7 mm, 18.3 mm, 8 mm, respectively). Pre-charring the 1064 nm fibre significantly increased the necrotic lesion size (mean diameter at 2W was 14.7 mm). We conclude that more strongly absorbing wavelengths (805 nm and 1320 nm) and pre-charring the fibre-tip cause greater thermal damage during ILP, contrary to previously held views that the optimal wavelength for ILP was 1064 nm using a clean fibre-tip.

Early experience with the wall stent self-expandable metallic endoprosthesis in malignant biliary obstruction

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This study aims to assess the effectiveness of palliation and the technical success rate of metallic stent placement. Complications, both long- and short-term, are presented. 50 patients presenting with malignant biliary tract obstruction have been treated during a two-year period from February 1991. Follow-up data has so far been collected on 37 patients although outcome data on the entire group is under review. 28 patients were stented using a percutaneous transhepatic route and nine were stented endoscopically. Obstructive jaundice was diagnosed as due to pancreatic head carcinoma ($n = 21$, 57%), cholangiocarcinoma ($n = 9$, 24%) and porta hepatis nodal secondaries ($n = 5$, 14%). Five patients (14%) had previous treatment with plastic endoprostheses and two patients had recurrent biliary obstruction following previous bypass surgery. Percutaneous stenting in our early patients was usually performed as a two stage procedure but we now favour a one stage procedure, with a reduced complication rate. Stent placement was satisfactory in all patients, with no stent migration on follow-up. Two patients developed late cholangitis, one due to debris causing partial stent blockage, which was cleared by a balloon catheter, and the other due to tumour ingrowth two months after insertion. Patient survival post-stenting averaged 3.5 months, reflecting the poor prognosis

of most of the initial primary diagnoses, but almost all patients returned home for substantial periods, jaundice-free.

Outcome analysis in 25 patients with gallstones who had emergency percutaneous cholecystostomy for cholecystitis: strategies for gallstone management

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The final outcome of 25 patients who had emergency percutaneous cholecystostomy (PC) for gallstone disease and presumed cholecystitis was analysed. All 25 patients presented with multisystem disease and sepsis of suspected gallbladder origin. Sonography of the gallbladder revealed gallstones in all: 15 patients had multiple small gallstones, 10 had a single stone. 17/25 patients had ultrasound findings suggestive of cholecystitis; 8/25 had questionable findings. PC was performed at the bedside in 19/25 patients. PC was technically successful in all patients; 7/25 patients did not respond and died within 30 days. Of the 18 survivors, 8/18 had elective cholecystectomies with one postoperative death, 9/18 were successfully treated percutaneously with either methyl tertiary butyl ether (MTBE) stone dissolution (2/9), or percutaneous cholecystolithotomy (PCCL) (2/9). Two of these patients subsequently underwent gallbladder ablation therapy. 3/9 with malignant disease and 2/9 with terminal respiratory disease were managed with long term catheter drainage, and one patient had no definitive gallstone therapy. Percutaneous treatment was successful in 4/5 patients who had no recurrent symptoms on follow-up over a mean of two years. 1/5 patients failed percutaneous therapy and required cholecystectomy several months later. *Conclusions:* (1) Definitive gallstone therapy is required after the acute problem is treated. (2) Surgery remains the most definitive treatment. (3) Percutaneous gallstone therapies are useful in patients unfit for surgery. (4) Patients with terminal disease may respond to chronic catheter drainage.

2.15 – 3.45

Clinical MRI III: Developing Applications

Argyll I

Practical pelvic MRI

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The relatively non-invasive character of magnetic resonance imaging (MRI) and use of non-ionizing radiation make it advantageous for pelvic imaging, particularly for patients in whom gonadal irradiation should be avoided. Advantages over other cross-sectional imaging techniques such as ultrasound and CT include high soft-tissue contrast, direct multiplanar imaging and the ability to alter image contrast and thus optimize lesion detection by modification of the MR pulse sequence used. Despite the complexity and great range of MR imaging options, most pelvic problems can be approached using a combination of T_1 and T_2 weighted spin echo sequences. The range of clinical indications continues to increase but currently pelvic MRI is mainly concerned with the staging or post-treatment follow-up of tumours of the reproductive organs, bladder, rectum and pelvic soft tissues. The pulse sequences used and the circumstances in which intravenous gadolinium-DTPA may be helpful will be discussed. The effect of chemical shift and susceptibility artefacts on the image will depend on the field strength of the magnet used and may influence the choice of pulse sequence and necessitate the use of imaging options such as variable band width. Commonly encountered artefacts and pitfalls in image interpretation will be illustrated. The role of the newer MR techniques such as three-dimensional imaging, fast imaging, dynamic contrast enhancement and MR angiography in pelvic imaging will be discussed.

The role of Magnetic Resonance Imaging in the diagnosis and management of endometriosis

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From a review of over 50 patients with proven endometriosis certain recommendations can be advanced as to the value of MRI in the diagnosis and management of this condition. In patients with clinical symptoms suggestive of the disease a sensitivity of 92% and a specificity of 83% were found when compared with the findings on laparoscopy. At a field strength of 0.15 T a careful comparison of pulse sequences has shown that a heavily T_2 weighted sequence (TR 1840 ms/TE 160 ms) was superior to conventional T_1 weighted (TR 500 ms/TE 40 ms) and T_2 weighted (TR 2000 ms/TE 80 ms) spin echo sequences as well as an inversion recovery sequence (TR 1600 ms/TI 400 ms) and the STIR sequence in the identification of small pelvic deposits. Laparoscopy showed, however, that the full extent of the disease was frequently underestimated because the method could not detect pin-point implants and show the full extent of secondary adhesions. Typical endometriotic cysts showed multiple loculi, variable signal intensity when different pulse sequences were applied, a lack of clear interface with adjacent structures and a peripheral hypointense rim on T_1 and T_2 weighted sequences. Dermoid cysts, haemorrhage into a cystic tumour and pelvic inflammatory disease can, however, all mimic an endometrioma. Follow-up in patients treated with hormonal therapy is particularly

valuable since regression and recrudescence of disease are readily monitored.

Pelvic and perineal complications of Crohn's disease: assessment using Magnetic Resonance Imaging

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We set out to determine the value of MRI in the demonstration of pelvic and perineal complications of Crohn's disease. 12 patients with active pelvic Crohn's disease were studied (4 male; mean age 43.6 years). MRI examinations were performed using a 1.5 Tesla system, on average 14 days after presentation. T_1 and T_2 weighted fast spin echo sequences in 2 or 3 orthogonal planes were performed, with fat suppression in some cases. The MRI results were correlated with surgical and clinical findings. In six patients, cutaneous, deep perineal or enterovesical fistulae or abscesses were diagnosed at MRI, with accurate correlation with findings at examination under anaesthetic (EUA). In five patients no complications were seen at MRI nor was there any evidence of disease on flexible sigmoidoscopy and rectal biopsy. One MR study did not demonstrate a suspected pelvic abscess, but on review there was a small quantity of gas in the bladder, thickening of the bladder dome and an adjacent loop of colon. Laparotomy 4 weeks later showed a colovesical fistula. We concluded that MRI can demonstrate accurately the pelvic and perineal complications and may obviate the need for EUA in Crohn's disease.

MR Angiography of the abdominal, thoracic and peripheral vascular system

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Over the past 5 years MR angiography (MRA) has evolved from a research tool into a practical clinical method of vascular imaging. Both time-of-flight (TOF) and phase-contrast (PC) methods are now widely available on commercial systems. There have been a number of technical hard and software developments that have improved the quality and applicability of these techniques. A number of major applications of MRA have evolved. In the abdomen, it has been shown to be a reliable method of screening for renal artery stenosis and for the assessment of abdominal veins including portal venous and IVC patency. Within the thorax, the development of fast, breath-hold imaging has facilitated cardiac imaging and MRA is well established for

the assessment of thoracic aortic aneurysms. Thoracic venous anatomy can be well shown and has been used to show vessel patency following shunt and catheterization procedures. When imaging the peripheral vasculature the large field-of-view necessary for major vessels requires either excessive imaging time or thicker slices and consequent reduced spatial resolution. However, there has been some success in demonstrating vessel run-off, small vessels and venous thromboses. Of recent technical developments, magnetization transfer, motion compensation of pulsatility artefacts and improved image processing algorithms offer further prospects of technique improvement.

Body Magnetic Resonance Angiography: experience with the first 1158 patients

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We assessed the impact of magnetic resonance angiography (MRA) on body vascular imaging: particularly, the impact of improvements (*i.e.*, bandwidth optimization, segmented k -space) in MRA technique on the quality of images and the need for complementary or alternative imaging investigations. Over a 36 month period, body MRA (defined as MRA performed on vessels below the carotid bifurcation) was performed using two-dimensional time-of-flight sequences. Cohorts of patients from the three years of the MRA programme were analysed to assess image quality, completeness of diagnosis, number of correlative imaging techniques required and accuracy, as determined by reviewing the patients' records. During the study period, MRA was performed on 1158 patients (485 abdomen, 323 liver transplants, 290 chests (including heart), 30 necks and 30 pelvis). Image quality analysis showed that there was a dramatic improvement in image quality over the study period and a reduction in the number of correlative tests performed in each patient. The image quality of MRA has improved over the last three years. The reasons for this are discussed. This has led to a greater confidence of diagnosis made with MRA and a reduction in alternative, possibly less satisfactory, imaging investigations.

Uses of Magnetic Resonance Angiography in the evaluation of pelvic vessels

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Evaluation of the pelvic veins by conventional imaging techniques can be difficult due to limited acoustic access (ultrasound), or difficulty in opacifying all veins with

contrast medium (CT and angiography). We investigated the use of magnetic resonance angiography (MRA) to see if the wide field of view and intrinsic contrast enhancement make this a more satisfactory technique for imaging pelvic vessels. 34 patients (19 female) were examined using two dimensional, time-of-flight MRA sequences on a superconducting system at 1T. Typical imaging parameters were flip angle 30°, Nex 1, TR 23 ms, TE 8 ms, FOV 400–470 cm, matrix 192 × 256. Images were obtained in appropriate anatomical projections using arterial and/or venous pre-saturation as appropriate. Indications included demonstration of vascularity adjacent to pelvic tumours or masses and the extent of venous thrombosis. In 18 venous studies, nine patients had occluded vessels which were demonstrated by MRA and three demonstrated collaterals. In 10 patients, relationship of pelvic vessels to pelvic masses was demonstrated satisfactorily. In three patients, there was good demonstration of the pelvic veins, excluding possible thrombosis suggested by alternative techniques. We concluded that MRA is a valuable technique for demonstrating patency of pelvic vessels and their relationship to surrounding abnormalities.

MR Angiography of the cervical carotid artery prior to endarterectomy

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The investigation of patients with transient ischaemic attacks (TIAs) is directed towards defining patients who will benefit from carotid surgery (*i.e.* stenosis greater than 70%), and excluding an unsuspected intracranial mass lesion. As part of their assessment prior to possible endarterectomy of the cervical carotids all our patients undergo cranial CT or MRI, with Doppler ultrasound of their carotid arteries. Over the past 18 months patients planned for endarterectomy were examined by Magnetic Resonance Angiography (MRA). Using a 1.5 Tesla GE Signa imager, 2D and axial 3D GRASS sequences using flip angles of 35° with short TE and TR were employed to image the carotid artery bifurcation. Images were independently read by two radiologists unaware of the preceding Doppler result. The degree of stenosis as judged by MRA was within 10% of the value obtained by Doppler ultrasound in 50% of vessels studied, and within 20% in 83% of cases. When comparing MRA with angiography, results were within 20% in 83% of cases as opposed to 67% when comparing Doppler with angiography. We conclude that MRA of patients with TIAs during their initial assessment by cranial MRI is a quick and accurate technique. It is as sensitive as Doppler ultrasound in deciding which patients should proceed to angiography with a view to endarterectomy. In addition the technique provides an assessment of the patency of the vertebral and intracranial cerebral arteries.

2.15 – 3.45

Musculoskeletal Imaging I

Argyll II

Bone and joint tuberculosis: five years' experience in an Inner London district

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A retrospective study was performed to look at all cases of adult bone and joint TB presenting to two hospitals in Tower Hamlets Health Authority over a 5-year period. Of the 580 cases identified 26 had bone and joint TB. All patients were immigrants, the majority from the Indian subcontinent, and presented to a wide range of clinical specialties. Symptoms and signs were focal but non-specific, and biochemical parameters were not consistently abnormal. The plain radiographs were abnormal in all cases of TB affecting peripheral joints and in 13 of 15 patients with spinal TB. CT and CT myelography were shown to be particularly useful in assessing extent of spinal and sacro-iliac disease. 71% of all cases had a normal chest radiograph. Focal bony symptoms and abnormal radiographs should alert the radiologist, who is in the best position to suggest the diagnosis.

Ultrasonography in septic arthritis of the hip

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The purpose of this study was to evaluate the use of arthrosonography of hips in 60 patients clinically suspected of having septic arthritis. They were investigated by clinical and laboratory evaluation, plain X ray, arthrosonography of the affected hip and contralateral normal hip. The technique of hip joint scanning, in a sagittal plane from the anterior aspect, using Toshiba Ultrasound Model SSA-90A with 7.5 MHz phased linear-array transducer, is described. All 50 sonographically positive cases of hip joint effusions

had needle aspiration and laboratory evaluation of the fluid collected. Sonographic diagnosis of hip joint effusions was by demonstration of capsular distention with hypoechoic or an anechoic area in superior, anterior or inferior recess and asymmetry of capsular anatomy on comparison with contralateral normal hip. Sonographic, aspiration and laboratory results confirmed (a) 40 cases of septic arthritis; (b) 10 cases of transient synovitis; (c) three cases of psoas abscess and seven patients having no abnormality. Out of 20 radiographically positive cases, five patients had osteomyelitis of upper shaft femur both on X ray and sonography. We concluded that ultrasonography is useful in the detection and localization of hip joint effusion, and in diagnosing osteomyelitis of femur and psoas abscesses on scanning the respective areas.

Simple bone cysts of the pelvis

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Simple or unicameral bone cysts are most common in the tubular bones and occur mainly in the first and second decades. After the age of 20, simple bone cysts are rare and have a predilection for the pelvic bones and calcaneus. We present seven cases of benign simple bone cysts in the pelvis (6 M, 1 F; age range 33 to 69 years, mean age 48 years). In all patients, follow-up confirmed the benign diagnosis, and biopsy proof had been obtained in three patients. Three patients had CT of the lesion and four had radioisotope bone scans. All the lesions occurred in the ilium, three on the right and four on the left. There were no associated upper femoral lesions. Three distinctive radiographic patterns could be identified, each group having a biopsy-proven diagnosis. This poster presentation will discuss the clinical presentation, plain film findings, CT and radioisotope findings, together with the differential diagnosis. The correct recognition of a benign pelvic bone cyst can prevent unnecessary investigations and anxiety.

Pulled elbow

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The conventional view is that a sudden pull on a child's arm in pronation and extension of the elbow dislocates the head of the radius forward from the annular ligament. The joint is held in slight flexion and pronation and the child refuses to use the arm. Supination followed by flexion with a thumb on the head of radius relieves the symptoms and after a few days in a simple sling the arm is normal. However, X rays, usually from shoulder to wrist, never show any displacement of the central axis of the radius from the capitellum. What is often seen is, in an AP view of the elbow, an AP appearance of the humeral metaphysis but an oblique or lateral view of the ulna. An alternative explanation is that the lower humeral epiphysis becomes displaced and rotated; the reduction manoeuvre would work. It seems likely that there is a spectrum of elbow injuries of this nature ranging from posterior rotation through varying degrees of anterior rotation to a complete epiphyseal fracture dislocation. Anterior dislocation of the radial head can occur but it is rare.

The aetiology of hallux valgus: Footwear, forefoot collapse and first metatarsal pronation

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We have recently shown that patients with hallux valgus have a first metatarsal pronation deformity of up to 30°^{1,2}. The present study was undertaken to correlate degree of first metatarsal pronation with the height of the medial longitudinal arch, in order to define the relationship between medial longitudinal arch collapse, first metatarsal pronation and hallux valgus. The weight-bearing AP and lateral views of feet of 48 patients (36 females, mean age 38 years; 12 males, mean age 40 years) were reviewed and in each case, patient's age, sex, medial longitudinal arch angle, amount of first metatarsal pronation and intermetatarsal angle were recorded by independent observers. There is a significant relationship between first metatarsal pronation and height of the medial longitudinal arch (right pronation V right arch -0.93, $p < 0.001$, left pronation V left arch -0.96, $p < 0.001$) Less marked association was noted between intermetatarsal angles and metatarsal pronation (0.69, $p < 0.001$) and between age and height of the medial longitudinal arch (0.32, $p < 0.04$). Multivariate analysis showed that the single most dominant variable affecting

metatarsal pronation was the height of the medial longitudinal arch.

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Should all calcaneal fractures be assessed by computed tomography (CT)?

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Although calcaneal fractures represent only 2% of all fractures, they can result in a disproportionately high degree of morbidity as they tend to occur in young, active manual workers. The mode of surgical treatment of calcaneal fractures depends on whether the fracture is comminuted or if there is articular facet involvement; thus precise radiographic definition is required. The aim of this study was to compare plain radiography with CT in the assessment of calcaneal fractures. 24 consecutive patients with calcaneal fractures were included in the study, 18 males and 6 females with a mean age of 36.5 years. Each patient was assessed by plain radiographs (lateral and axial views) and CT. All the films were reported independently by two radiologists who characterized the fractures as intra-articular, extra-articular or comminuted (the number of fragments was also identified). In the 24 patients, CT identified more calcaneal fractures with articular facet involvement compared with plain radiographs (21/24 vs. 3/24). There were also more comminuted fractures identified by CT (21/24 vs. 12/24). These results suggest that CT is superior to plain radiography in the evaluation of patients with calcaneal fractures and should be a mandatory investigation in such patients.

The heel pad following calcaneal fracture: ultrasound findings

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The heel pad has been reported to be disrupted following calcaneal fracture. We have used ultrasound to measure the

thickness of the heel pad and to correlate these findings with weight, pain and disability. The technique was initially validated using normal volunteers and was proven to be reproducible ($0.5 > p > 0.1$). 21 patients with a history of unilateral calcaneal fracture were studied (average age 49.8 years, average 21 months post-injury). Information regarding pain and disability was also obtained. The heel pad was significantly thickened on the affected side ($p = 0.001$). Surgery and resulting disability were not related to heel pad thickness. The heel pad thickness was proportional to body weight ($r = 0.15$, $p < 0.001$). Pain was a feature in 14% but did not correlate with heel pad thickness. Ultrasound has been found to be a useful method of assessing heel pad thickness. Our findings indicate that the heel pad thickness is not decreased following calcaneal fracture, as is claimed in current orthopaedic literature.

Follow-up of intra-articular calcaneal fractures with 3D FISP MRI

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MR imaging is of limited value shortly following a calcaneal fracture because of extensive marrow and soft tissue signals from contusion, haemorrhage and oedema. This study was undertaken to assess the value of 3D FISP MR imaging in the long-term follow-up of calcaneal fractures. 18 intra-articular fractures in 17 patients were examined six months or more after injury. 64 slices, 1.4 mm thick, were obtained in the coronal plane on a Siemens IT Impact Magnet. The images and reconstructions were reviewed on an independent console for evidence of subtalar and calcaneocuboid joint osteoarthritis and abnormalities of the peroneal and other tendons. Comparisons were made with coronal spin echo MR images and computed tomography of the hindfoot. MR of the contralateral asymptomatic foot was also performed in 12 cases. The 3D FISP MR images excellently demonstrated all the bone and joint abnormalities and the reconstructions were particularly valuable in delineating the position and course of the various tendons. Tendon abnormalities were more common on the 3D FISP than the spin echo images, raising the question as to whether it is more sensitive. However, approximately 25% of the asymptomatic hindfeet examined also revealed abnormal signal changes within their tendons. This finding would suggest that the so-called "magic angle" phenomenon can simulate disease of the tendons in gradient echo imaging of the hindfoot. Clinical correlation and illustrative cases are presented.

3D-SPGR of musculoskeletal lesions at 0.5T

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The 3D Spoiled Gradient Recalled Echo in the Steady State (3D-SPGR) sequence provides thin-section T_1 -weighted images with better spatial resolution and signal-to-noise ratio than multisection spin echo (SE) sequences obtained in a similar time. Its application to diagnostic imaging of the musculoskeletal system has been evaluated in 30 patients with bone, soft-tissue or joint abnormalities and compared with multiplanar 3–5 mm T_1 -weighted SE sequences. Typical parameters used in 3D-SPGR imaging were TR = 50 ms, TE = 12 ms, flip angle 45°, 30–50 partitions of 1.0–1.5 mm and acquisition time 5–10 min. The increased spatial resolution and the ability to reconstruct the 3D-SPGR data in any plane without loss of resolution improved lesion evaluation compared with multiplanar T_1 -weighted SE images, particularly in areas of complex anatomy such as joints and the hands and feet. Contrast between medullary and cortical bone, cartilage, tendon, subcutaneous fat and muscle was sufficient on unenhanced 3D-SPGR images for evaluation of abnormality within these anatomical areas and for delineation of intraosseous lesions. Intrinsic contrast between soft tissue tumour and muscle, however, was poor on unenhanced 3D-SPGR sequences and was improved by the use of intravenous gadolinium-DTPA. The saving in scanning time achieved by using 3D-SPGR compared with multiplanar SE acquisitions has to be weighed against the increased radiological time required for post-processing and image viewing. Data storage, display and hard copy production all require optimization. Nevertheless, 3D-SPGR can be of significant diagnostic value in the musculoskeletal system.

Use of 3D-SPGR sequence for the demonstration of complex spinal anatomy.

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The 3D-SPGR (Spoiled Gradient Recalled Echo in the Steady State) sequence utilizes an RF spoiling gradient to reduce the influence of T_2 relaxation and confer greater T_1 weighting on the image than a standard 3D gradient echo sequence. This 3D-SPGR sequence has recently been added to the 0.5T Vectra software (GE) and has been employed in patients with lesions of the spine. 3D-SPGR acquisitions were obtained, in addition to the standard spin echo (SE) sequences, in 36 patients with spinal abnormalities. Typical parameters for the 3D-SPGR sequence were: TR 50, TE 12, flip angle 45–90°, slice thickness 1.0–1.5 mm with 30–60

partitions. The acquisition time was 5–10 min. Parameters for the SE sequence were: TR 500, TE 25, slice thickness 3–5 mm, in axial and sagittal planes. Whilst contrast on the 3D-SPGR sequence was lower than on the SE sequences, the thinner sections permitted better spatial resolution and good quality reconstructions in alternative planes. More information was obtained in complex morphological abnormalities (e.g. spinal dysraphism) from the reconstructed 3D-SPGR images than from the SE sequences in orthogonal planes. 3D-SPGR is of clinical benefit in selected patients. The potential saving in scan time is counterbalanced by the input needed for post-processing and viewing data. Data storage and hard copy production also require rationalization.

Distal radial fractures and associated carpal ligamentous injury

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This study was to determine the association of carpal ligamentous injury with distal radial fracture. Carpal bone fracture and overt dislocation have been described with concomitant radial fracture. Recent articles on carpal ligamentous injury and radial fracture, all in orthopaedic journals, may underestimate this incidence. Retrospective analysis was made of 50 adult patients presenting to the Hermann Hospital with distal radial fracture. Mechanism of injury, type of fracture and associated carpal ligamentous injury, as determined by altered intercarpal angles and distances or alignments, were assessed. Overall, positive carpal injury as determined by scapholunate (S/L) distance > 4 mm, loss of carpal "arcs", or S/L angle > 80°, totalled 18 patients (36%). 10 patients (20%) were equivocal with S/L distance 2–4 mm and S/L angle 60–80°. 22 patients (44%) were normal. The association of carpal ligamentous injury with distal radial fracture is surprisingly frequent. Most are not recognized at initial presentation. "Stress" views may even increase this number. Associated carpal injury, if recognized, alters the treatment of the radial fracture. Missed carpal injury and its potential sequelae of instability and late carpal collapse have implications for the duration of morbidity and productivity.

Post-traumatic knee joint effusions: A predictor of morbidity?

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It has been suggested that following trauma, the presence of a radiologically detected knee effusion, even without asso-

ciated fracture, is a predictor of high morbidity. However, there are no controlled trials to evaluate this. We evaluated 204 successive knee radiographs of patients presenting to the Casualty Dept. following knee trauma in which there was no evidence of underlying bony abnormality. Follow-up at three months was by postal questionnaire. A response rate of 82% was obtained, of which 44% had knee joint effusions. The effusion and non-effusion groups were matched with regard to age, sex and mode of injury. There was no difference in duration or severity of symptoms between the two groups. The patients with effusions required more support bandages (87% versus 72%) than did the non-effusion patients but there was no difference in any other treatment modality between the two groups. There was a higher self-referral rate to general practitioners in the effusion group (47% versus 30%) but referral rates to other healthcare professionals were similar in the two groups. We conclude therefore that the radiological demonstration of a knee effusion following acute trauma is of no value as a prognostic indicator.

Detection of non-radiopaque foreign bodies in musculoskeletal system by ultrasonography

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The purpose of this study is to evaluate the use of ultrasonography in non-radiopaque foreign bodies in the musculoskeletal system. Sonography was performed in 50 patients presenting with definite history of foreign body injuries. All patients underwent low kV plain radiography of the affected area and sonography of the affected and contralateral normal area. The technique of scanning using Toshiba Ultrasound Model SSA-90A with 7.5 MHz phased linear array transducer is described. Surgery was done in all patients. Size and depth of the foreign bodies were noted both on sonography and at surgery and results compared. No foreign bodies were detected on plain X ray. 46 patients showed sonographic evidence and 49 patients, evidence of foreign bodies at surgery. One patient showed no evidence of foreign body at all. Sonographically foreign bodies were visualized as hyperechoic foci. Correct size and depth on sonography were found in 46 and 40 cases respectively. Additional findings were comet-tail artefact (nine patients) and acoustic shadow (two patients). 41 date thorns and five pieces of wood were found. Ultrasonography has proved to be useful in detection, precise localization and pre-operative assessment of non-radiopaque foreign bodies in the musculoskeletal system.

The detection of wooden and plastic foreign objects by conventional and digital radiography

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Whilst it is widely known that glass and metallic foreign bodies are visible on conventional radiography the visibility of woods and plastics has not been studied. The visibility of commonly encountered plastics, timbers, fresh wood and thorns in fresh porcine tissue was assessed using conventional low kV radiography and digital radiography using a FUJI AC-1 digital unit and imaging plates. The latter system allows production of a conventional and an edge-enhanced image from one radiographic exposure. Visibility was scored by three radiologists separately. All of the timbers (oak, pine, mahogany and teak) were visible initially as low-density areas in soft tissue. However at 24 h their visibility was reduced, presumably due to absorption of water from the surrounding tissues. The thorns (black-thorn and hawthorn) and fresh woods were invisible. Visibility of plastics was variable with glassfibre, Foamex, polyvinyl chloride and acrylonitrile butadiene styrene clearly being shown whilst Perspex and Lexan were invisible. The digital radiography with edge enhancement improved the clarity of those objects which were visible by conventional films but did not bring about identification of any which were invisible by conventional radiography. These results show that the visibility of commonly encountered woods and plastics is variable. Digital radiography brings about an improvement in visualization of some of the foreign bodies but a number are invisible to both techniques.

A comparison of radiography, digital radiography, computed tomography and ultrasound in the detection of foreign bodies

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Foreign body detection by means of conventional radiography is often unsatisfactory. Digital radiography offers the advantage of an edge-enhanced image but its value in foreign body detection is unclear. An assessment of digital radiography of foreign bodies is presented and a comparison with other imaging modalities made. Foreign bodies were examined in porcine soft tissue. The foreign bodies studied were fish bone, chicken bone, glass, wood, metal and plastic. Radiographs of the specimen were taken with conventional film and a digital scintillation plate (Fuji FCR AC1) system in both edge-enhanced and standard modes. The specimen was also assessed using CT and ultrasound. Conventional and digital radiography clearly visualized the metallic foreign body. The fish bone, chicken bone, glass and plastic foreign bodies were moderately well demonstrated using conventional radiography but visualization improved with digital radiography. CT clearly visualized all of the foreign bodies. Ultrasound clearly visualized all the foreign bodies except plastic, which was poorly visualized. Digital radiography offers advantages over conventional radiography in the visualization of foreign bodies. Ultrasound may provide additional information in remaining cases but is time-consuming.

2.15 – 3.45

Oncology Clinical Practice

Argyll III

The benefits of adjuvant radiotherapy in breast cancer

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The aim was to quantify the beneficial effects of radiotherapy administered after “complete” breast cancer surgery in the various settings encountered in clinical practice. Recent prospective, randomized studies were reviewed in order to investigate the relative reduction in local recurrence risk (LRR) associated with “standard” megavoltage radiotherapy (SRT, defined as the equivalent of 46–50 Gy in 2 Gy fractions): (1) administered to the breast after local excision (LE); (2) administered locoregionally after total mastectomy and axillary dissection (RM); (3) administered in combination with chemotherapy (CT) or tamoxifen (TAM). The endpoints of uncontrolled locoregional disease and survival were also considered. It was found that SRT alone reduces LRR by a factor of 3 after LE and 4 after RM. After LE with SRT, the addition of CT or TAM reduces LRR by a factor of 2–3 compared with SRT alone. In patients treated with RM, the addition of SRT to either adjuvant CT or TAM results in marked reductions of LRR. Data on uncontrolled locoregional disease are sparse. In one study of patients treated with RM, twice as many patients died with local disease present when SRT had not been given. No survival benefit has yet been demonstrated for breast SRT, but recent trials suggest improved survival in patients treated with locoregional SRT after RM. Clinical trials allow the benefits of SRT to be appreciated quantitatively. LRR is markedly improved by associating SRT with systemic therapies. Whether such LRR reductions are judged worthwhile depends on the baseline absolute risk of the individual patient, the side effects of the adjuvant therapies, and the perceived clinical consequences of local failure. Meta-analyses are underway to assess the question of effects on overall survival.

Measurement of the effect of tamoxifen on bone mineral density

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Tamoxifen is widely used as adjuvant hormone therapy for breast cancer. It has also been proposed as a chemopreventative agent and as treatment for benign conditions such as mastalgia. There is an increasing tendency for treatment to be continued for at least five years, and for its use in women who may not have had cancer. The toxicity profile of tamoxifen is favourable but there is little data with regard to the effect on bone mineral density (BMD). This study was designed to determine whether long term administration of tamoxifen is detrimental to bone mineral density by virtue of its antioestrogen activity. 19 women who had taken tamoxifen for at least five years as adjuvant therapy for breast cancer were identified from patients attending our follow-up clinic. These were then matched with respect to age (to within five years) and time since onset of menopause (to within three years) with 19 controls who had also had breast cancer at least five years previously but had not received any form of systemic adjuvant therapy. Age range was 45–84 years (median 62). Duration of tamoxifen therapy was 60–140 months (median 75). 10 had received 20 mg daily, nine had received 40 mg daily. All had a WHO performance score of 0. None had evidence of metastatic disease previously or active breast cancer at the time of assessment. All 38 patients then underwent a dual energy X-ray absorptiometry (DEXA) scan to determine BMD at the lumbar spine (L2–L4), femoral neck and total body. Serum calcium, phosphate and alkaline phosphatase were measured from a single serum specimen. Results were compared using a paired *t*-test. BMD data was complete for 18 of the 19 pairs at each site of interest. Mean BMDs (g cm^{-2}) for lumbar spine, femoral neck and total body

were 1.081, 0.934 and 1.078 respectively in the tamoxifen group versus 1.065, 0.877 and 1.057 in the controls ($p > 0.1$ in each case, 95% CIs -0.045 to $+0.094$, -0.047 to $+0.165$ and -0.036 to $+0.07$ respectively). Analysis according to dose again suggested a trend towards preservation of BMD that was greater for the 40 mg daily dose of tamoxifen than for 20 mg, particularly at the femoral neck (mean increase in BMD 0.063 for 40 mg vs. 0.056 for 20 mg), but again these results did not reach statistical significance. Mean serum calcium (mmol l^{-1} corrected to an albumin of 40 g l^{-1}), phosphate (mmol l^{-1}) and alkaline phosphatase (IU l^{-1}) were available for all patients and were 2.30, 1.10 and 63.7 respectively in the tamoxifen group versus 2.39, 1.20 and 76.2 in the controls, indicating a trend towards reduction with tamoxifen treatment which reached statistical significance for the calcium ($p < 0.05$, > 0.01 , 95% CI -0.16 to -0.02) and alkaline phosphatase ($p < 0.05$, > 0.01 , 95% CI -21.5 to -3.1). We conclude that in long term administration, tamoxifen acts as a partial oestrogen agonist on both trabecular and compact bone, with preservation of BMD at sites where morbidity from osteoporosis is greatest. No clinically relevant effect on bone biochemical parameters was observed.

The influence of risk factors and treatment on survival in invasive squamous cervical carcinoma

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289 cases of invasive cervical carcinoma were graded for risk according to a microscopical grading system (MGS). In 195 cases a flow cytometric analysis could also be carried out. Of the 195, 29 were initially treated by surgery, 123 by radiotherapy only and 43 with individual combinations of radiotherapy and surgery. 65 patients also had adjuvant chemotherapy due to high risk according to MGS. 80 patients were in an early clinical stage and 115 in late stages. In a multivariate analysis diploid tumours with high S-phase comprised a high risk group. In early clinical stages radiotherapy only and primary surgery resulted in similar prognoses while preoperative radiotherapy gave significantly worse results. Chemotherapy improved prognosis for high malignancy grades. In late clinical stages adjuvant chemotherapy gave no improvement. The MGS-system is of value in defining risk in early stages. Diploid tumours with high S-phase also make a well defined risk group. In our experience adjuvant chemotherapy improves the prognosis for certain patients. In this material, treatment plans with initial primary surgery or radiotherapy only give better prognoses than others.

Carcinoma of the tongue

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121 patients with histologically proven squamous cell carcinoma of the tongue have been treated at Canniesburn Hospital and the Beatson Oncology Centre between 1982 and 1988. All the patients were treated by surgery with or without post-operative radiotherapy. Patients with Stage T1 N0 M0 were treated by wide local excision of the lesion from the tongue. All the others who were considered as advanced tumours were treated by radical excision of the lesion associated with a radical or functional neck dissection, followed by immediate reconstruction using a radial forearm flap, and then 4 weeks later went on to receive a radical course of post-operative radiotherapy (6000 cGy in 30 fractions given over 42 days). The five-year survival for the 26 patients with Stage T1 N0 M0 treated initially by surgery is 52%. The five-year survival for the 34 patients with Stages P2, P3, N0, M0 treated by radical surgery followed by radical post-operative radiotherapy is 50%, and the corresponding survival for the 56 patients with Stages P1, P2, P3, P4-node-positive M0 patients treated by radical excision followed by radical post-operative radiotherapy is 25%. There was a statistically significant difference in the results between these two groups. The pathological presence of tumour in the lymph nodes and whether or not the tumour was completely excised were the only two factors which statistically affected overall survival. The P stage did not appear to affect survival though the numbers in the groups were small. Again, invasion into nerve, blood vessel or bone did not appear to affect prognosis. Extent of muscular invasion has not been recorded as the tongue is a muscular organ. This practice should possibly be revised.

Uterine sarcoma: survival, patterns of spread and prognostic factors: a review of 76 patients

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We have reviewed the medical records and diagnostic imaging of 76 patients presenting to this hospital for treatment of uterine sarcoma between 1960 and 1990. Patients were divided into those presenting before 1980 ($n = 22$) and after 1980 ($n = 54$), when sectional imaging (ultrasound, CT scanning) and modern chemotherapy became available. No survival difference was observed between these two groups. Overall, the median age of patients was 54 years

(range 18–80), and median survival 21 months from initial diagnosis. Factors associated with a significantly improved survival were low grade (although not histological type) of initial tumour ($p = 0.006$), Stage I disease at presentation ($p = 0.006$), and complete debulking of the primary tumour at initial surgery ($p = 0.003$). Patients receiving pelvic radiotherapy following initial surgery had a significantly increased disease-free interval ($p = 0.006$) but this did not improve their overall survival. Following diagnosis of relapse, the median survival was nine months, with the outcome significantly worse if multiple metastatic sites were involved ($p = 0.001$). No survival benefit was demonstrated for either local radiotherapy or combination chemotherapy once relapse had occurred. Most diagnoses of relapse were established clinically, although CT often demonstrated disease extent beyond that suspected on examination. Relapse was most frequent in the pelvis, followed by lung and abdomen. Pulmonary relapse was accompanied by spontaneous pneumothorax in two cases. Bone and brain metastases were rare (10%). Policies for optimum management and follow-up of uterine sarcoma will be discussed.

Single fraction prophylactic cranial irradiation for small cell carcinoma of the lung

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The use of a single 8 Gy fraction prophylactic cranial irradiation regime was assessed in 114 patients with small cell carcinoma of the lung. All patients had a good prognostic score on the Manchester Index and received combination chemotherapy consisting of either cisplatin or carboplatin with ifosfamide, etoposide and vincristine (VICE). Cranial irradiation was administered 24 h after the first cycle of chemotherapy and was well tolerated, producing no clinically significant neurological sequelae. Overall two-year survival for patients with limited stage disease was 34% and cranial relapse occurred in 15%. This compares favourably with cranial relapse rates of 36% previously reported with the same chemotherapy regime after a minimum follow-up of 18 months.

Multimodality treatment for operable carcinoma of the oesophagus — long term survival

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A prospective non-randomized study to assess the value of combined pre-operative chemotherapy and radiotherapy

for operable carcinoma of the oesophagus was started in 1976. Pre-operative radiotherapy 25 Gy over one week was combined with chemotherapy varying with cell type and time of entry into study. 221 patients with a minimum follow-up of one year have been assessed. The pre-operative therapy had acceptable toxicity and contributed to a high resection rate (90%). The tumour (both adeno- and squamous) was completely ablated in 13%. The majority of cases were adenocarcinoma (57%). In 200 patients who had complete resection, the crude survival at one year was 103/200 (52%), at three years 37/176 (21%), at five years 24/153 (16%), at 10 years 8/69 (12%); and for patients with squamous cell carcinoma: at three years 21/71 (30%), at five years 15/58 (26%) and at 10 years 6/27 (22%). The local recurrence rate was low (15%). The combination of pre-operative chemotherapy and radiotherapy appears to improve the resectability and reduce local recurrence. There is an apparent survival advantage for patients with squamous cell carcinoma. A prospective randomized MRC study was started in 1992 to evaluate the place of pre-operative chemotherapy and radiotherapy in operable oesophageal carcinoma.

Image-directed surgery for intrinsic tumours: overcoming the limitations of stereotaxy

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There is good evidence that radical removal of gliomas increases survival. Freehand techniques are notoriously inaccurate and conventional image-directed stereotactic surgery has major limitations with respect to general neurosurgical practice. A point source localization can be achieved with reasonable ease with all stereotactic systems, particularly for lesions deep within the brain, but accurate resection of the radiological margins of a tumour not only is time-consuming but requires very expensive dedicated stereotactic equipment (such as the "Compass" system) which precludes its use in general neurosurgery. This report describes the preliminary experience with the ISG viewing wand in the surgery of 30 intrinsic brain tumours. The advantages of this system over stereotaxy are as follows: 1. pre-operative image data sets are used, which avoids the need for per-operative scanning; 2. the Allegro computer allows pre-operative planning of the surgical approach; 3. accurate localization of small lesions anywhere in the brain is feasible; 4. radical resection of large tumours within eloquent areas of the brain can be achieved. Although the

ISG viewing wand brings the advantages of image-directed surgery to a far greater proportion of intrinsic tumour cases, it is too early to know whether its use has had any influence on the long term outcome. Nevertheless the ease and accuracy of surgery using this equipment makes it a major breakthrough in the treatment of intrinsic brain tumours.

Analysis of MDR-brachytherapy failures in treatment of carcinoma cervix uteri

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Gynaecological brachytherapy has undergone a spectral change in all concepts and practice in the past 5 years. Introduction of remote controlled afterloading devices and better understanding of radiobiology and dosimetric methods have created a renewed interest in this field. Carcinoma cervix still remains one of the major oncological problems in the developing countries. Brachytherapy is the main line of curative therapy. A medium dose rate (MDR) intracavitary brachytherapy ($180-210\text{cGy h}^{-1}$) has been practised in the Kamala Nehru Memorial Hospital, Allahabad, for the past 6 years. Brachytherapy has been practised in a wide range of patients with varying stages either alone or in combination with teletherapy as per the protocol practised in the hospital. ICRU-38 based dosimetry has been practised with the use of a CTW-700 CT scanner in about one-fifth of the cases. The cases were evaluated periodically. The treatment results and complications were analysed with special reference to the factors and causes of failure of treatment. It was observed in 308 cases of cancer cervix treated by intracavitary brachytherapy with combination of teletherapy in Stages IB, IIA, IIB, IIIA and IIIB that the overall two- and four-year disease-free survival rates were 76% and 72% respectively. A critical analysis of the cases of failure and complications was made in the light of various patient and tumour characteristics, treatment protocol, type of intracavitary applicator, method, dose rate and radiobiological factors. In this presentation the results of analysis of the various factors influencing the treatment failure and complications will be discussed.

The treatment of locally advanced carcinoma of the cervix with radiation, 5-fluorouracil and mitomycin C

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In a group of 44 patients with locally advanced or recurrent carcinoma of the cervix treated by radical irradiation, synchronous infusion 5-fluorouracil (5-FU) and bolus mitomycin C, the cumulative local control probability at 36 months is 66% and cumulative survival probability is 56%. RTOG Grade 3 acute haematological toxicity occurred in 5% of the group, Grade 3 acute upper gastrointestinal effects in 2% and Grade 3 acute large bowel effects in 2%. There were no cases of RTOG/EORTC Grade 3 late effects. This combination may be an important advance in poor prognosis carcinoma of the cervix.

Individualized brachytherapy of ENT tumours — technique and first results

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In the period from October 1983 to September 1992 19 patients received an individualized brachytherapy, mostly for recurrent tumours in the cavity of the mouth, the oropharynx or the hypopharynx. After taking individual dental impressions models were made of plaster of Paris. Using the deep-drawing method, elastic dental prostheses were formed. Plastic tubes were fixed on those as guidelines for brachytherapy catheters. Radiation was performed using the ¹⁹²Ir high dose rate afterloading method (Sauerwein Gammamed III) with single doses of 5 Gy (computed at a distance of 10 mm from the applicator surface) up to total doses of 5–20 Gy in one to four (mean: 3.2) sessions. In 63% of the patients, brachytherapy was combined with teletherapy (total doses ranging from 40 to 60 Gy). Fibrous mucositis was seen in 58% of the patients. Mean empirical survival was 246 days, the one-year survival probability 28%. We achieved a good relief of pain. In conclusion, this method may be an advantageous way for palliative radiotherapy of patients with painful recurrences. Furthermore it can be used as a boost after teletherapy. In our patients we did not see any improvement of survival or local control. The side-effects were acceptable.

2.15 – 3.45

Teach-in: Radiology and the Law

Seminar Suite I

We are all familiar with the many uses of radiation in the world of medicine. There are, however, other users. The public also have a right to know and a need to know about the procedures they may undergo as part of a diagnostic workup or therapy plan which involves the use of radiation. This teach-in explores some of these aspects. The first speaker will discuss the question of informed consent, with particular emphasis on radiotherapy. We all know that many practitioners other than those who qualify for membership of the BIR use radiation in the course of their work. The second speaker will illustrate the use that forensic pathologists have for radiation. The third speaker will talk on a non-medical use of radiation, but one which affects most of us at some time or another, namely airport security and the role of the baggage X-ray machine. This promises to be a session quite unlike any offered by the Congress before, and I commend it to your attention.

Informed consent in the cancer patient

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Abstract not received

The place of radiology in forensic pathology

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Radiology is a necessary part of diagnostic activity in the clinical arena but its value in routine forensic pathological investigation is underestimated in many centres. The use of radiology in the police mortuary, particularly in regard to identification of remains and cause of death, is reviewed with examples from recent Aberdeen cases, and special attention is drawn to particular circumstances where radiology provides invaluable documentary evidence in the investigations. The possibility of reproducing radiographic material to illustrate injuries to the court is introduced. The ever advancing technology and consequent increase in resolution capacity, coupled with new imaging modalities such as MRI, must open up the field of forensic radiology, just as it has in clinical practice. The need for constant liaison between the two specialities in general terms, as well as in the approach to specific cases, is emphasized.

The use of radiation in airport security

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Abstract not received

2.15 – 3.45

Nuclear Medicine II

Seminar Suite II

The clinical utilization of nuclear cardiology

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It is almost 20 years since the introduction of nuclear cardiology. Clinically applicable techniques are now available for myocardial perfusion evaluation, ventricular function studies and acute myocardial infarct detection, and can be provided by any nuclear medicine department with standard equipment. It is notable, however, that the level of utilization of these procedures in the UK is significantly lower than that in the USA or continental Europe. Myocardial perfusion imaging is performed with either thallium-201 or technetium-99m labelled compounds such as MIBI. Myocardial imaging is mainly employed in ischaemic heart disease, though there are other valuable applications. The accuracy of detection of coronary artery disease is high, especially when single photon emission computed tomography (SPECT) and quantitative analysis are employed. Myocardial imaging is most valuable when other investigations are equivocal. It also has an increasing role in the evaluation of the functional significance of a known coronary lesion, in studying myocardial viability and in measuring the efficacy of revascularization procedures. Studies of right and left ventricular function can be performed at rest and during exercise using radionuclides. The role of radionuclide ventricular function studies may decrease as ultrasound techniques become more widely available. The scintigraphic study, however, does still have a role in studying ventricular function reserve and in patients in whom echocardiography is not feasible. Indium-111 labelled antimyosin has largely replaced technetium-99m pyrophosphate for acute infarct imaging. It demonstrates high sensitivity and specificity. It has not been widely employed in routine diagnosis of acute myocardial infarction but has a useful diagnostic and localizing function when more standard techniques are equivocal. It also

is employed in myocarditis and in cardiac transplant rejection.

New radiopharmaceuticals

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The major advance in nuclear medicine in recent years has been the development of single photon emission computed tomography (SPECT); the technology of the scintillation crystal, however, seems unlikely to be bettered in the near future and so the most promising area is in radiopharmaceutical development. Monoclonal antibodies offered much promise, but have generally failed to live up to expectation. Recently, Oncoscint (an anti-CEA agent) has gained a UK product licence and is undergoing trials in colorectal cancer. Polyclonal human immunoglobulin has been introduced as an infection imaging agent and shown to have good sensitivity and specificity. Iodine-123 labelled serum amyloid P appears to have an important contribution in the diagnosis and management of patients with systemic amyloidosis, having been demonstrated to be quantitatively related to the abundance of amyloid. The search for a thallium-201 replacement has continued, yielding teboroxime and isonitrile agents. Even the superior agent, isonitrile, has not gained widespread acceptance as being significantly superior to thallium in clinical practice. HmPAO is used not only for cerebral perfusion but also white cell labelling, giving a readily-available technetium-99m agent. Much work is presently being carried out on receptor ligands, with successful imaging of dopamine and muscarinic receptors being reported. In therapy, monoclonal antibodies have been used with varying success, but the numbers of patients involved are too small for definitive statements to be made. MIBG is now established in the treatment of pheochromocytoma and neuroblastoma.

Strontium-89 is used increasingly for the palliation of bone metastases from both prostate and breast cancer. Rhenium-186 HEDP and samarium-153 EDTMP are undergoing clinical trials. The use of α -emitters, such as astatine-211, is at the evaluation stage in animal models.

Comparison of radiographs, isotope bone scanning and high resolution CT in suspected scaphoid fractures

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Twenty patients with a clinical suspicion of scaphoid fracture and normal plain radiographs underwent further radiological evaluation. All had isotope bone scanning (IBS) and high resolution CT scanning 10 (1–17) days after initial assessment. All initial plain films, including scaphoid views, were normal. In three patients both IBS and CT were also normal. In a further six cases CT confirmed the suspected fracture on IBS. CT scans were normal in the remaining patients. The IBS in these cases showed increased uptake in relation to the scaphoid specifically, in six patients. In these cases, the patients' clinical courses suggest a less severe injury and probably less need for prolonged internal immobilization.

Comparison of ^{99m}Tc nanocolloid and indium-111 leucocytes in the diagnosis of orthopaedic infections

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It has been suggested that ^{99m}Tc nanocolloid is as effective an inflammatory radiopharmaceutical as ^{111}In leucocytes. This study compares the efficacy of ^{99m}Tc nanocolloid and ^{111}In leucocytes in the detection of orthopaedic infection in 19 patients with a high clinical suspicion of infection. The two scintigrams were performed within 24 h of each other. A scintigram was considered positive where there was an increase in tracer uptake at the site of interest. Concordance rate of 73% was achieved. The numbers of false positives with ^{111}In leucocytes and ^{99m}Tc nanocolloid were three and six respectively. The single false negative in both was of a patient with tuberculous spondylodiscitis. Sensitivity was 75% in both. Specificities were 79% and 60% for ^{111}In leucocytes and ^{99m}Tc nanocolloid respectively. Positive predictive value was only 33% with ^{99m}Tc nanocolloid and 50% with ^{111}In leucocytes. ^{99m}Tc nanocolloid also proved more unreliable in accurately detecting infected prostheses. We conclude that ^{99m}Tc nanocolloid cannot replace ^{111}In leucocytes in the diagnosis of orthopaedic infections.

The labelling of leucocytes with technetium 99m: a very simple kit

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Technetium-99m is widely used in different nuclear medicine procedures besides biological studies. This is due to several important biological, chemical, physical and environmental characteristics. Kits have been developed for obtaining various radiopharmaceuticals, as molecular or cellular kinds. Recently, the authors suggested a very simple kit for the labelling of red blood cells with ^{99m}Tc to get selective splenic scintigraphy (*Acta Medica et Biologica*, 1992, in press). In this communication we present the establishment of conditions to manufacture a kit for the labelling of white blood cells (WBC) with ^{99m}Tc . These cells are used to localize abscesses and infection sites and have been labelled with different methods and kits. The majority of these methods present disadvantages such as high cost, the decrease of cell viability, the use of heparin and many manipulations. Early, we have studied the effects of: 1. stannous chloride concentration; 2. incubation time; 3. incubation temperature; 4. presence of platelets; and 5. plasma in the incubation medium in the labelling WBC process with ^{99m}Tc . Our results make it possible to suggest the production of a kit to label WBC with ^{99m}Tc in the conditions: 1. 12 μg of stannous chloride ($\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$); 2. 9 mg of sodium chloride and set pH at 5.0. Then we have compared the scintigraphs obtained with our kit with the ones obtained with hexamethylpropyleneamide-oxime (HMPAO). The analysis of both shows that a suitable, very simple and inexpensive kit to label WBC with ^{99m}Tc has been developed by us.

Comparison in the efficacy of gallium and radiolabelled immunoglobulins in identifying infection in HIV positive patients

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This study was performed to determine if radiolabelled polyclonal human immunoglobulin (HIG) could replace gallium-67 citrate (^{67}Ga) in finding infection in human immunodeficiency virus (HIV) antibody positive patients presenting with fever of undetermined origin. In a retrospective investigation, 75 studies, performed on HIV positive patients with fever of undetermined origin, were

analysed, 25 using ^{67}Ga , 25 with $^{99\text{m}}\text{Tc}$ labelled HIG and 25 with ^{111}In labelled HIG. As multiple sites of infection are common in this patient group, each patient's study was analysed in three zones: intra-thoracic, intra-abdominal and peripheral tissues. A zone was scored positive if there was abnormal accumulation of the relevant tracer in that zone. ^{67}Ga identified 19/20 sites of infection that were confirmed clinically, $^{99\text{m}}\text{Tc}$ HIG confirmed 11/20 sites of infection and ^{111}In HIG confirmed 20/22 sites of infection. There were 17 false positive sites of ^{67}Ga accumulation, eight false positive sites of $^{99\text{m}}\text{Tc}$ HIG accumulation and four false positive sites of ^{111}In HIG accumulation. Therefore ^{111}In HIG has a similar sensitivity (91%) to ^{67}Ga (95%) and a better sensitivity than $^{99\text{m}}\text{Tc}$ HIG (55%) but a better specificity (92%) than either ^{67}Ga (69%) or $^{99\text{m}}\text{Tc}$ HIG (85%). Further work should now be done to determine if ^{111}In HIG is the agent of choice in these patients.

Correlation of X-ray and radioisotope examination in the diagnosis of bone and joint tuberculosis

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In a retrospective study of adult TB presenting to two hospitals, 26 of 580 cases had bone and joint disease. All patients were first generation immigrants, from the Indian subcontinent and Africa. Eight of these patients presented with progressive neurological signs resulting in early surgical intervention leading to the diagnosis of spinal TB. The remaining 18 patients had radioisotope bone scans. Three of these patients had normal bone scans; however, they all had radiological changes in keeping with TB and the diagnosis of spinal TB was subsequently made on bone biopsy. A further four patients with spinal TB had abnormal radioisotope bone scans. Nine patients with non-spinal TB involving bone or joints all had abnormal radioisotope bone scans. Four patients had multifocal disease, including one clinically unsuspected case. 25 of the 26 patients had radiological changes in keeping with the diagnosis of TB at presentation. The patient without radiological changes had an abnormal isotope bone scan. In all cases the diagnosis of TB had been confirmed by culture or histological examination. The findings of this study suggest that in the majority of cases of bone and joint TB the diagnosis may be suggested by radiological examination; however, radioisotope bone scans may be of help in the few cases of non-spinal TB where radiological examination fails to provide a diagnosis. Isotope scanning in spinal TB appears to be of less benefit compared to plain X-ray examination and may fail to reveal the focus of infection.

Radionuclide evaluation of nephroblastoma chemoembolization efficacy

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The purpose of this investigation is the evaluation of nephroblastoma chemoembolization (CE) efficacy using scintigraphy with $^{99\text{m}}\text{Tc}$ -pyrphotech. The mixture of radio-pharmaceutical drug (RPD) and chemoembolizate (adriamycin and myodil) penetrates renal arteries during selective angiography of nephroblastoma. The investigation includes dynamic scintigraphies during 1 h following 2 h and 24 h after CE. The use of scintigraphy enables evaluation of tumour drainage according to RPD levels in the projection of the tumour, bones and bladder. In the first group of patients high levels of RPD tumour incorporation on scintigrams (more expressed than in bones and bladder) and the character of activity-time curves (plateau) from the tumour zone of interest during two days of investigation points to a delay in significant drug amount in the tumour tissues and supports effective blocking of tumour vessels. In the second group of children, the decreasing character of the curves points to marked tumour drainage. Sometimes discrepancy of contrast medium distribution on angiograms and RPD distribution on scintigrams apparently testifies to some advantages of scintigraphy in the evaluation of CE efficacy compared to angiography. Immediate results of combined treatment with CE form the basis for using this scintigraphy in predicting the results of treatment and working out of indications for excluding pre-operative irradiation.

$^{99\text{m}}\text{Tc}$ -mercapto acetyl triglycine ($^{99\text{m}}\text{Tc}$ -MAG3) scans and renal scarring: are analog images necessary?

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44 $^{99\text{m}}\text{Tc}$ -MAG3 scans (87 kidneys) on patients with a mean age of 5 years 11 months were reviewed to assess renal scarring and the role of parametric images. The scans were performed for the investigation of urinary tract infections using an IGE mobile gamma camera attached to a Nuclear Diagnostics Gamma 11 processing system. In 27 kidneys there was comparison with $^{99\text{m}}\text{Tc}$ -dimercaptosuccinic acid (DMSA) scans and in all cases the $^{99\text{m}}\text{Tc}$ -DMSA and $^{99\text{m}}\text{Tc}$ -MAG3 camera "analog" images were in agreement. The $^{99\text{m}}\text{Tc}$ -MAG3 scan was assessed in 87 kidneys: the parametric images (uptake and uptake rates) overestimated the degree of scarring in comparison with the analog

Seminar Suite II

images with agreement in only 70% (uptake) and 78% (uptake rate). Comparison with ultrasound was also made; it was found to be less sensitive than ^{99m}Tc -MAG3 or ^{99m}Tc -DMSA scans with agreement with the analog ^{99m}Tc -MAG3 images in 84%. It has been suggested that ^{99m}Tc -MAG3 parametric images are superior to camera analog images

for assessment of renal scarring in children. Our results show that it is important to continue to produce ^{99m}Tc -MAG3 analog images as they are more accurate than parametric images alone for the assessment of renal scarring.

4.15 – 5.30

Teach-in: Radiation Protection

Argyll III

Training in radiation protection: what you need and how to get it

A P Hufton

North Western Medical Physics Department, Christie Hospital, Manchester M20 9BX, UK

It is the employer's legal responsibility to ensure that everyone who works with ionizing radiation is appropriately trained in radiation protection. For some employees such training will have been included in their basic professional training, whilst for others additional training will be required. This review concentrates on the latter group: in particular on the training of radiation protection supervisors, radiation protection advisers, and persons clinically or physically directing medical radiation exposures. Consideration is given to the detailed requirements of UK legislation, and to guidance from other sources. Training objectives and ways of achieving appropriate training are discussed, including matters such as the availability and suitability of training courses, subject matter covered, and any inadequacies in the present procedures. Finally, training in radiation protection and its formal recognition is considered in the wider context of professional qualifications and developments in Europe.

The implications of ICRP 60 for medical exposures

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The International Commission on Radiological Protection (ICRP) has given new guidance in Publication 60 on the fundamental principles for protection against ionizing radiation. These 1990 recommendations take account of the new biological information and trends in the setting of safety standards since the previous recommendations of Publication 26 in 1977. The National Radiological Protection Board provides formal advice on the acceptability and applicability of ICRP recommendations to the UK. This presentation considers the conceptual framework recommended by ICRP in relation to medical exposures, which are defined principally as exposures of persons as part of their own diagnosis or treatment, although this category

has now been extended to include exposures (other than occupational) incurred knowingly and willingly by individuals helping in the support and comfort of patients undergoing diagnosis or treatment. Aspects discussed include the requirements for the justification of practices involving exposure of patients and the optimization of protection within these practices. The introduction of dose constraints, which is a major new concept, will provide a powerful method for promoting the implementation of optimization. Consideration is also given to the suitability of the new weighted-dose quantity-effective dose for assessing detriment arising from medical exposures.

The national protocol for patient dose measurements in diagnostic radiology

A P Hufton

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Following on from the publication in 1990 of the report by the Royal College of Radiologists (RCR) and the National Radiological Protection Board (NRPB), *Patient Dose Reduction in Diagnostic Radiology*, the Institute of Physical Sciences in Medicine, in conjunction with the College of Radiographers and NRPB, prepared a protocol for the measurement of patient doses in diagnostic radiology, which was published by the NRPB in 1992. The measurement of patient doses is seen as an essential step in auditing the quality of diagnostic radiology services, and the protocol describes a nationally agreed method by which such information can be obtained. It discusses the need for dose measurements, appropriate dose quantities, and the choice of suitable dose measuring devices. Suggestions are made on the types of examinations to be monitored, how frequently measurements need to be carried out, and what patient sampling would be appropriate. Measurement techniques are outlined, along with dosimeter calibration procedures and accuracy requirements. The concept of reference doses is proposed, and appropriate values recommended. This review further considers the practical problems associated with the implementation of such a patient dose measurement programme.

Tuesday 18 May

9.00 – 10.15

Vascular Ultrasound

Argyll I

Colour duplex carotid sonography in the modern management of cerebrovascular disease

P Butler

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It is likely that the demand for duplex carotid sonography (DCS) will grow following recently published guidelines for the management of transient ischaemic attack and stroke. It should be provided to screen all patients who are at risk from stroke and who might benefit from carotid endarterectomy. As is appropriate for a screening test, the presence of a significant stenosis requiring angiography can be identified and conversely patients with minor disease need not be subjected to angiography unnecessarily. DCS is simple and safe for the patient but requires careful attention to detail on the part of the operator to avoid the pitfalls. The presentation will review DCS under the following headings: (a) the conduct of the examination ("How I do it"); (b) the B mode study—plaque morphology, stenosis assessment; (c) the Doppler study—normal and abnormal; (d) pitfalls for the unwary; (e) the contribution of colour. The lecture will be illustrated by both video recordings and transparencies.

Reference

BROWN, M M & HUMPHREY, P R D, 1992. Carotid endarterectomy: recommendations for management of transient ischaemic attack and stroke (Association of British Neurologists). *Br. Med. J.*, 305, 1071-1074

Correlation of findings on duplex Doppler carotid artery imaging with lipoprotein (a) levels in patients with familial hypercholesterolaemia

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Patients with heterozygous familial hypercholesterolaemia carry a markedly increased risk of coronary artery disease but the susceptibility varies dramatically between families and is linked to lipoprotein (a) (Lp(a)). A comparative study of the carotid arteries in patients with familial hypercholesterolaemia relating the levels of circulating plasma Lp(a) to the extent of atheromatous disease was conducted. A total of 30 patients who were asymptomatic for carotid artery disease were investigated and divided into Group A (17 patients), mean Lp(a) level of 12.8 mg dl⁻¹; and Group B (13 patients), mean level of 72.4 mg dl⁻¹. The groups were matched for age, sex, blood pressure, smoking, serum cholesterol and triglycerides. Duplex scanning of the carotid arteries was carried out using a 5MHz probe on an Acuson 128. Assessment was made of plaque distribution and morphology, intimal thickening, ratio of the peak systolic velocity and minimal diameter of the common carotid artery. Results show that all patients in Group B and eight of the patients in Group A had carotid artery disease. Both groups had normal (less than 60%) peak systolic velocity ratios, whereas Group B had a smaller common carotid artery lumen diameter, a greater number

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of hypoechoic plaques and more extensive intimal thickening. We conclude that there is a trend towards greater extent of disease in the high Lp(a) group, that the use of duplex Doppler scanning is a reliable non-invasive method of screening these patients, and that the carotid artery findings may be used as a marker of coronary artery disease.

The incidence of ultrasonographically detected significant stenosis in the mesenteric vasculature in the asymptomatic population

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It has been recognized that patients may have significant disease (occlusion or stenoses greater than 70%) of both the coeliac axis (CA) and the superior mesenteric artery (SMA) on angiography and be asymptomatic. The incidence of asymptomatic disease in the population is, however, unknown. We therefore undertook to investigate the incidence as detected by duplex Doppler ultrasound (DDU). Using duplex ultrasound criteria obtained from previous angiographic-DDU correlation studies, we assessed the incidence of significant disease in both the CA and SMA in patients presenting for ultrasound. Patients were examined using a 3.5 MHz sector scanner (Acuson 128) and then angle-corrected gated DDU signals obtained at the level of stenoses, or the vessel origin if no stenosis was seen. 140 patients were studied in total, age range 4-92. Below the age of 65 significant disease was rare (1%) and isolated to one vessel only. Above 65 the incidence of isolated disease to one vessel was 9% and to both vessels was 10%. The incidence was similar in patients of 65-75 and those above 75. Single vessel disease was more common in the coeliac axis than the SMA (81% vs. 19% respectively).

Duplex Doppler measurements of the portal vein in portal hypertension

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The validity of duplex Doppler ultrasound quantitation of portal venous blood flow has been questioned because of

the numerous potential sources of measurement variability. Many of these sources can be excluded by carefully controlled studies on the same machine; however, observer variability persists. In order to be applicable the variation between observers and for the same observer on different occasions must be acceptably small. Few such studies have been undertaken on patients with known liver disease. In this study 10 patients with known portal hypertension owing to diffuse liver disease were examined on several different occasions by two independent observers, using a consistent technique, and the inter- and intraobserver variability calculated. The results demonstrated significant ($p < 0.01$ or better) correlations for most intraobserver measurements and all the interobserver measurements. These results indicate that for a group of patients with known diffuse liver disease, duplex Doppler ultrasound is a valid method for serial assessment of portal vein blood flow.

Portal vein thrombosis: is invasive imaging necessary?

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Portal vein thrombosis (PVT) is an uncommon finding but can be readily diagnosed non-invasively using real-time ultrasound, combined with duplex Doppler and Colour Doppler Imaging (CDI). We investigated nine patients with a diagnosis of PVT due to a variety of aetiologies, using an Acuson 128 with colour Doppler facility. We discuss the role of CDI as the new "gold standard" in the diagnosis of PVT and its use in the further management of these patients. The underlying aetiology was correctly determined by CDI in all patients, together with ultrasound-guided biopsy confirmation in three patients with suspected malignancy. CT and MRI did not add further useful information to that already obtained. CDI confidently diagnosed PVT in all nine patients. This technique gave accurate information regarding the aetiology of PVT, complications and staging of suspected malignancy, as well as a guide to optimal management. Portal venography was not used to diagnose PVT and we believe further costly imaging adds little information.

The use of Doppler ultrasound in the diagnosis of Budd-Chiari syndrome

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We wished to evaluate which of the many described ultrasound features of Budd-Chiari syndrome (BCS) are most reliable in confirming the diagnosis. The duplex Doppler ultrasound findings, in eight patients with BCS were compared with scans performed on 153 consecutive patients with chronic liver disease (CLD) undergoing assessment for liver transplantation. In 10 of the patients with CLD no hepatic veins could be visualized, whereas one or more veins were identified in all of the patients with BCS. In five (62%) of the BCS and 18 (11%) of the CLD patients, one of the hepatic veins could not be visualized. A damped hepatic vein flow pattern was demonstrated in four (50%) of the BCS and 116 (76%) of CLD patients. An absence of signal when insonating an identifiable hepatic vein (62%) and the presence of collateral venous channels (25%) were only seen in patients with BCS. Splenomegaly and ascites occurred frequently in both groups. Absence of flow in an hepatic vein or the presence of collateral channels are reliable signs of BCS but were demonstrated in only 75% of the patients in this series. Many of the other described features of BCS are non-specific, being seen in many patients with CLD of other aetiology.

Colour flow ultrasound: first line imaging in calf vein thrombosis

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Colour flow imaging has been successfully used in the diagnosis of lower limb venous occlusive disease. The technique has shown promise in the diagnosis of calf vein thrombosis; however, there has been no prospective trial to date specifically to evaluate its potential. We therefore compared the accuracy of colour Doppler ultrasound with venography in the diagnosis of thrombosis both above and below the knee but particularly with respect to calf vein clot. Of the 50 patients comparison was only possible in 40 as there were eight venographic and two ultrasonic failures. As in previous studies, colour flow imaging was extremely

accurate above the knee with both sensitivity and specificity of 100%. There was one false negative scan within the calf vein group giving a sensitivity of 95%, specificity of 100% and accuracy of 97.5%. In view of the above results we feel that colour flow imaging should be the first-line imaging modality in cases of suspected deep venous thrombosis both above and below knee, and that venography should be reserved for patients who are unsuitable for ultrasound or who have an equivocal ultrasonic scan.

A sonographic study of the incidence of proximal deep vein thrombosis in acute geriatric medical admissions

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The incidence of deep vein thrombosis is known to be high (30–80%) following fractured neck of femur or stroke. There is little data however on the incidence of occult deep vein thrombosis in the non-surgical group of elderly medical patients admitted acutely to hospital with medical conditions, e.g. heart failure, chest infections, etc. We present the early results of a prospective screening study to look at the incidence of proximal deep venous thrombosis in acute geriatric medical admissions to St Thomas's Hospital. All patients over 70 years with no history of recent fractures or strokes and who were able to give informed consent were included in the study. Compression colour Doppler scanning was performed on both lower limbs in all patients between one and two weeks after admission. The presence or absence of thrombus in the iliac, femoral or popliteal segment was recorded. The preliminary results in the first 50 screened patients are presented. 24 male and 26 female patients, age range 72 to 98 years (mean 81.8 years) were scanned. The time of the scan post-admission ranged from 4 to 26 days with a mean of 10.5 days. 47 patients out of the 50 (94%) had a normal proximal venous system with no thrombi seen. One scan showed old post-phlebotic change; one was positive with thrombus in the superficial femoral vein; and in one patient the test was equivocal, the patient being very obese. The only positive case in this series was in a patient who had had an operation two months previously. In six patients out of the 50 (12%) the following incidental findings were noted: left knee effusion (1), Baker's cyst (1), femoral artery

aneurysm (1), a small abdominal aortic aneurysm with a left common iliac aneurysm (1) and dilated superficial veins (2). The preliminary results suggest that the incidence of occult proximal venous thrombosis in medical patients with no known risk factors may be lower than previously described.

Investigation of DVT—an audit of changing practice and outcome analysis of colour Doppler imaging

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Colour Doppler Imaging (CDI) is recognized as an accurate technique in the diagnosis of suspected lower limb deep venous thrombosis (DVT). As a result our department has changed its policy and CDI is now the first line investigation rather than contrast venography. We reviewed the results obtained during the first eight months after the introduction of this policy. 183 CDI scans were performed during this period; all scans were performed by one of two experienced operators. The distribution of thromboses and proportion of positive studies was similar to published venographic series. Venography was performed in 15 cases and the results concurred with ultrasound in 14. In one case an isolated posterior tibial vein thrombosis was missed on ultrasound. The effectiveness of this policy was assessed by outcome analysis from review of both hospital and general practitioner's notes. The results will be discussed. As a result CDI is now firmly established as the first line investigation for lower limb DVT in our institution. Venography is reserved for patients with equi-

vocal scans or in whom the scan is negative but there is a strong clinical suspicion for DVT.

Imaging deep venous thrombosis: venography or colour Doppler ultrasound? Changing trends and resource management implications

J G Houston, A L Mclellan, E Partridge and G M Baxter

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With increasing movement to clinical directorates and hospital trusts, the assessment of trends in imaging service demands and the imaging modality used is vital if adequate resource planning is to be effective. The use of colour Doppler ultrasound as an alternative to conventional peripheral venography to image deep venous thrombosis (DVT) is one such example. We undertook a survey of trends in DVT imaging (Doppler or venography), both in teaching hospitals and district general hospitals in Scotland, over the period 1987–1991. There was an overall increase in requests by 80% over the five year period, with a similar prevalence of positive results (ranging from 10 to 58%) for each year. In 1991, 33% of the total number of investigations were carried out with ultrasound (one centre used ultrasound in 80%). The cost of an ultrasound examination ranged from £82 less than venography to the same cost for either examination (average £20 less than venography). The increasing use of Doppler ultrasound as an alternative to venography in the imaging of DVT and the large increase in requests imply a need for increased resources for ultrasound both in terms of capital investment and radiologist training, but result in reduced patient dose and cost.

9.00 – 10.15

Teach-in: Dental Radiology

Argyll II

Dental radiology—an overview

L M Brocklebank

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The teeth and their immediate supporting structures form a unique microcosm within the human body. The specialized dental tissues result in disorders peculiar to teeth, particularly well demonstrated by the inflammatory conditions of caries and periodontal disease, and a variety of interesting developmental anomalies. The supporting bone is subject to a variety of pathology of odontogenic and non-odontogenic origin, which may affect the teeth themselves. An illustrated classification of "dental radiology" will be presented.

Radiation protection in dental radiology

K Horner

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Dental radiography represents the most frequent diagnostic radiological investigation in the industrialized world, with over 16 million examinations performed annually in England and Wales alone. Although individual doses are low in dental radiography, the collective dose is not inconsiderable and many examinations are performed in younger age groups. Dental radiography includes intraoral, panoramic and cephalometric radiography. In intraoral radiography the use of fast (E-speed) film and rectangular collimation offer dose reductions of approximately 50% and 60% respectively. Constant potential X-ray units, longer focus-to-skin distances and rare-earth filtration permit further reductions. In panoramic and cephalometric radiography, improved collimation offers a simple means of dose limitation, while doses can be reduced by up to one eighth by combining the use of constant potential X-ray units, rare-earth intensifying screens and rare-earth filtra-

tion. Lead protection of the abdomen has little relevance to dental radiation protection; however, thyroid shielding is a simple and effective protective measure. Concern has been expressed about the poor diagnostic quality of radiographs taken in general dental practice. Consequently a quality assurance programme plays an essential part in dental radiation protection by improving diagnostic yield and limiting repeat examinations.

Radiolucent lesions of the jaws

J McIvor

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Radiolucent lesions of the jaws differ pathologically from radiolucent lesions occurring in other bones as they are usually of dental origin. The commonest radiolucent lesions, the dental abscess and the apical granuloma, are rarely seen by general radiologists and are usually diagnosed and treated by dental surgeons. *Benign cysts* of dental origin are usually unilocular and are the commonest radiolucent lesions seen in hospital practice. The commonest of these is the simple dental cyst. *Dentigerous cysts* and other cysts, such as the odontogenic keratocyst and the incisive canal cyst, are rarer. *Benign tumours* are less common than cysts. They are often multilocular and are more likely to resorb the roots of adjacent teeth than simple cysts. The commonest benign tumours are osteoclastoma and giant cell granuloma. The *ameloblastoma* is usually multilocular and is difficult to classify as its behaviour ranges from benign to locally malignant. *Malignant tumours* of the jaws are very rare. Osteogenic sarcoma occurs in young adults and carcinoma in the middle-aged and elderly. Metastatic deposits can occur but are extremely rare. The principal aim of radiology is to define the extent of the lesion so that surgical excision can be planned. CT may be helpful in large lesions. A comprehensive list of differential diagnoses will be available at the time of the teach-in.

9.00 – 10.15

MR Technology I

Argyll III

Assessment of cardiomyopathies with tagged cine MRI

J P Ridgway, U M Sivananthan, A Cuburku, S P Verma, K Bann, J Cullingworth and M R Rees
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The introduction of tagged cine MRI allows accurate assessment of regional wall motion and has particular potential in the assessment of patients with cardiomyopathies. We have used tagged cine MRI in combination with routine SE and GE imaging to assess cardiac anatomy and function in 15 patients (10M, 5F). The two groups of patients consisted of 10 with hypertrophic obstructive cardiomyopathy (HOCM), and five with clinical diagnosis of dilated cardiomyopathy (DCM). Images were obtained on a 1.0 Tesla Siemens Magnetom system. Tagged images were acquired using FISP sequence (TR 50 ms; TE 9 ms; flip angle 35°) with two 1:3:3:1 binomial pulses to obtain an orthogonal grid pattern with 9 mm line spacing. In all cases the tagged imaging sequences improved the qualitative demonstration and quantitative analysis of regional wall motion compared with conventional cine imaging. Quantitative analysis of the images allowed accurate evaluation of abnormal segments, especially in HOCM. Subaortic region and upper septal motion were clearly assessed, providing insight into the pathophysiology of HOCM. In DCM the extent of the chamber dilatations and segmental wall contractions could be accurately assessed. MRI tagging provides valuable additional information in cases of HOCM and DCM.

Fat/water suppression in pulsed saturation transfer experiments on a 0.5 Tesla MRI system

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Magnetization transfer (MT) can enhance contrast in MR images. Pulsed saturation transfer (ST) methods have the

advantage of high RF dose efficiency. In this study, magnetization transfer contrast (MTC) imaging sequences using a binomial (121) pulse for presaturation have been implemented in a 0.5 Tesla GE Vectra MR scanner. It has been demonstrated that the 121 pulse can effectively saturate fat or water while producing MTC. A computer simulation of the Bloch equation was used for optimization of pulse parameters and prediction of the appropriate selective chemical shift effect. Images of the abdomen, neck and lower limbs from healthy volunteers have been obtained. The on-resonance 121 pulse generates effective fat suppression with low RF amplitude but requires a long irradiation time ($t_{off} = 14$ ms), which approaches the τ time used in traditional binomial $(1-\tau-2-\tau-1)$ sequences. The presaturation time can be significantly shortened by applying the 121 sequence with resonance offsets. A 4 ms duration 121 pulse applied at the local maxima adjacent to the first to third spectral zero crossings of $M_z(\theta, \nu_{off})$ of free water has been shown to produce adequate fat suppression on both phase contrast angiographic and FAST images without prolongation of the minimum TR of the unmodified sequences. The 121 pulses can also suppress motion artefacts from rapid blood flow. Simultaneous suppression of fat and tissues with active magnetization transfer is possible using off-resonance binomial pulses.

The role of digital subtraction in MRI of the post-operative lumbar spine

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10–15% of patients who undergo surgery for lumbar disc disease will re-present with the failed surgical back syndrome. Gadolinium-enhanced Magnetic Resonance Imaging (MRI) is the method of choice in the differentiation of recurrent disc herniation and epidural fibrosis on the basis of contrast enhancement and morphology. MR subtraction techniques have not previously been described in the post-operative lumbar spine. This study was undertaken to evaluate its routine use in the assessment of 100

consecutive patients with the failed surgical back syndrome. Images post-subtraction reveal enhancement in areas where it would otherwise not be obvious. Fat within the spinal canal commonly failed to subtract, suggesting fibrous infiltration or inflammation. The operative track and degree of associated fibrosis are easier to define, and appear more extensive on subtracted images. Schmorl's nodes and muscle fascial layers strongly enhance. The superior contrast resolution of the subtracted image for enhancement was rarely necessary to distinguish epidural fibrosis from recurrent disc protrusion. However minor degrees of peridiscal enhancement normally not appreciated may be misinterpreted as scar tissue if viewed in isolation. Digital subtraction available on Siemens Magnetom 63 scanner is easy to perform, and although revealing some information not available on standard imaging protocols is rarely of use in routine clinical practice.

Early experience of oral gadolinium for MR imaging of the duodenum

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We studied the efficacy of oral gadolinium in improving duodenal delineation and in demonstrating duodenal infiltration by tumour. 27 patients (20 men and seven women, mean age 60 years) were examined. There were 14 pancreatic masses, five ampullary and four bile duct tumours, two liver lesions, one duodenal carcinoma and one patient with retroperitoneal nodes. All patients were imaged on a 1 Tesla scanner using T_1 weighted spin-echo sequences. 10 ml kg^{-1} of oral gadolinium (Magnevist, Schering) was given and patients were immediately rescanned. Four patients were unable to tolerate the whole dose. Intravenous Buscopan was administered after the oral contrast in the last 16 patients of the series. Contrast was present in the duodenum in 24/27 patients. Duodenal delineation was assessed as good or satisfactory in 21 patients. Images were partially degraded by contrast-induced artefact in eight cases but this was reduced by Buscopan. Although the delineation of all five ampullary masses was improved by the oral contrast, in no case was diffuse tumour infiltration of the duodenum identified. No unwanted effects were reported. We conclude that although oral gadolinium improves duodenal delineation in the majority of patients it does not increase the rate of diagnosis of duodenal tumours/infiltration as compared with unenhanced scans. Buscopan is useful for reducing contrast-induced artefact.

Novel polymeric MR contrast agents for unequivocal discrimination of the GI tract

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With the development of rapid MR imaging techniques, there is considerable demand for a gastrointestinal (GI) contrast agent for MR studies of the abdomen. Polymeric fluorinated contrast agents have been evaluated *in vivo* using a 1.5T clinical system utilizing a standard Helmholtz coil and a range of standard SE and GE imaging techniques. Fluorine images of the polymer in anaesthetised CBH/Cbi rats were viewed directly or superimposed on proton images of normal anatomy. The physical properties of the silicon-based polymers could be readily modulated by mixing compounds of differing viscosity. The agents are chemically similar to common food additives and appear not to be absorbed through the gut wall. Imaging demonstrated excellent delineation of the GI tract and sectional or maximum intensity projection images can be generated. Only the fluorinated compound, which exhibits a single resonance, was evident in the fluorine images. Spectroscopic studies showed the material to be rapidly eliminated. The relaxation properties of the material can be readily modified and lend themselves to fast imaging techniques. The unequivocal identification of signal as being within the GI tract is a major advantage compared with existing approaches.

Gd-BOPTA in Magnetic Resonance Imaging of ischaemic myocardium

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Gd-BOPTA shows a higher and more persistent enhancement of the myocardium than that observed with Gd-DTPA. Tissue concentration data have shown no preferential distribution of Gd-BOPTA to the myocardium, suggesting that the enhancement of cardiac tissue by Gd-BOPTA is due to alteration of relaxivity. We have investigated the use of Gd-BOPTA to detect areas of ischaemic myocardium following infarction. 20 patients aged between 44 and 64 had MRI performed between five and seven days following their first myocardial infarct. Five patients received 0.05 mmol kg^{-1} , five received 0.1 mmol kg^{-1} and 10 received 0.2 mmol kg^{-1} . Three short axis views of the left ventricle were acquired using T_1 and T_2 weighted sequences prior to contrast administration. T_1 images were acquired 0, 15, 30, 45 and 60 min following intravenous Gd-BOPTA. The smaller doses of contrast medium did not provide

adequate delineation between normal and ischaemic myocardium. Of the 10 patients receiving the 0.2 mmol kg^{-1} dose, three had technically inadequate scans. In the remaining seven patients there was enhancement of ischaemic regions of the myocardium. There was good correlation between myocardial enhancement and the area of infarction shown by the ECG. These findings suggest that there is a difference in the relaxivity of the normal and ischaemic cardiac tissue when Gd-BOPTA is present and opens up new possibilities for imaging ischaemic myocardium.

Magnetic Resonance guided frameless stereotaxy for planning and carrying out epilepsy surgery

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In many cases of epilepsy, no structural abnormality is demonstrable. The neurosurgeon needs a mechanism of directing surgery in a manner that is simpler, more precise and more interactive than conventional stereotaxy. The ISG viewing wand is the first interactive system of this kind and has had a radical influence on epilepsy surgery in Bristol. Using volume acquisition MR scans of the patient's temporal lobes, the viewing wand can be used in a number of ways to facilitate epilepsy surgery: 1. directing the placement of deep brain electrodes; 2. transgyral selective amygdalohippocampectomy becomes a minimally invasive procedure; 3. the amalgamation of anatomical and electrophysiological data is enhanced, particularly in the awake craniotomy; 4. accurate definition of the event of a callosotomy is easily seen on sagittal reconstructions; 5. minimally invasive surgery of epileptogenic structures is greatly enhanced. Apart from deep brain stimulation, the ISG viewing wand has now become essential for epilepsy surgery and has replaced conventional stereotaxy.

3D threshold segmentation of MRI brain images gives superior grey/white matter separation

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Literature reports exist of 2D threshold segmentation of MRI brain images. Each tissue is assumed to be represented by a range of image intensities. In this method

intensities of proton density (PD) and T_2 weighted images are plotted as a 2D histogram. Thresholds from each axis form a box within which the target tissue lies clustered. The most serious problem with this technique is partial voluming (pv) which causes the clusters to overlap. Using a sequence consisting of an inversion pulse followed by two spin echoes (SE 3000/23 and 85/145) on a Siemens IT SP42E imager gives T_1 and combined T_1/T_2 weighted images. PD was collected separately. A program has been written to display the resulting three histograms, viz. T_1 versus T_1/T_2 , T_1 versus PD and PD versus T_1/T_2 . Thresholds placed on any two histograms define a cube enclosing the cluster. Grey and white matter clusters are much better separated in the T_1 versus T_1/T_2 and T_1 versus PD plots than in the PD versus T_1/T_2 display. CSF still suffers from pv and appears as a streak along the side of the clusters. Only "pure CSF" voxels from the centre of the ventricles form a discrete cluster.

Identification of intracranial tumours by localized proton MR spectroscopy

M Lowry, D Manton, D Buckley, S Blackband, R Kerslake and A Horsman

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We set out to identify the parameters necessary for proton magnetic resonance spectroscopy (MRS) to discriminate between normal and tumorous tissue. We examined an 8 cm^3 voxel in white matter of 20 volunteers (NV) and in histologically identified lesions of 11 patients using STEAM at several echo times. Peak areas obtained by frequency domain fitting were normalized to the choline or water peak. Of 11 lesions studied, seven were meningiomas (M) and four high-grade gliomas (G). When compared to NV, both M and G showed NAA/choline and creatine/choline ratios indistinguishable from localization errors determined in phantom studies. Normalization to water showed almost no NAA or creatine in either M and G whilst choline increased in M with no change in G. M and G could be further identified by the presence of alanine in M but not in G. All G and 3/7 M also contained lactate. Spectra of M at $TE = 30 \text{ ms}$ contained lipid peaks not present in G or at longer TE. We conclude that MRS is able to discriminate between normal and tumorous tissue by a combination of differences, in particular choline and alanine. These differences are most apparent when expressed quantitatively. Some of these differences are only visible at short TE, suggesting that lesions should be examined at multiple TEs for optimum discrimination.

9.00 – 12.00

Workshop: Radiology in the Trust Hospital; 2 Years Before the Mast

Seminar Suite I

The speakers have all been involved in Liverpool Hospitals which attained Trust status in the first wave, April 1991.

Dr A T Carty, *Consultant Radiologist and Medical Director, Royal Liverpool Hospital*: **Job Plans**. Will address issues related to job plans and workload. Problems of altering casemix and skill mix. Extended working hours.

Mr M F Stamp, *Chief Executive, Royal Liverpool Hospital*: **Contracting for change**. How to use the annual purchaser/provider contract review to change the clinical profile of a hospital and reduced fixed overhead costs. How contracts can be used to improve the service to patients and make room for the developments involving new technology.

Mrs C E Fiddies, *Radiology Service Manager/Superintendent Radiographer, Alder Hey Children's Hospital*: **Faster, Cried the Red Queen**. Highlights the change in the traditional role of Superintendent Radiographer to Service Manager. Management training helps but does not prepare fully for the accelerating pace of change. Relationships with Clinical Director. **Business plans**. Equipment procurement. In-house decisions. Outward answerability.

Dr D W Pilling, *Director of Clinical Imaging, Liverpool Maternity Hospital Fetal Centre*: **The Rhetoric and the Reality**. An objective review of how the reality of change has measured up to the politicians' promise. Frustrations and opportunities in planning imaging services for a new integrated Women's Services Hospital.

TUESDAY

9.00 – 10.15

Teach in: Adjuvant Treatment of Bowel Cancer

Seminar Suite II

The last decade has seen a resurgence of interest in the role of adjuvant chemotherapy for Dukes B and C colorectal cancer. Controversy still exists as to how efficacious such therapy is and what is seen as standard optimal therapy in North America is still viewed with scepticism by some in the UK. The logistics of routinely treating the huge number of patients with this disease are daunting and many feel

further trials are necessary before adjuvant chemotherapy is accepted as routine. Controversy also exists regarding the optimal agents, timing of therapy and overall duration. These issues will be reviewed and discussed by three clinicians from different specialties who have a particular expertise in the management of this disease.

TUESDAY

10.45 – 12.00

CT Comes of Age I

Argyll I

Computed tomography comes of age

S Golding

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Twenty one years ago, in a session at the 1972 Congress modestly entitled "New Techniques for Diagnostic Radiology", James Ambrose and Godfrey Hounsfield presented their paper *Computerised Transverse Axial Tomography*. No-one in the audience that day can have been in any doubt that a dramatic development in imaging had taken place. The presentation, supported by a press conference, and repeated with acclaim at that year's meeting of the Radiological Society of North America, was the result of several years' intense — and to a certain extent undercover — research and collaboration between industry, medicine and the Department of Health and Social Security. During work on computing and pattern recognition Hounsfield, working at the Central Research Laboratories of EMI, had conceived a system which would overcome the drawbacks of conventional transmission radiography. A patent was taken out in 1968. The DHSS provided funding for the development of a clinical system and clinical evaluation was carried out at Atkinson Morley's Hospital, the results of which formed part of that first presentation in 1972. In the meantime the DHSS had had sufficient confidence in the success of the prototype to support the construction of the first production models. The introduction of CT was a watershed in imaging. It was immediately obvious that the technique was capable of a powerful effect on clinical management. Neuroradiology was transformed by the first wave of system purchases, and invasive and sometimes dangerous procedures were replaced in large numbers. Further technical development brought the first body images in 1975 and the impact of CT on the management of malignant and musculoskeletal disease in particular became clear. The success of the technique made high technology and high expense imaging thinkable and acceptable; emission computer assisted tomography and magnetic resonance imaging followed rapidly. This symposium is not an attempt to tell the story of CT or to pay tribute to the many

involved in its development. Rather it is a celebration of the events of 1972 and what has happened since. The growth of CT from idea to mature clinical product was the result of enlightened research collaboration between interested parties in widely differing fields; such multidisciplinary interaction is the *raison d'être* of the Institute and it is wholly appropriate that CT had its first clinical presentation at an Annual Congress, and that we should be celebrating this today.

The history of CT pre-1972

S Webb

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At the 1972 BIR Congress the news of the development of the world's first commercially-produced CT scanner was announced. It was a revolution in radiology and came about from a unique collaboration between the EMI Company, Atkinson Morley's Hospital and the DHSS. The name of Sir Godfrey Hounsfield will always be associated with the invention. Whilst Hounsfield and EMI undisputedly brought the CT scanner to fruition, it is well known that there were several historically-antecedent experiments which achieved CT in limited settings. An adaptation of one of Kuhl's radioisotope section imagers made an *in-vivo* transmission X-ray CT image in 1965. Reputedly a medical CT scanner was built in Kiev in 1958. The mathematical principle of reconstruction from projections was published in 1917. Gabriel Frank patented the fundamentals of the experimental technique in 1940. Cormack's laboratory experiments in 1956 were recognized in his sharing the 1979 Nobel Prize for Physiology and Medicine with Hounsfield. Takahashi was also very close to achieving CT in the late 1940s. Oldendorf also patented the basis of the technique in 1963. There were also numerous individual contributions to reconstruction theory and experiment in the 1970s. As with much in science, the curious wisdom of hindsight allows us to identify these events with the development of CT.

TUESDAY

However it must be stressed that none of these led to the ability to routinely achieve section imaging in a hospital setting, the accolade of the 1972-announced machine. Nor did they constitute a coordinated programme of research leading to the EMI scanner. But these developments illustrate the truth of Newton's remark that to see furthest one must stand on the shoulders of giants.

Reference

WEBB, S, 1990. From *The Watching of Shadows: The Origins of Radiological Tomography* (Adam Hilger, Bristol).

Review of imaging performance and dose measurements made on CT scanners since the mid-seventies

S Edyvean

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This paper presents a review of dose and imaging performance data collected from CT scanners since the mid-seventies by the CT evaluation group funded by the Department of Health and now called ImPACT. More than 36 different scanner models have been evaluated, starting with the early EMI scanners and continuing to include most of the scanners which are on the UK market today. For the majority of scanner assessments the measurement techniques and test objects have remained unchanged, giving rise to data that is easily intercomparable, unlike the data supplied by the manufacturers, which is often measured using different techniques and different size phantoms. The basic measurements made by ImPACT consist of noise, high contrast spatial resolution, slice thickness and surface dosimetry. Scan parameters for typical clinical examinations are employed. The measurements are presented in comparison form, and attention is drawn to improvements and compromises that have occurred in the dose and imaging performance of CT scanners over the 21 years of development and design.

Assessment of QCT — Hounsfield Unit/detail diagram

S D Tabakov

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Quantitative Computed Tomography (QCT) is often underestimated because of imprecise density measurements.

These are most often due to contour spread and noise in the image. Therefore it is necessary to estimate the ability of a CT scanner to perform precise density measurements. For the purpose the density-profile method and an original test object were used. 1–10 mm objects were investigated in a wide density interval. Account was taken of the smallest object and corresponding CT density numbers—in Hounsfield Units (HU)—for which the density measurement remains precise. From the results obtained, a diagram of Hounsfield Unit/detail size was built which can be used for QT assessment. Other experiments were made to determine the minimum dimension of ROI at which density measurement keeps precise. It was found that at ROI bigger than 40 mm² density measurements are repetitive and precise independently of the pixel size. The HU/detail diagram differs from the usual contrast/detail diagram. The latter determines the visual limits of a CT scanner (although the contrast is measured in HU) while the HU/detail diagram determines the lower limits of precise density measurements of the investigated CT apparatus.

The role of the scientific and technical branch in the development of CT

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Since soon after the formation of the National Health Service, the Department of Health (as it is now designated) has used a small proportion of its funds to support the development of new or improved medical devices. Many new devices have been produced as a result of support from these funds. Several of the most noteworthy have been in medical imaging and there can be no doubt that the most outstanding is the CT scanner. The revolutionary idea of Godfrey Hounsfield was first put to the Department in 1968. A partnership between the Department of Health and the EMI Company ensued in which the financial risk was shared and the ingenuity of Hounsfield was complemented by the medical and technical experience provided by the Department. The cautious progression through laboratory and animal trials to a clinical prototype was accomplished in only two and a half years, and a few months later the exciting capabilities of CT were described at the 1972 BIR Congress. This joint industry/Government development programme can now be seen as a model of its kind.

10.45 – 12.00

The Chest II

Argyll II

Cystic and cyst-like lesions in the newborn chest

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The purpose of this review lecture is to discuss the several causes of respiratory distress in the newborn which present radiographically as cystic or cyst-like lesions in the newborn chest. The only true cystic lesion in the newborn is cystic adenomatoid malformation, a rare hamartomatous abnormality. The remaining conditions which have a radiographic cystic appearance, but are not true cysts, represent a heterogeneous group of either developmental anomalies or acquired conditions. These include congenital lobar emphysema, congenital diaphragmatic hernia, and pseudo-cysts of the lungs as a sequela of pulmonary interstitial emphysema in hyaline membrane disease. Most of the cystic or cyst-like lesions of the lung present either at birth or within the first week of life. Correlation of pertinent clinical findings with their radiographic features will be emphasized.

Pulmonary manifestations in the immunosuppressed child

N D P Marchbank, R Given-Wilson, R A Morgan and
'M Sharland

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UK*

We present a retrospective study of the pulmonary diseases encountered in 10 immunosuppressed children. The cause of the immunosuppression in nine children was infection with HIV, whilst Common Variable Immune Deficiency accounted for the tenth case. We review the chest X rays of these children during the course of their illness. Our series includes five cases of *Pneumocystis carinii* pneumonia, three of lymphocytic interstitial pneumonitis, two episodes of pneumonia due to *Streptococcus pneumoniae*, one case of miliary tuberculosis, one episode of respiratory syncytial virus pneumonia and one case of bronchiectasis. We describe the typical radiological patterns of these disease processes and show some of the variations in radiological signs that

are encountered. We also highlight the differences in the range and frequency of pulmonary disease in the immunosuppressed child compared with the immunosuppressed adult. We discuss the role of radiology in the diagnosis and management of pulmonary complications in the immunosuppressed child with particular reference to AIDS.

An audit on the use of portable chest X ray in the general wards

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This two-part study aims to audit the use of portable chest radiography in general wards and to set guidelines in our hospital. In the first part doctors were asked confidentially to give reasons for their requests. The second part involved radiographers answering specific questions regarding the patient's condition. This information was reviewed by the auditing radiologists together with details on the request card to decide whether the requests were appropriate. 50% of ward chest radiographs were performed on the general wards, the Geriatric Unit having the highest usage, followed by Nephrology/Transplant wards and Medical Admissions Unit. Most of the requests for the latter were done "on call". All doctors gave the patient's poor condition as the reason for the request rather than lack of nurse escorts or speed with which a portable could be obtained. 17% of requests were inappropriate as the patients could have attended the Radiology Department. We conclude that portable chest radiography in our general wards is in the main appropriately used.

Chest radiography following cardiac surgery — pathological or "normal" changes?

D A Collie and J H Reid

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Changes on the chest radiograph following cardiac surgery are manifold. Mediastinal and pericardial haematomas,

pleural effusions and lobar collapse are commonly encountered, their frequency varying with the nature of the surgery performed. Valve struts, clips, markers, grafts and wires abound — yet there is little in the radiological literature to help the radiologist correctly differentiate “normal” changes from pathology. We have reviewed the post-operative chest radiographs of patients undergoing thoracotomy in a large cardiac surgical centre (Royal Infirmary, Edinburgh) over a 2 year period. The most frequently encountered post-surgical radiological changes in uncomplicated cases are presented. Guidelines for determining the development of significant pathology and its early detection are discussed. Particular reference is made to iatrogenic Type A aortic dissection, pericardial collections, sternotomy complications and differentiation of surgical hardware from retained surgical packs.

Audit of chest radiographs following coronary artery bypass grafting

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Following routine coronary artery bypass grafting (CABG) at this hospital, chest radiographs (CXR) are taken at specific times irrespective of clinical indications. It is usual practice for CXR to be taken on return from operating theatre to the ward, following removal of the endotracheal tube, when the pericardial and pleural drains are removed and again at some time before discharge. A further CXR is routinely taken at the first attendance at the Out-Patients Clinic; additional CXRs are taken if clinically indicated. We have reviewed postoperative CXRs and correlated these with contemporary clinical notes on 100 consecutive patients undergoing CABG, to determine the average number of CXRs performed and how often the routine CXR altered clinical management. The average number of post-operative CXRs before discharge was 5.5 (range 2–11). Routine CXR appeared to alter management in only four cases (two pleural effusions drained, one increase in Inotropic support, one antibiotic therapy). In no case was it obvious that clinical outcome had been altered. We have found no evidence that the practice of taking repeated CXRs following CABG alters clinical outcome. The requirement for CXR should be based on the clinical situation rather than following routine post-operative procedures.

Is routine chest radiography necessary for day case coronary angiography?

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The routine chest radiographs of a random sample of 102 of the 1200 annual patients who underwent day-case coronary angiography were reviewed independently by two observers. There was good observer concordance, and the number of patients with significant abnormalities, agreed after discussion on the discrepancies, was 26. In 15 patients, the abnormalities related to the heart size or the presence of pulmonary venous congestion. In nine patients these were non-cardiac, including four cases of consolidation where patients would have been symptomatic; two other patients had both significant cardiac and non-cardiac abnormalities. 75% of the radiographs did not show any significant abnormalities. By nature of their short stay, day-case patients should be clinically fit, and it is unlikely that the radiographs of this 75% group would have contributed to their management. We estimate a potential saving of about £25,000 *per annum* by taking chest radiographs only in the presence of clinical indications. It would also mean a reduction in radiation dose. The cardiologists' reaction to our findings will be discussed.

Lateral chest radiograph: an underused projection?

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Indications for lateral chest radiography are not clearly defined in the established literature. Many hospitals have guidelines which allow identification of patients in whom lateral views should be performed. Manchester Royal Infirmary, a 630-bed teaching hospital, has not previously had such guidelines. The aim of this study was to quantify the number of lateral chest radiographs performed and to assess the effect that the introduction of various criteria would have on the number. In a four week period in March and April 1992, 1,862 chest radiographs were performed. A random sample of 612 examinations was reviewed. Details of the examinations were obtained from the departmental computer and the patient's film packet. In 13 patients the details were incomplete. In only 20 patients had a lateral radiograph been obtained. These patients did not appear to differ significantly in their age, referral point or indications from the group without lateral radiographs. From these data the effects of the application of various guidelines on the number and cost of chest radiographic examinations were assessed.

Improved detection of pneumothoraces in ICU patients with lateral shoot-through radiography

R A Morgan, C M Owens, C D Collins, T W Evans and D M Hansell

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Pneumothoraces are common in patients on Intensive Care Units (ICU) because of the high ventilatory pressures used. In these patients, early diagnosis is essential because even small pneumothoraces can cause cardiorespiratory decompensation. The pathognomonic sign of a visceral pleural edge is seldom seen in supine patients. The wide exposure latitude of phosphor plate computed radiography makes it possible to take lateral shoot-through radiographs (LSTR) of diagnostic quality. The aim of this study was to compare the sensitivity of LSTR with supine frontal digital radiographs in the detection of pneumothoraces. 146 pairs of digital radiographs were performed on 32 ventilated ICU patients. Each radiograph was assessed independently by three observers. The technique and problems encountered in obtaining LSTR are presented. A pneumothorax was diagnosed by at least 2/3 observers in 43 lateral and 13 frontal radiographs respectively. A pneumothorax was seen on both the supine and lateral film in 10 patients. A pneumothorax was detected on the lateral film only in 33 patients ($p < 0.00005$). We conclude that lateral shoot-through digital radiographs are much more sensitive than frontal digital radiographs in the detection of pneumothoraces in supine patients.

The radiographic features of pulmonary infection with *Mycobacterium malmoeense*: a comparison with *Mycobacterium tuberculosis* infection

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The reported incidence of pulmonary infection with *Mycobacterium malmoeense* (MM) is increasing. The purpose of this study was to ascertain whether culture positive pulmonary MM infection and pulmonary *Mycobacterium tuberculosis* (MTb) display differences in their radiological appearances at presentation. As far as we are aware there have been no previous detailed radiological studies of pulmonary MM infection. The chest radiographs of 16 patients with pulmonary MM infection were compared with those of 32 age, sex and race matched patients with

pulmonary MTb. None was known to be HIV positive. Two radiologists viewed the radiographs independently and were blinded to the infecting organism. The radiographs of the MM group more commonly showed the following features than MTb controls: cavities larger than 6 cm (6 vs. 2, $p < 0.01$), air-fluid levels within cavities (4 vs. 1, $p < 0.05$), loss of volume (12 vs. 11, $p < 0.01$) and coexistent pneumoconiosis (4 vs. 0, $p < 0.01$). Airspace shadowing involving more than one bronchopulmonary segment was significantly less common (3 vs. 16, $p < 0.05$) in the MM group. Thick-walled cavities (> 2 mm) were more common in the MM group, though this was not statistically significant. Radiological evidence of pleural effusions, local pleural disease, cavitary disease, and coexistent emphysema were seen with similar frequency in both groups. The presence of the above features may be useful in alerting the radiologist to the possibility of infection with MM.

Catheter-related SVC thrombosis — the value of the plain chest radiograph

G Brown and J E Husband

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The availability of reliable long-term venous access in oncology patients has resulted in increased recognition of catheter-related thrombosis. The appearance of superior mediastinal widening as the only radiographic sign of clinically unsuspected superior vena cava thrombosis (SVCT) in a patient with a Hickman catheter prompted a study to determine the incidence of radiographic changes in SVCT. Chest radiographs of nine patients with SVCT related to Hickman catheters were evaluated. Measurements were taken of maximal mediastinal widths at the aortic knuckle from serial chest radiographs of these and of 20 control patients who had no clinical/radiological evidence of thrombotic complications following catheter insertion. An increase of greater than 5 mm was considered abnormal. All nine patients showed mediastinal widening associated with SVCT. This sign was present in four patients before onset of symptoms. Five patients demonstrated lateral displacement of the catheter with thrombosis. No abnormal increase in mediastinal width was found in the control patients. The development of superior mediastinal widening in a patient with a central venous catheter is concluded to be an important sign of SVCT. This may be accompanied by lateral displacement of the catheter. Recognition of these signs may allow earlier diagnosis of this potentially serious complication.

10.45 – 12.00

Imaging Technology

Argyll III

Picture archiving and communication systems

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The concept of digital archiving and communication of medical images has emerged during the last decade as a result of the increasing number of digital images produced by CT, DSA and MRI. However, despite significant research and investments, the initial concept of a total digital department was not feasible as long as computing costs were too high and conventional radiology was not amenable to daily practice because of unreasonable costs. Therefore, many projects have successfully implemented partial solutions, grouping available low resolution digital modalities. Before the turn of this century, standardization efforts, decrease in costs of modalities for digital acquisition of conventional X rays, together with dramatic decreases in computing costs and progress in the design of interactive viewing and workstations will render digital management of medical images in the medical imaging department and in the hospital feasible. Providing those systems for image management archiving and communication (IMAC) are designed according to the medical imaging process and medical requirements, significant benefits can be expected in overall management of the patient and of the medical imaging department.

Considerations concerning the organization of PACS images on monitors

N H Strickland and DJ Allison

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The Hammersmith Hospital is installing a complete picture archiving and communications system (PACS) which will replace film-based radiology throughout the hospital. The

purpose of this paper is to present the system we have devised for the spatial and temporal organization of PACS images. It explains how this scheme was devised, taking into consideration the requirements for: 1. Displaying PACS images from all radiological modalities and their inter-correlation; 2. Comparison of current and previous examinations in a manner which is both temporally and spatially coherent; 3. Minimizing the workstation operator's need to rearrange images on the monitors; 4. Adapting the scheme to suit the different types of viewing monitors in the radiology department, *i.e.* batteries of four portrait monitors and pairs of two landscape; 5. Modifying the scheme for the single ward monitors and adding different design features to these monitors to suit non-radiologists.

iLAN — a new path to a filmless radiology department

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The design philosophy and the structure of an operational partially filmless radiology department, equipped with a semi-intelligent image network (iLAN) based on a sophisticated relational database (Sybase), is described. The Conquest Hospital is a medium-sized district hospital in East Sussex. It has the first UK hospital radiology department to be fully equipped with, and to use, the filmless concept. Equipment from a number of manufacturers, notably Siemens, Philips and 3M, including a Siemens AR.T CT and Diacam 120/Icon nuclear medicine systems, Philips Integris V3000 angiography system, DSI and ACe computed radiography unit and 3M XL and Dual laser imagers and digital disk interface unit, has been interfaced to an SMI iLAN image network which has optical disc archiving and Sun-based viewing stations for radiologist reporting. The way in which day to day working and reporting has been affected is reviewed.

Fluorescent screens in diagnostic radiology

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In the paper we review the phosphor materials used for X-ray screen preparation with respect to their efficiency, spectral distribution of luminescence and quality of the image produced. Apart from the phosphors already known in the literature (CaWO₄, ZnS:Cu, ZnCdS:Ag, ZnCdS:Au,Cu, CsI:Na, Y₂O₃:S:Tb, Gd₂O₃:S:Tb etc) a number of new materials (YVO₄:Eu, Y₂O₃:S:Eu, La₂O₃:S:Tb etc) have been extensively studied. The study took place under fluoroscopy conditions on screens prepared by sedimentation from aqueous solutions and also on screens prepared by electrophoresis. Some of the new materials (like Y₂O₃:S:Eu and La₂O₃:S:Tb) proved to be much more efficient than the older ones, while others (like YVO₄:Eu) have a very poor efficiency. As regards the method of preparation, the screens prepared by electrophoresis have shown a number of improved properties (better resistance to mechanical and thermal shocks, better uniformity of substrate coverage), but also a number of inferior properties (especially the optical ones) in respect to the conventional ones prepared by sedimentation. The main purpose of the paper is to present through appropriate figures and tables a comprehensive comparison of the various phosphor materials and screen preparation methods and indicate the most appropriate ones for each specific use.

Measurement of a human fetal head from ultrasound images using mathematical morphology

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Ultrasound imaging is a major diagnostic method for non-invasive visualization and measurement of internal body structures. Manual measurements are subjective and can be inconsistent. In this paper, a semi-automatic technique is developed for measuring the diameter of a human fetal head from an ultrasound image. The technique uses an emerging class of non-linear image processing tools known as morphological operators, which process images according to their shape characteristics. Firstly, a combination of grey-scale morphological operations removes noisy regions and a binary image is then created. Since the fetal head contour is not closed, a combination of binary dilation and morphological thinning is applied iteratively

until connection occurs between independent regions. The fetal head is then isolated from its background using a growing-filling algorithm and its contour obtained. As the original image contains some artefacts due to refraction in the fetal skull, the morphological contour more accurately determines the circular shape of the fetal head using a new operation called ultimate opening. Finally an automatic measurement of the diameter of the fetal head is obtained and compared with the manual measurement. This technique may be applied at different stages of human fetal head development to provide useful information

Transfer functional analysis and image intensifier performance

D W McRobbie
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Video signal analysis has been shown to be a rapid and robust means of quantifying fluoroscopic system performance. There is however a lack of practical knowledge as to how the image science based parameters (modulation transfer function (MTF), noise power spectrum, signal-to-noise ratio, noise equivalent passband) relate to the well established subjective measurements furnished by the Leeds Test Objects. We have been using a prototype video signal analysis system for nearly two years and the technique has become incorporated into our standard quality assurance programmes. On the basis of this experience, we are now able to use video signal analysis (particularly the MTF) to make judgements and predictions about image quality, system performance and potential dose rate reductions. The technique has the advantage of being objective, extremely rapid and not critically dependent upon achieving standardized X-ray beam conditions. This means that equipment can be examined in its optimal or normal conditions and at variable energies, thus providing a powerful performance evaluation tool for the physicist or engineer.

Neural network discrimination of myocardial ischaemia and infarction in ²⁰¹Tl SPECT imaging

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'Department of Adult Cardiology, Riyadh Al Kharj
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The ability of neural networks (NNs) to identify myocardial disease from bullseye images was investigated.

Training criteria ranged from detection of lesion extents to discrimination between ischaemic and infarcted regions. Bullseye data from 133 patients were divided into two sets for training and testing NN performance. An inexpensive software package, simulating three-layer back-propagation NNs, was used on 386/486 PCs operating at 25/33 MHz. Training times required were between 5 and 30 min. An initial demonstration was undertaken to reproduce regional lesion-extents as defined by the Emory criteria. This NN tested with 82% sensitivity and 97% specificity at default thresholds. Subsequent neural networks were trained on six possible outcomes, identifying the presence of ischaemia and/or infarction in the LAD, RCA and LCX regions. As more examples became available in the training set the accuracy of diagnosis, relative to two experienced observers, rose toward the target of 90% sensitivity and specificity. We conclude that neural networks can serve as aids in the diagnosis of coronary artery disease.

Improved imaging performance utilizing dual plate Computed Radiography

A Workman

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Computed Radiography (CR) normally employs a single image plate as its image detector. We have developed a system which uses the simultaneous exposure of two CR image plates in a CR cassette. This increases the fraction of X-ray quanta which are absorbed from the X-ray beam. The spatial frequency response of the images produced by both screens is unaffected by this arrangement. Spatial registration and combination of these images leads to an increase of the Detective Quantum Efficiency (DQE) by 60% compared to single plate exposures. A cross-correlation technique is used to spatially register automatically the images from front and back plates. The improvement in DQE at higher spatial frequencies is dependent on the accuracy of the registration of the images from both plates. A contrast detail test-piece was used to determine the improvement in imaging performance of the dual plate technique. A computerized method was used to measure the imaged detail signal-to-noise ratios for different detail sizes. Limits on the accuracy of the plate scan mechanism and degree of misregistration necessary to retain the improved performance with the dual plate technique have been derived. Given accurate registration this technique provides a significant improvement in image quality compared to the single plate technique for the same exposure level. This can lead to a reduction of 40% in exposure without reduction in image quality.

A physical evaluation of Computed Radiography as an imaging system for mammography

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Computed Radiography (CR) can provide images of adequate quality in a wide range of diagnostic X-ray examinations. Perhaps the most demanding X-ray examination for CR is mammography. Despite its rather modest spatial resolution limit the image quality of CR mammograms has proved promising. We have undertaken an evaluation of the physical imaging properties of CR under mammographic imaging conditions and compared them to those of a mammographic film-screen system. Sensitometric response, Modulation Transfer Function and Noise Power Spectrum were measured for the CR HR-III image plate and the film-screen system (Fuji HR Mammo Fine/CEA MA). These properties were also measured for the latest generation of CR image plate, HR-IIIIN. A 2-AFC study was carried out to determine the detectability of details of various sizes for each of the imaging systems. Results indicate that the CR system exhibits good Detective Quantum Efficiency (DQE) over a wide exposure latitude. The film-screen system exhibits good DQE over a wider spatial frequency range; however, this is maintained over a limited exposure latitude.

Spinal Morphometry — new specialist computer software

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Measurement of spinal deformity directly from plain radiographs can be extremely time-consuming and has a number of inherent technical limitations. With the ability to digitize radiographs and the use of specialist computer software these problems can be reduced. We have developed specific software, "Morphometry," for spinal deformity measurements in connection with a study to assess the efficacy of a treatment to prevent early post-menopausal bone loss. Over 400 radiographs were digitized using an OmniMedia 3cx flat bed scanner connected to a Macintosh IISI computer. The digitized radiographs were enhanced using Adobe "Photoshop." "Morphometry" was used to measure the anterior, middle and posterior height of each vertebral body. We found that this technique had a number of advantages over measurements from plain radiographs: 1. measurement time was considerably reduced; 2. image enhancement improved precision; and 3. the number of

vertebrae available for measurement increased. In conclusion, this new software provides a fast and accurate method of assessing vertebral deformity for use in both population studies and drug trials.

Advances in image-directed neurosurgery — the technique and implications for radiology

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The development of image-directed neurosurgical techniques which are independent of the stereotactic frame represents a major advance in neurosurgery. The use of imaging for therapy as well as diagnosis will have a major impact on the organization of radiological services in terms of selection of scanner hardware, techniques of data acquisition and image transfer. The ISG viewing wand consists of an independent image processing computer, the Allegro, which is attached to a mechanical arm on the viewing wand. MR data was acquired using a Siemens 1T Magnetom Impact and a Picker Vista 0.5T. CT data was acquired from an IGE 8800 Scanner. The technique and preliminary experiences of frameless stereotaxy using this equipment are reported. Our initial studies suggest that image-directed techniques can be used for a far wider variety of procedures than frame-based stereotaxy. We anticipate that in the future up to 30% of intracranial procedures will be carried out using an image-directed system and that this technique will be used in other surgical specialities which will have major consequences for radiological services.

The effects of prompting on the detection of clustered microcalcifications in digital mammograms

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One possible application of computer-aided diagnostic systems to mammography is the automated detection of clustered microcalcifications to generate attention cues, or "prompts". These prompts may then serve to direct the attention of the radiologist towards suspicious regions of

the mammogram. In order to investigate the effects of prompting, a computer vision system based on mathematical morphology was developed for the purposes of detecting clustered microcalcifications and generating prompts. In a series of signal detection experiments, digitized mammograms with and without prompts were presented on a computer screen to a number of radiologists who were required to locate any clusters. The results were processed by means of receiver-operating characteristic (ROC) analysis. The results indicated that the radiologist working in conjunction with a moderately sensitive computer system exhibits a significantly more accurate detection performance than either the radiologist or the system working alone, though a slight increase in study time was observed when prompts were present. Experiments are currently in progress to investigate the effects of varying the accuracy of the detection system and the effects that the prompting of clustered microcalcifications may have on the detection of other abnormalities.

Abstract withdrawn just prior to printing.

Assessment of catheter room imaging equipment

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Coronary arteriography is the definitive test for evaluating patients with coronary artery disease. The radiographic equipment is expensive and the procedure invasive, carrying a small but definite risk. We assessed two cine angiography imaging systems — one installed in 1982 and the other in 1991 — to compare image quality both objectively and subjectively, with the aim of demonstrating the differences between the old and newer technology. Objective tests were made using the Leeds Test Tool, TOR (18 FG), to measure the spatial resolution, low-contrast sensitivity and automatic exposure device consistency. Home-made test objects were used to assess each system subjectively and the results analysed to form Receiver Operator Characteristic (ROC) curves. Objectively the new equipment produces more consistent and reliable results and shows greater low-contrast sensitivity, and the ROC curves show it to have greater diagnostic capability in this test case. Although advances in technology have allowed improvements in the resolving power of cine imaging systems, compromises are necessary and thus the low contrast sensitivity is reduced. It is not yet clear whether this loss of information has any effect on the diagnostic capability of the system in clinical use.

A personal computer based picture archiving and communication system for clinical sonography

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A computer system designed for handling daily sonographic practice was constructed in our department. This system was aimed at simplifying imaging, reporting and archiving processes. System benefits include reductions in costs, shrinkage in storage space and increase in filing efficiency. This system was built on a personal computer (PC) local area network (LAN). A PC station in our reception room is responsible for patient data input. A patient list will be displayed on a PC monitor in front of the sonographer. After a name has been selected from that list, a procedure called image capture will be executed. Before next patient selection, each sonographic image generated will be captured and sent to the file server with identifications. Doctors may review these images and generate reports on diagnostic PC stations. There were about 1200 images saved in the file server and they can be called back for reviewing or consultation instantly. Replacement of optical disks is the only thing to do for long-term archives.

10.45 – 12.00

Radiobiology Study Day I

Seminar Suite II

Intrinsic radiosensitivity as a predictor of response to radiotherapy

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Over the last decade the intrinsic radiosensitivity of a tumour has become increasingly recognized as an important factor determining response to radiation. This has led to interest in the possibility of using radiosensitivity measurements as a prognostic test prior to patient treatment with radiotherapy. The parameters of interest are those that describe the initial portion of cell survival curves: surviving fraction at 2 Gy (SF2) or a measure of the initial slope, α . Results from several studies are emerging showing promising correlations of cellular radiosensitivity and tumour response. Using a growth assay (the cell adhesive matrix assay) on 77 head, neck and cervix tumours, workers in Paris have shown a statistically significant higher local control rate at two years for patients with sensitive *versus* resistant tumours (α values above and below cut-off giving the greatest discrimination). In Manchester data are available (assayed using a clonogenic assay) for 79 patients with carcinoma of the cervix and at a minimum of two years following treatment with radical radiotherapy alone. The results have shown a statistically significant difference in the mean SF2 values obtained for tumours taken from patients developing pelvic recurrence compared with those alive and well following treatment. The relapse-free survival rate was significantly higher for patients with SF2 values less than the median SF2. Three smaller studies using the MTT assay, a micronucleus assay and a rapid flow cytometry method also show preliminary promising results (all studies reviewed in West & Hendry, 1992 (BIR Report 24, pp 145–151)). There is a generally held opinion that not only tumours but also normal tissues differ in their intrinsic radiosensitivity, as evidenced by a small number of patients suffering severe normal-tissue damage following radiotherapy. A number of reports have been published showing that fibroblasts from apparently

normal individuals, who sustained unusual adverse reactions, were more radiosensitive *in vitro* than cells from patients treated similarly whose reactions were not excessive. In Manchester peripheral blood lymphocytes have been used to show that the ranking of intrinsic radiosensitivity is consistent between individuals and that a wide range in radiosensitivity was found for around 100 cervix carcinoma patients (sampled pre-treatment). Thus showing the feasibility of carrying out routine normal tissue radiosensitivity measurements on patients prior to radiotherapy.

The radiobiology of brachytherapy

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Brachytherapy applications are the subject of continuous change and innovation. High dose-rate afterloaders employing new technology have overcome many of the practical limitations of traditional low dose-rate therapy, and offer greater versatility and improved access to a wider range of clinical sites. However, there remain a number of radiobiological aspects of brachytherapy which are not yet fully understood, particularly in relation to the significance of dose-gradient and volume effects. Although radiobiological models indicate the nature of the relationship between low and high dose-rate therapy, comparisons based on such theories lose some of their validity when the geometrical dose distributions differ. Furthermore, for a brachytherapy treatment, there is no simple relationship between biological dose and tumour cure probability. This presentation will outline the most essential elements which are relevant to the radiobiological analysis of brachytherapy, and will consider some physical approaches for studying the dose-volume characteristics of such treatments. The combination of newer physical and radiobiological methods of analysis may offer some interesting possibilities in treatment design, and for predicting the likely outcome of various forms of brachytherapy treatment.

TUESDAY

Does nicotinamide produce tumour oxygenation changes which are directly measurable by oxygen electrodes?

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Nicotinamide at 1000 mg kg⁻¹ given 1–2 h before radiation radiosensitizes RIF-1 tumours¹; this is reportedly due to reducing tumour hypoxia by lowering the proportion of intermittently closed blood vessels². The aim of this study was to determine whether nicotinamide causes measurable changes in tumour oxygen tension (pO₂), using the Eppendorf polarographic microelectrode. Groups of C3H/Km mice with 200–450 mm³ RIF-1 tumours grown on the lower back were used. Mice treated with 1000 mg kg⁻¹ nicotinamide (*n* = 6) had median pretreatment pO₂ (10–90 percentiles) values of 31 (8–55) mmHg and at 60 and 90 min after treatment had median values of 42 (7–68) mmHg and 26 (9–51) mmHg respectively; *i.e.* there was no discernable change. By contrast, in mice treated with 5 mg kg⁻¹ hydralazine the median pretreatment values of 29 (8–46) mmHg fell to 0.5 (0–3.7) mmHg at 50–60 min after treatment, a clearly significant drop. Thus although large decreases in oxygenation can be directly measured with the Eppendorf machine, the supposed increases associated with 1000 mg kg⁻¹ nicotinamide are either too small to measure, or occur in too small a subpopulation of the tumour to be directly assessed in this manner.

References

- ¹HORSMAN ET AL, 1987, *Rad. Res.* 109, 479–489.
²CHAPLIN ET AL, 1990, *J. Nat. Cancer Inst.*, 82, 672–676.

The immunosuppressive effects of radiographic contrast media on leucocytes

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Radiographic contrast media (RCM) are known to have adverse effects on a wide range of biochemical parameters but little is known about the effects of leucocyte function. We examine the effects of RCM on leucocyte phagocytosis of *Escherichia coli*. Leucocytes phagocytosis was assessed by laser interrogation of 10 000 leucocytes per sample using flow cytometry. Data was obtained for a control sample and for samples exposed *in vitro* to ionic RCM (diatrizoate and ioxaglate) and to non-ionic RCM (iohexol and iotrolan). Samples were also examined following angiography. The percentage of leucocytes undergoing phagocytosis *in vitro* was 88% in the control population but fell to 78% following exposure to non-ionic RCM (*p* < 0.05).

There was a difference (*p* < 0.05) in this adverse effect between the ionic (70%) and non-ionic (78%) RCM. The phagocytic activity of the cells undergoing phagocytosis was no different in the RCM and control groups. Similar findings were observed following angiography with iohexol and iotrolan. Phagocytosis is affected by ionic and non-ionic RCM although the effect is less with the non-ionic RCM. This is consistent with an adverse effect on a subgroup of leucocytes, leaving the remaining leucocytes unaffected (Work supported by Newby Trust Grant).

Abstract withdrawn just prior to printing.

The morbidity and role of hyperfractionated (1.2 Gy b.d.) radiotherapy in the treatment of extremity sarcoma

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The late sequelae of a previous regime of 1.25 Gy twice daily to a maximum total dose of 75 Gy are greater than 60 Gy in daily fractions. Assuming an α/β ratio of 3 Gy for late damage, a prospective study using 1.2 Gy twice daily to a maximum total of 72 Gy was carried out evaluating the

Seminar Suite II

early and late damage and local control. 21 patients, median age 50, have been treated: 14 post-operatively, two preoperatively, and five palliatively. 17 patients have received over 70 Gy, three 60 Gy and one 58.8 Gy. Only four patients had tumours of ≤ 5 cm maximum dimensions. Moist desquamation was seen in nine patients; eight patients had moderate erythema and six severe erythema during their treatment. One patient had treatment discontinued because of wound breakdown. After a median follow-

up of 18 months 44% of patients have developed moderate or severe fibrosis within the high dose volume. Eleven patients have developed metastases and seven of them have died. There have been four local recurrences. We conclude that the use of hyperfractionated radiotherapy using 1.2 Gy twice daily at six hour intervals is feasible. The morbidity is minor. The evidence for a dose response in soft tissue sarcoma will be reviewed using data from previous studies.

12.15 – 1.15

Mackenzie Davidson Memorial Lecture

Argyll I

Recent advances in obstetrical and gynaecological ultrasound

Professor S Campbell

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Since the first description of the application of diagnostic ultrasound to obstetrics and gynaecology by Donald in 1958, there has been a continuing development of new applications which has made ultrasound an essential investigation for almost every obstetrical and gynaecological condition. These clinical advances have been made

possible by technological breakthroughs from the introduction of "grey scale" and "real time" in the mid-1970s to transvaginal sonography and colour Doppler in the mid-1980s to three dimensional ultrasound in the 1990s. This lecture will plot the evolution of ultrasound diagnosis in obstetrics and gynaecology but will concentrate mainly on the recent applications of transvaginal sonography in the prenatal diagnosis of karyotype abnormalities and colour Doppler in the early prediction of fetal asphyxia, the assessment of ovulation and implantation and screening for ovarian and endometrial carcinoma.

TUESDAY

12.15 – 1.15

Cardiovascular MRI

Argyll II

MR angiography: can it replace conventional angiography for assessment of severe carotid arterial disease?

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Approximately 800 patients with transient ischaemic attacks have their carotid arteries assessed by colour flow duplex sonography at Bristol Royal Infirmary's Vascular Studies Unit each year. Patients shown to have significant stenoses are considered for treatment with carotid endarterectomy. In approximately 5% of patients, no flow can be demonstrated in the internal carotid artery. Demonstration of a complex occlusion precludes surgical endarterectomy. It may be difficult to distinguish on sonography between extremely slow flow in a severe stenosis and no flow in a complete occlusion. For this reason these patients should undergo conventional angiography to elucidate whether the patient has a near occlusion or a complete occlusion. It is well recognized that conventional carotid angiography is an invasive procedure, which carries a certain morbidity and even mortality. During the last year we have also been carrying out 2D time-of-flight magnetic resonance angiograms (MRA) on this particular group of patients. Preliminary results suggest that MRA correlates well with conventional angiograms and also gives additional intracranial information. In future we hope to replace conventional carotid angiography with MRA in this group of patients.

MR Imaging of acute and chronic aortic dissections

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This study was to evaluate the feasibility, the image quality and information given by MR Imaging in patients presenting with aortic dissection. The study group consisted

of 14 patients (11 men and three women) with an average age of 66 years. Seven examinations were performed specifically to evaluate for acute aortic dissection. All studies were done on a superconductive imager (Elscent, 2T Gyrex). Cardiac and respiratory gating were used in all cases. The section thickness was 5 or 8 mm, and the field of view 40 mm. We performed axial and sagittal spin-echo T_1 weighted images, axial gradient-echo T_2 weighted images and gradient-echo cine-MR in sagittal oblique plane. Of 20 examinations, six studies were rated as excellent, 10 as diagnostic, and only four as barely diagnostic. The intimal flap was seen in 14 cases. In seven cases, the false channel was thrombosed. Five patients had Type A and nine patients Type B dissection. In follow-up studies, three complications were diagnosed: two aneurysmal dilatations and one extension of the dissection to the left common carotid artery. Gradient-echo cine imaging proved to be very useful to assess the blood flow velocity in both channels and the major aortic branches, and to demonstrate the sites of intimal tears. MR imaging appears as a reliable tool for follow-up of aortic dissection. Its role in acute dissection is still controversial but it may be recommended in haemodynamically stable patients or when transoesophageal echocardiography is doubtful.

MRI assessment of re-stenosis of treated coarctation of the aorta

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Coarctation of the aorta corrected by surgical methods or balloon dilatation can recur and a non-invasive method of detecting this is desirable. We report our findings using MR phase shift velocity mapping. 75 patients were studied using a 0.5T magnet. MR spin echo and phase shift velocity mapping sequences were used to measure the diameter of the aorta at the site of the coarctation and the peak jet velocity across it. The velocity findings were compared with Doppler ultrasound in all patients and with catheter

gradient in 26 patients by applying the modified Bernoulli equation. There was good agreement between MR and Doppler for measurements above 20 mmHg. Below this MR values were lower than Doppler. There was good agreement with catheter gradient in 13 patients. Catheter gradients were lower than MR and Doppler measurements in 13 patients. This may have been due to decrease in blood pressure owing to sedation during angiography and, in those cases studied post-balloon dilatation, immediate re-stenosis. MR velocity mapping was found to be a useful non-invasive method of assessing re-stenosis.

Dynamic MRI of the portal venous system—correlation with arterio-portography and Doppler ultrasound

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In previous studies we have found that the splenic, superior mesenteric and portal veins, and the main intrahepatic portal vein divisions were well shown on post-contrast gradient echo MR images obtained in the coronal oblique position. In patients undergoing pre-operative assessment before hepatic resection or transplantation dynamic MRI, Doppler ultrasound and arteriportograms were obtained. MRI was performed at 1.0 Tesla. Serial acquisitions, each of 11 5 mm slices, were obtained before and for two minutes after bolus injection of Gd-DTPA. The anatomy and patency of the portal venous system were assessed on individual slices and on maximum intensity projection images. Arteriportograms were carried out by selective superior mesenteric and splenic or coeliac injections using either conventional rapid sequence filming or digital subtraction angiography. Ultrasound scans used colour flow Doppler imaging to assess patency and direction of flow in the portal vein and its major branches. Results showed almost total concordance for patency of the splenic, superior mesenteric and portal veins. Details of discrepant cases will be presented and the specific advantages and disadvantages of each technique will be discussed.

A comparison of MR and Doppler ultrasound for vascular assessment prior to orthotopic liver transplantation

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The purpose was to compare magnetic resonance (MR) imaging and duplex Doppler ultrasound (DUS) for the

assessment of vascular patency and anatomy prior to liver transplantation. 23 patients with end-stage liver disease were examined with both techniques. Independent observers recorded the patency and location of the portal vein and inferior vena cava (IVC) as well as the locations of any porto-systemic collateral vessels. Breath-held axial flow compensated gradient echo images combined with T_1 weighted spin echo images were employed for the MR examination. Both MR and DUS confirmed the patency of the IVC in all patients and the presence of a complete portal vein thrombosis in one patient. MR proved more sensitive than DUS for detecting porto-systemic collateral vessels. Thus-MR examination can equal DUS in the assessment of abdominal vascular patency prior to liver transplantation.

Dipyridamole stress Magnetic Resonance myocardial perfusion imaging and ventriculography in the assessment of coronary artery disease

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Conventional Magnetic Resonance Imaging (MRI) perfusion and angiographic techniques lack sensitivity for detecting coronary artery disease in resting patients. We evaluated the use of stress for increasing the accuracy of MR perfusion imaging combined with MR ventriculography. 14 patients were examined using a 1T MR imager (Siemens, Iselin, NJ). Perfusion imaging used a fast T_1 Turbo-flash sequence (TR/TE = 12 ms/5 ms, matrix 64×128) during injection of gadolinium-DTPA ($0.04 \text{ mmol kg}^{-1}$). Ventricular function was assessed using multiplanar MR ventriculography. Images were acquired in identical positions before and after dipyridamole, the information combined to indicate areas of fixed and reversible abnormality and compared with thallium- ^{99m}Tc Sestamibi scintigraphy, using the same stress. Pre- and post-stress images were obtained in 13 patients; one developed severe angina after persantine, requiring reversal. In 11/13 patients, combined MR imaging agreed with scintigraphy in identifying fixed or stress-related abnormal areas. In one there was disagreement about distribution of perfusion defects. In another patient with documented myocardial infarction, scintigraphy was normal but MR identified inferior hypokinesia. Early results indicate that combined stress MR ventriculography and perfusion imaging can

provide information on cardiac function and perfusion and is worthy of further investigation.

Selective presaturation increases the accuracy of intracardiac shunt detection by Magnetic Resonance Angiography

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Magnetic Resonance Angiography (MRA) may not show some intracardiac shunts. We investigated the use of selective presaturation to increase the sensitivity of MRA in showing shunts, especially those outside the imaging plane. Cine MRA was performed in conventional projections to show areas of septum under investigation. If a suspected shunt was not seen on baseline MRA, the same sequence was repeated with selective radiofrequency presaturation through each ventricle or atrium in turn, parallel to the septum. Shunting was demonstrated by the appearance of saturated dark blood not seen on initial MRA. In eight patients with nine intracardiac shunts, seven shunts were not clearly seen by conventional MRA, by other imaging techniques or were subsequently shown to be very small. Pre-saturation MRA detected all shunts, including two small muscular VSDs, one seen only on colour Doppler, and one only on angiography with no detectable shunt on oxymetry. Two ASDs were detected by echo contrast only, one having no detectable shunt on oxymetry. Selective presaturation increases the sensitivity of MRA to the presence of intracardiac shunts not seen by standard imaging techniques. This may make it a valuable technique when alternative, non-invasive methods are equivocal or unsuccessful.

Cardiac cine MRI measurement of left ventricular ejection fraction using a single central slice

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Cardiac cine MRI was performed on 13 patients (mean age 58 ± 10 years). One cm contiguous slices were acquired through the entire left ventricle utilizing a modified long axis plane. TE was 13 ms and TR was 25 ms. LV volumes were measured using Simpson's rule and left ventricular ejection fraction (LVEF) derived. LVEF was also measured using the area-length method for the largest central slice (LCS) and the average of two largest central slices (TLCS). One experienced observer (OBS-A) and one inexperienced observer (OBS-B) performed all measurements twice. LVEF was also measured at cardiac catheterization by single-plane technique for 12 patients one day after MRI. LCS LVEF correlated well with volume-derived LVEF: OBS-A, $r = 0.9$, $y = 0.86x + 13\%$; and OBS-B, $r = 0.91$, $y = 0.9x + 9.4\%$. TLCS LVEF correlated well with volume-derived LVEF: OBS-A, $r = 0.89$, $y = 0.81x + 15\%$; and OBS-B, $r = 0.91$, $y = 0.89x + 9.4\%$. Intra-observer variation for OBS-A was $r = 0.98$, $y = 0.97x + 1.0$ and for OBS-B was $r = 0.98$, $y = 0.96x + 3.4\%$. Inter-observer variation was $r = 0.98$, $y = 1.06x - 4.9\%$. The correlation for MRI volume-derived LVEF vs. catheter-derived was $r = 0.83$, $y = 0.93x + 4.3\%$ and for MRI LCS vs. catheter-derived for OBS-A: $r = 0.85$, $y = 0.88x + 11.5\%$; and for TLCS vs. catheter-derived for OBS-A: $r = 0.89$, $y = 0.88x + 11\%$. It is concluded that use of the LCS in the long axis plane yields a clinically reliable measure of LVEF in much shorter time compared to measurement of LV volumes.

2.15 – 3.45

CT Comes of Age II

Argyll I

Industrial/professional interrelationships in CT

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Why was CT scanning so successful? Radiologists, looking back, or medical historians, may well answer in terms of it having been "the right technique at the right time", or "because it worked so well". Economists are of course inclined to assess success in other terms (for example, profit or return on investment yielded), so that the source of success has also to be sought elsewhere. Some economists have argued that success in high technology sectors (like medical electronics) depends crucially on the involvement of the user in the innovation process. The perspective of this paper, though hopefully doing justice to the work of historians and economists, will be different. It will be argued that successful performance is not inherent in a new medical device. It is the result of a complex process in which technologists and clinicians gradually converge on a design, on one or more sets of uses, and on the criteria according to which utility will be measured. Looked at in this way, the success of CT cannot be understood only in terms of the brilliant work of Hounsfield and Ambrose, central though this was. It has also to be understood in terms of the relations between the profession and its supplying industry, as these had evolved over the previous half century.

Applications of spiral CT

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The continuous radiation exposure now available in many CT systems offers new diagnostic possibilities. The most widely exploited has been spiral CT, whereby the patient is moved within the gantry during a long exposure (e.g. 20 s). The helical data set thus acquired can be reviewed in numerous ways. It obviously provides very good 3D data. In practice it is used extensively for parts of the body which

are subject to the deleterious effect of movement. Thus it has gained wide clinical acceptance for evaluating solitary pulmonary nodules and adrenal lesions which can be examined during one breath-hold, thereby ensuring anatomical contiguity between slices. Limitations in permissible mA result in slight reduction in image quality for abdominal examinations but the improved contiguity and reduction in dose of contrast medium needed for vascular opacification provide real benefit. Thus spiral CT is now widely used for the assessment of the mediastinum and hilar structures. Excellent enhanced images can be obtained with modest volumes of contrast medium. The continuous exposure without table movement allows other analyses. It permits some functional assessments as well as evaluation of physiological movement. We find it helpful in the assessment of aortic dissection.

Spiral CT evaluation of coronary artery bypass graft

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We set out to assess the utility of spiral CT in determining the patency of coronary artery bypass grafts (CABG). Twenty patients who had undergone CABG procedures 0-8 years prior to the study were examined prospectively with spiral CT within 10 days of cardiac catheterization. All studies were performed on a Somatom Plus-S with 24 s breath-hold technique, 5 mm section thickness, and 5 mm s⁻¹ table feed. The examinations were started after a patient-specific time delay during infusion of 100 ml of Solustrast 300 (4 ml s⁻¹). Images were reconstructed at 1 mm intervals. 3D reconstructions of 10 standardized projections were obtained from each patient. The overall sensitivity and specificity in diagnosing the patency of CABG were 94% and 75%, respectively. All venous CABG were diagnosed correctly. For the internal mammary artery CABG, there were two false negative results. Stenosis of CABG could not be detected by spiral CT. The 3D reconstructions revealed no apparent diagnostic advantage or new

evidence. Spiral CT is a minimal invasive technique to assess the patency of CABG in a superior way to conventional CT, and could possibly replace cardiac catheterization in asymptomatic patients.

Spiral acquisition CT in the assessment of pulmonary metastatic disease

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Spiral acquisition CT (SACT) has several theoretical advantages over conventional CT (CCT) in the detection of pulmonary metastatic disease, not least in avoidance of breathing artefacts and misregistration of adjacent slices. This study was undertaken to evaluate SACT of the thorax in pulmonary metastatic disease with regard to lesion detectability, radiation dose, effects of reconstruction at varying slice increments, and patient compliance with the single breath-hold technique. Spiral acquisition CT and CCT were compared using a standard resolution phantom and an anthropomorphic chest phantom with simulated metastases of varying sizes. 80 patients with primary neoplasms known to metastasize to the lung were examined with SACT of the thorax. Images were assessed for the presence and size of lesions, image quality and artefact. In a proportion of these patients both SACT and CCT were performed and results compared. Full dosimetry of both techniques was carried out using the chest phantom. In addition the doses applied during SACT and CCT of the chest *in vivo* were estimated. Images were reconstructed at both 5 mm and 10 mm slice intervals and the two methods of reconstruction were evaluated for lesion detectability by two independent assessors. Patient compliance with the prolonged breath holding required in SACT is discussed. Initial results suggest that SACT is as sensitive as CCT in laboratory testing, and has additional advantages in pulmonary lesion detection in clinical practice. The full implications of this new technique in relation to dosimetry and other parameters are discussed.

Visualization of the superior pericardial recess using different section thickness—comparison between conventional and ultrafast CT

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On CT the superior pericardial recess has a density and characteristic location that should allow one to identify it

with confidence but in the past it has been mistaken for a mediastinal mass, adenopathy and aortic dissection. This study reviews the appearances on different section thicknesses with and without contrast using conventional and ultrafast CT. A total of 187 scans were reviewed, 147 using ultrafast CT (Imatron, scan time 200 ms) and 40 using a conventional CT (Elscent 2002, scan time 5.5 s). On contiguous sections the recess was identified in 40% of cases using conventional CT and in 61% of cases using ultrafast CT. The difference was much less marked when thin sections (3 mm every 10 mm) were used. Review of patients with adenopathy ($n = 29$), mediastinal masses ($n = 12$) and aortic dissection ($n = 3$) using ultrafast CT demonstrated that confusion between a possible recess and these lesions did not arise due to good preservation of density differences between fat, fluid and soft tissue. On conventional CT, motion artefact associated with longer scanning times made this distinction often equivocal. Our conclusion is that the recess is more frequently and confidently visualized using ultrafast CT with contiguous sections; administering contrast medium confers no advantage

The CT appearances of hepatic angiosarcoma

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Hepatic angiosarcoma is a rare malignancy which is associated with exposure to specific carcinogens, namely vinyl chloride monomer (VCM) and Thorotrast. In this study five cases of hepatic angiosarcoma are presented and the CT appearances are described. Five males (average age 56 years) presented between 1988 and 1992. All patients had been exposed to VCM in the petrochemical industry for periods between 7 and 17 years, and all had worked in the industry before the mid 1970s when stricter controls on VCM exposure were introduced. Prominent clinical features included upper abdominal discomfort and hepatomegaly. Pre-contrast CT scans showed large hypoattenuating liver lesions, which were multifocal in four cases. Curvilinear calcification was present within the tumour in one case. Dynamic contrast-enhanced CT showed irregular, mainly peripheral enhancement, with hyperdense areas becoming isodense with background parenchyma on delayed images. The CT findings in angiosarcoma of the liver are non-specific and in particular, may resemble giant cavernous haemangioma. However, in patients with a history of carcinogen exposure, angiosarcoma is the likely diagnosis. Biopsy should be avoided

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because of a high risk of life-threatening haemorrhage from these vascular tumours.

Liver regeneration after partial hepatectomy: results from a quantitative and prospective CT-volumetry long-term study

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For almost 60 years the ability of the mammalian liver (rat, dog) to regenerate after resections has been well known. Nevertheless, quantitative data on the process of regeneration in humans are still limited although liver surgery has made important progress during recent years. Using the extraordinarily precise CT-volumetry technique we determined liver volumes pre-operatively and 2/12/26/52 weeks post-operatively in 34 (15 male, 19 female) patients who underwent liver surgery for 10 benign lesions and 24 malignant tumours. The mean pre-operative volume was 1600 ml, the resected specimen volume was 480 ml (measured by water displacement) — consisting of tumour (190 ml) and resected parenchyma (290 ml). The first post-operative period shows a swelling of 16.2% and a decrease in liver density of 12.7%. A regeneration is obvious at six months and achieves 97% of the resected volume (tumour and resected healthy liver parenchyma) after one year. In contrast to animal models the "speed of regeneration" in humans is much slower (0.5–1.0 ml/day). In conclusion, the liver remnant in patients who underwent liver surgery for malignant tumours shows a significant regeneration. Contrary to most data derived from animal models, regene-

ration in man takes much longer. In addition to the blood flow theory a new hypothesis can be discussed: liver regeneration in all patients continues up to a quotient of 0.8 l m^{-2} liver volume/body surface.

Audit of brain computed tomography in a district general hospital

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We compared the rate of referral for brain computed tomography (CT) with expected referral rates obtained from epidemiological data and published work. All patients referred for brain CT over a period of three months were included. The request/report forms were assessed for clinical diagnosis and the CT scan result. The number of scans performed in three of the major clinical categories (stroke, epilepsy and head injury) was compared with the expected number of scans obtained from epidemiological data. 204 patients were scanned. 113 (55%) of all scans fell into four categories (head injury, epilepsy, stroke and focal neurological signs). 103 (51%) scans were abnormal. 27 patients with head injury were scanned (32% of expected number). 35 patients with epilepsy were scanned (41% of number expected to present to a neurologist). 21 patients with a stroke were scanned (79% of expected number). It appears that there are too few referrals for brain CT after head injury. The number of referrals for other clinical categories is approximately correct. The local guidelines for use of CT after head injury are being developed as a result. These findings and their impact on departmental practice will be discussed in full.

2.15 – 5.30

Finzi Prize Papers

The following papers have been shortlisted for The Royal Society of Medicine Junior Radiologist Prizes.

Argyll II

Solid organ perfusion: absolute quantification with computed tomography

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¹M Korman, ¹R J Coulsen, ²D J Allison and ¹M J Lipton

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Since the early days of computed tomography (CT), it has been hoped that dynamic CT performed to image sequentially an organ after a bolus of intravenous contrast would enable absolute perfusion to be quantified, non-invasively and reliably. The value of this in studying normal physiology, vascular insufficiency or tumour blood flow, for example, is clear. Perfusion (expressed as flow per unit volume) should be calculable from the time/density curves of organ and vessel regions of interest. Unfortunately, attempts to do this have been bedevilled by the problems of contrast recirculation, slow scanner speed, and acceptable patient dosimetry, but in particular the need for large boluses of contrast often resulting in "washout" of venous blood from an organ while the arterial input is continuing. Mathematical analysis in this situation becomes more difficult; it is a particular problem if organ blood flow is rapid in comparison to the bolus width, such as occurs in the renal cortex or stimulated myocardium. Successful quantification of organ perfusion has essentially only been possible with one machine: the ultrafast CT scanner (Imatron Inc C-100, South San Francisco, CA, USA) which can perform up to 17 scans a second and has a multi-slice capability. Perfusion work has been mainly confined to the myocardium; even here there is a significant underestimation at high flow rates.

The currently accepted method of calculating flow is to divide the peak increment in organ density by the area under the aortic (or other input vessel) curve after correc-

tion for recirculation. The purpose of this study was to investigate in a broad sense the potential of perfusion quantification in the abdomen, and to specifically explore and try to improve on existing algorithms. Future applications to the myocardium and possibly brain are envisaged. The work was performed on an Imatron C-100 scanner, for practical reasons and because of lower patient dosimetry, although with an eye to applications on conventional fast scanners.

Two new algorithms have been investigated: first, that due to Peters et al which calculates perfusion as the ratio of the peak gradient of the organ time density curve to the peak arterial density. This has been successfully applied to the DTPA renogram, and reduces the problem of washout correction. The second is original, and works by dividing the incremental organ density at any time t by the area under the aortic curve (corrected for recirculation) also up to time t . This ratio is then plotted against time. By slightly shifting the aortic curve on the time axis (approximately 0.5 s, to allow for the time difference between the aorta and renal bed) using a computer, the plot attains a plateau for all t less than the washout time; the plateau value is read off as perfusion.

Perfusion is being studied in dog kidneys, with the comparison of values obtained from ^{99m}Tc-labelled 15 μ m microspheres and calculated from CT studies. (This has required the development of an original technique to label latex microspheres, due to problems obtaining albumin microspheres.) Sequential scans are taken at one level after 0.5 ml kg⁻¹ iohexol intravenously. Only one dog has been studied to date, but the value obtained by the Peters method agreed to within 10%, as opposed to a > 20% underestimate with the conventional method. However, the value obtained from the second method was correct to within 1%. Four more dogs are to be studied next month.

A number of kidney scans have also been performed in patients without renal disease, using 20 scans (0.1–0.4 s duration) at one level after 25 ml of iohexol 300 intravenously. (Peters has shown his method may underestimate

*MB was a Visiting Fellow at the University of Chicago for much of this work.

by 50% for larger contrast boluses, e.g. 50 ml.) Mean renal cortical perfusion was 2.47 ($n = 20$) using the Mullani-Gould relationship, and 3.0 ml min⁻¹ ml⁻¹ ($n = 20$) using the Peters relationship, Mean medullary perfusion was 0.784 ($n = 11$) and 0.746 ml min⁻¹ ml⁻¹ ($n = 10$) respectively. Using the data from the dog study, the patient data may be re-evaluated, as cortical perfusion is lower than that expected from microsphere work.

Splenic perfusion has been studied likewise. In 29 patients studied, using the Mullani-Gould relationship, mean splenic perfusion was lower (0.75 ml min⁻¹ ml⁻¹, $n = 6$) in cirrhotics than controls (1.21 ml min⁻¹ ml⁻¹, $n = 23$). The values and differences are similar to those obtained using intra-arterial xenon. Marked regional inhomogeneities of early enhancement in some spleens were noted, although by 2 min all spleens were homogenous. These differences have been quantified; perfusion varies by twofold in some "high perfusion" zones of the spleen as compared to "low perfusion" areas. Inhomogeneity was seen in normal and abnormal spleens; results so far suggest it may be more common in cirrhotics.

Using splenic perfusion as a "template," absolute hepatic arterial perfusion of the liver can be calculated using the Peters method. In 21 control subjects studied so far, mean hepatic arterial perfusion was 0.19 ml min⁻¹ ml⁻¹, but was markedly higher in two patients with vascular metastases (0.44 and 0.49 ml min⁻¹ ml⁻¹). In a single patient with cirrhosis, mean hepatic arterial perfusion was 0.25 ml min⁻¹ ml⁻¹.

In about half of patients studied, portal venous time curves can be obtained, although many patients find the long breath-hold difficult. Using a variant of the original method described above, portal perfusion may be calculated, although formal verification (which would probably involve portal venous cannulation of a dog) is needed.

Measurement of colonic transit using radionuclide scintigraphy

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Large bowel disorders are common and yet there is relatively little information on the behaviour of the meal in the colon. Most of the tests described are invasive (manometric measurement), or non-physiological (oro-caecal intubation for delivery of bolus), or use markers which may not represent true progression of the meal (radiological methods).

The aim of this study is to develop a new non-invasive method of measuring colonic transit time for routine

clinical application, using radionuclides meal. We have developed a novel way of data processing and presentation to enable easy assessment of the complex transit time data obtained over a period of 3 or more days.

2 MBq of ¹¹¹In is absorbed on a resin (Amberlite 1R-12 OH) and contained in a gelatin capsule. The capsule is then coated twice with a pH-sensitive polymer (Eudragit S), designed to deliver the radionuclide-resin complex at the terminal illium pH. Imaging is commenced 3 h after the administration of the capsule and contained intermittently for 3 days, obtaining both anterior and posterior images (geometric mean for accurate quantification) and marker images for movement correction. Four regions of interest over the colon are selected (right colon, transverse colon, splenic flexure, left colon and rectum) and progress of the activity through these regions is measured. The percentage defaecated is calculated from reduction of total abdominal activity with each defaecation. The percentage of activity in these regions, and faeces at each time interval during the 3 days of study, are presented in the condensed images specifically developed for this purpose with X-axis representing time, Y-axis the regions and colour coding to represent the percent of activity in these regions.

Colonic transit time is assessed in eight control subjects and in 87 patients with chronic constipation. Normal transit, left-sided delay (21%), generalized delay (21%), right-sided delay (39%), and fast transit patterns are clearly identified using the parametric images, which is not possible to assess accurately using any other methods. This has enabled the clinicians to differentiate the different forms of constipation in chronic constipation patients and, in conjunction with other tests (colonic motility, proctogram, and sphincter manometry), to decide on the area and the extent of colectomy.

This method is also used to investigate patients with IBS ($n = 12$), faecal incontinence ($n = 12$) or diabetic neuropathy ($n = 4$). Faecal transit patterns associated with each of these conditions are described. A simplified method for routine clinical use has been proposed. Single imaging at 4, 24 and 48 h (three images) is sufficient to distinguish most of these conditions and determine if delay is generalized, right-sided or left-sided.

The imaging of heel pain

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In the vast majority of patients intrinsic heel pain is the result of soft-tissue pathology and is more appropriately investigated by high resolution ultrasound or MRI rather than conventional radiography or isotope bone scan. Primary bone tumours of the hindfoot comprise less than

1% of all such tumours and isolated secondary tumours are extremely rare while haematogenous calcaneal sepsis is also rare in a non-immunosuppressed adult. Review of 64 $^{99}\text{Tc}^m$ MDP isotope bone scans performed at the Cardiff Royal Infirmary for unexplained foot/ankle pain revealed only four positive scans for pericalcaneal pathology, of which three represented plantar fasciitis or Achilles tendinitis, and only one primary bone lesion, this being a calcaneal stress fracture. The second stage of the study was to perform an audit of general practitioner referrals for calcaneal radiographs in patients with heel pain. 87 radiographic investigations were performed in Cardiff Hospitals over a 12 month period, of which 36% demonstrated calcaneal spurs and 4% calcaneal erosions. A telephone questionnaire of referring GPs showed a poor response to local steroid or non-steroidal anti-inflammatory therapy, and 55% of patients remained symptomatic 2-5 months following initial investigation. There was no significant correlation between presence of calcaneal spur and persistence/severity of symptoms.

The next stage of the study was the sonographic examination of the heels of 25 approximately age- and sex-matched asymptomatic volunteers and 27 patients with chronic heel pain. 14 patients had posterior heel pain with sonographic diagnoses of: chronic Achilles tendinitis (4 patients, 2 bilateral); retrocalcaneal bursitis (3 patients, 2 bilateral with associated erosions in RA patients); precalcaneal bursitis (2 patients, 1 bilateral); calcific tendinitis (2 patients, 1 with hyperparathyroidism); partial Achilles rupture (2 patients); and recurrent Achilles paratendinitis (1 patient).

13 patients had inferior heel pain, all of whom had sonographic appearances of the plantar fascia similar to those recognized in tendinitis and presumably compatible with plantar fasciitis. The magnitude of plantar fascia thickening was similar to that recorded in plantar fasciitis on MRI.

We now discuss our findings and suggest that ultrasound should be the first investigation in patients with intrinsic heel pain, although if MRI were available without cost constraints, its greater tissue window and field of view would probably make this the ideal imaging modality in such cases.

Three-dimensional imaging of blood flow in benign and malignant conditions of the prostate

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Transrectal ultrasound (TRUS) is a sensitive tool for detecting prostate cancer. It has been criticized as a

screening method because of its poor specificity, which has been reported as low as 20%. Benign conditions of the prostate such as adenomatous hyperplasia or localized prostatitis may have an identical appearance to prostatic carcinoma – usually a focal hypoechoic area.

We have found colour Doppler imaging (CDI) to have a high specificity with 85% of prostatic cancers showing focal abnormality (Lees & Rickards 1991; Rifkin et al 1991). We have however encountered two problems with CDI: the poor sensitivity and the lack of quantification. We may not be detecting true tumour neovascularization and even the distribution of vessels is difficult to map using real time imaging.

We propose to solve these problems by using a blood pool enhancing contrast agent to increase the sensitivity of CDI. This enables us to map the distribution of blood flow using 3D reconstruction techniques.

Three-dimensional acquisitions were performed on 12 patients with either benign prostatic hypertrophy or carcinoma. All patients in this study received the intravenous contrast agent Levovist (Schering), which is composed of a stable solution of microbubbles. This agent increases the sensitivity of CDI by 10 to 15 dB. Each patient was scanned on an Acuson 128 using both 7.5 MHz transrectal axial and sagittal probes. Images were acquired for 3D reconstruction using multiple axial sections on a single pull-through or sagittal sections on a sweep. All scans were recorded on VTR to allow retrospective comparisons. The colour Doppler signal was separated from the grey-scale image and reconstructed using a 3D graphics workstation developed at University College London.

We have been able to generate 3D “maps” of prostatic vessels in all of our patients. By performing multiplanar reformatting (reslicing) on each of the 3D acquisitions we can accurately locate the area of abnormality on the original scan and relate this to local changes in blood flow.

Two of the patients with prostatic carcinoma have increased local subcapsular blood flow with minimal flow within the hypoechoic lesion itself.

This is the first demonstration of the 3-dimensional blood flow within the prostate. It is an important step towards quantification of colour Doppler imaging and may provide unique information about prostate cancer.

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Stereotactic radiotherapy for irregular targets: the advantage of static conformal beams over conventional non-coplanar rotations

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Stereotactic radiosurgery/radiotherapy has been used for over 40 years. Traditionally targets treated have been small (< 10 cm³ in volume) and usually benign. In the 1980s it became apparent that similar isodose distributions that had previously been obtained using the Gamma Unit could be produced with a number of non-coplanar rotations. Because of the increased flexibility of the linear accelerator systems in terms of target size, fractionation and availability of equipment there has been increasing interest in using the technique to treat larger and more malignant tumours. These tumours are often irregular in shape and this poses a problem because the available technique using the linear accelerator produces a spherical isodose distribution. This is emphasized by a dose escalation study we performed using stereotactic radiotherapy (SRT) on recurrent high grade gliomas; radiation-induced damage was observed in patients receiving higher doses and those with larger tumour and treatment volumes. The increase in normal tissue irradiated in these larger tumours probably

accounts for the complications. It has therefore become important to establish whether improved dose distributions in terms of sparing normal tissue would be obtained using conformally blocked static beams when compared to conventional non-coplanar rotations for irregular targets.

CT images (4 mm cuts) from a middle-aged woman were transferred to the Voxelplan Heidelberg planning system. A theoretical target was produced that could be changed in shape by changing the length of its three axes, and placed in the region of the thalamus with a fixed isocentre. Three shapes of target were studied: sphere, ellipsoid with two perpendicular axes reduced by 25%; and ellipsoid with two perpendicular axes reduced by 50%. Three sizes of target were used, as defined by the longest axis 20 mm, 40 mm, and 50 mm. All targets were irradiated using a single isocentre and four 120° non-coplanar rotations were compared to 6, 4, and 3 static non-coplanar conformally blocked beams. The maximum target inhomogeneity was ±7%. Comparison of the different distributions was performed by analysing the volume of tissue, excluding the target irradiated, to 50 or 80% of the isodose that just encompassed the target.

The results for the nine targets are summarized in Table I. The volume of tissue irradiated excluding the target to ≥ 50% is displayed graphically in Figures 1-3. For all spherical targets there was a small advantage in using non-

Table I. The volume (cm³) of tissue, excluding the target, irradiated to 20%, 50% and 80% of the treatment isodose.

	Target 1			Target 2			Target 3		
	20%	50%	80%	20%	50%	80%	20%	50%	80%
20mm target									
4 arcs	58	16	7	53	16	8	55	18	9
6 beams	163	18	8	123	13	6	90	11	5
4 beams	206	24	10	168	18	8	135	14	6
3 beams	232	22	9	194	16	6	180	15	6
40mm target									
4 arcs	280	67	31	295	67	38	251	76	49
6 beams	460	75	35	353	56	26	287	49	22
4 beams	502	85	36	395	61	27	316	51	22
3 beams	525	81	34	431	60	29	414	62	30
50mm target									
4 arcs	462	102	44	412	103	57	388	99	55
6 beams	602	106	41	508	99	46	354	63	29
4 beams	683	136	51	545	106	46	372	68	26
3 beams	659	124	52	596	107	52	514	83	45

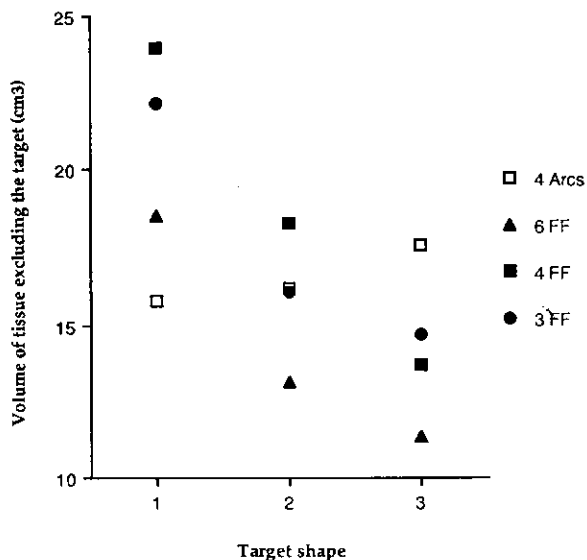


Figure 1. Volume irradiated $\geq 50\%$ for 20 mm targets.

coplanar rotations. However with irregular targets for doses $\geq 50\%$ conformally blocked static fields conferred an advantage in sparing normal tissue.

Within the theoretical constraints of this study it appears that the optimal technique of treating irregular tumours with stereotactic radiotherapy is the use of non-coplanar conformally shaped beams. This may be termed stereotactically guided conformal therapy. The number and spatial arrangement of the beams will depend on the shape and location of the target.

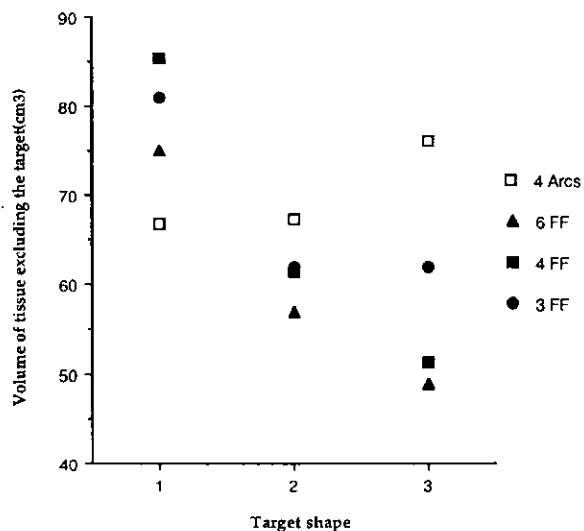


Figure 2. Volume irradiated $\geq 50\%$ for 40 mm targets.

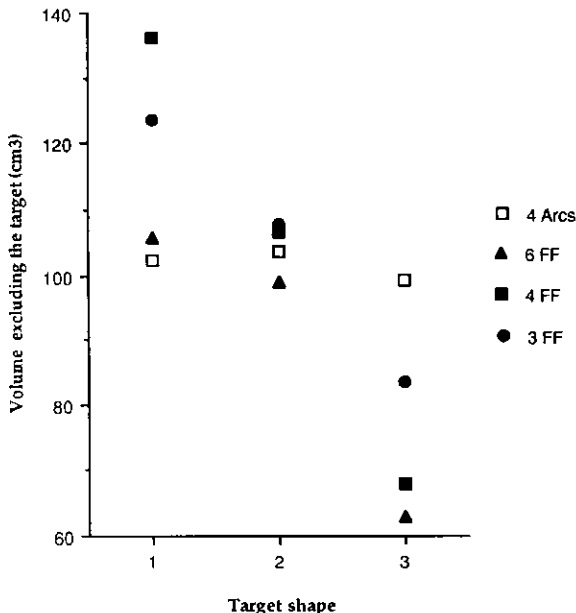


Figure 3. Volume irradiated $\geq 50\%$ for 50 mm targets.

Does long-term administration of tamoxifen affect bone mineral density?

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Tamoxifen is widely used as adjuvant hormone therapy for breast cancer. It has also been proposed as a chemopreventative agent and as treatment for benign conditions such as mastalgia. There is an increasing tendency for treatment to be continued for at least 5 years, and for its use in women who may not have had cancer. The toxicity profile of tamoxifen is favourable but there is little data with regard to the effect on bone mineral density (BMD). This study was designed to determine whether long term administration of tamoxifen is detrimental to bone mineral density by virtue of its antioestrogen activity. 19 women who had taken tamoxifen for at least five years as adjuvant therapy for breast cancer were identified from patients attending our follow-up clinic. These were then matched with respect to age (to within five years) and time since onset of menopause (to within three years) with 19 controls who had also had breast cancer at least five years previously but had not received any form of systemic adjuvant therapy. Age range was 45-84 years (median 62). Duration of tamoxifen therapy was 60-140 months (median 75). 10 had received 20 mg daily, nine had received 40 mg daily. All had a WHO performance score of 0. None had evidence of metas-

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tatic disease previously or active breast cancer at the time of assessment. All 38 patients then underwent a dual energy X-ray absorptiometry (DEXA) scan to determine BMD at the lumbar spine (L2-L4), femoral neck and total body. Serum calcium, phosphate and alkaline phosphatase were measured from a single serum specimen. Results were compared using a paired *t* test. BMD data was complete for 18 of the 19 pairs at each site of interest. Mean BMDs (g cm^{-2}) for lumbar spine, femoral neck and total body were 1.081, 0.934 and 1.078 respectively in the tamoxifen group *versus* 1.065, 0.877 and 1.057 in the controls ($p > 0.1$ in each case). Analysis according to dose again suggested a trend towards preservation of BMD that was greater for the 40 mg daily dose of tamoxifen than for 20 mg, particularly at the femoral neck (mean increase in BMD 0.063 for 40 mg; 0.056 for 20 mg), but again these results did not reach statistical significance. Mean serum calcium (mmol l^{-1} corrected to an albumin of 40 g l^{-1}), phosphate (mmol l^{-1}) and alkaline phosphatase (IU l^{-1}) were available for all patients and were 2.30, 1.10 and 63.7 respectively in the tamoxifen group *versus* 2.39, 1.20 and 76.2 in the controls, indicating a trend towards reduction with tamoxifen treatment which reached statistical significance for the calcium ($p < 0.05$, > 0.01) and alkaline phosphatase ($p < 0.05$, > 0.01). We conclude that in long term administration, tamoxifen acts as a partial oestrogen agonist on both trabecular and compact bone, with preservation of BMD at sites where morbidity from osteoporosis is greatest. No clinically relevant effect on bone biochemical parameters was observed.

Radioiodine dose-response in differentiated thyroid carcinoma using quantitative scanning and positron emission tomography

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Radioiodine (^{131}I) has been used to treat differentiated thyroid carcinoma for the past fifty years. The activity administered remains empirical and most clinicians prescribe a fixed activity for ablation and therapy based upon experience and likely side-effects. This lack of tumour dosimetry contrasts sharply with planning for external-beam radiotherapy where precise tumour-dose prescription is mandatory. Estimation of absorbed radiation dose delivered to target tissue has been largely ignored in the past, partly because of the difficulty in accurately measuring that

part of the target volume which is metabolically active. Where absorbed dose has been estimated there is no consensus as to what absorbed dose should be delivered to destroy thyroid remnants and metastatic lesions.

In order to calculate the absorbed radiation dose to those tissues which concentrate radioiodine, three parameters must be determined: the initial activity in the target tissue, the effective half-life of the radioiodine and the mass of the tissue. Tumour and normal thyroid absorbed doses have been determined using a dual-headed whole body scanner with special high-resolution low-sensitivity collimators. Improved accuracy in the estimation of functioning tumour mass has been achieved using positron emission tomography.

Dosimetry studies were performed for 54 patients with differentiated thyroid carcinoma (40 papillary, 14 follicular). There were 39 females and 15 males, ages 22 to 79 years. Dose-response graphs were constructed to determine the tumoricidal dose for differentiated thyroid carcinoma metastases and thus enable precise activities of radioiodine to be prescribed in order to maximize tumour kill and reduce morbidity. The data demonstrate that the administration of fixed activities of radioiodine results in a very large range of absorbed dose to residual normal thyroid tissue and metastases. Following near-total thyroidectomy and $3.0 \text{ GBq } ^{131}\text{I}$, a mean absorbed dose of 349 Gy achieved complete ablation of thyroid remnants in 67% of patients (73% of sites). Patients who had persistent uptake in the thyroid region on subsequent radioiodine scanning had received a mean absorbed dose of only 80 Gy. Failure to ablate was attributed to two factors: large residual following less than radical surgery, and the presence of tumour in association with normal tissue. For these two groups of patients higher activities of radioiodine are indicated.

Successful destruction of cervical node metastases was accomplished with absorbed doses of 150 Gy following functional neck dissection. Bone metastases, which are generally associated with a poor prognosis, required doses in excess of 100 Gy for eradication, but this was achieved for solitary deposits following initial surgical debulking. Nevertheless, palliation may be achieved with absorbed doses lower than this. However, the clinical data suggest that absorbed doses less than 20 Gy are sub-therapeutic and that alternative therapy should be considered if less than this can be achieved with radioiodine therapy.

The dose-response data explain the spectrum of clinical response to fixed activities of radioiodine. In future they will enable precise prescription of radioiodine to achieve tumoricidal doses whilst avoiding the morbidity, staff hazards and expense of ineffective treatment.

2.15 – 3.45

Musculoskeletal Imaging II

Argyll III

Plain film and MRI of the bone and joint diseases

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Since MRI had been introduced to the imaging diagnosis of bone and joint, diagnostic approach has been certainly modified. The radiologists play a role in the diagnosis of bone and joint lesions but must also provide information to allow staging and to monitor the results of therapy. The radiologists must be conversant with the needs of the surgeon. In this sense we radiologists must ask several questions regarding the available images. Images alone do not give us any answers. In the evaluation of bone tumours our inquirers should ask: (1) Is there an abnormality? (2) What symptoms has it caused? (3) Is it benign or malignant? (4) Should it be biopsied? (5) How should it be managed? (6) What is the response to therapy? As far as diagnostic imaging of bone and joint is concerned, plain radiographs, CT, MRI, and nuclear medicine are the major four methods. Plain radiographs remain the least extensive and most reliable modality value in defining the radiographic features of lesion, which arise in complex bones. MR is of limited value in the diagnosis of intraosseous lesion but is usually the examination of choice for evaluating soft tissue lesions. In addition, MRI is a sensitive modality, particularly for screening and evaluating the extent of the lesions. Also, MRI is great for the diagnosis of osteonecrosis and articular abnormalities. The ultimate goal of the presentation will be to make the listeners aware of the available MR imaging techniques and their application to the assessment of a variety of bone and joint diseases.

The comparison between Magnetic Resonance Imaging and plain film radiography in detecting destructive lesions of bone in rheumatoid arthritis of the knee joint

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Plain radiographs are accepted as the "gold standard" in assessing rheumatoid disease. Of particular importance

with regard to therapy is the presence or otherwise of cortical erosions and other destructive bone lesions. The finding of such an abnormality may modify drug therapy. MRI is considered to be inferior to plain films and/or CT in the detection of cortical destruction and endosteal lesions of bone. However some studies have suggested that MR is far superior to plain films in assessing disease, for example at the wrist. Bony changes in 44 knees of patients with clinically established rheumatoid disease were examined using MRI and plain film radiography. MRI demonstrated 25 marginal erosions and 42 subchondral cysts, while the numbers seen on plain films were three and eight respectively. These results emphasize the problem in visualizing bony erosions in large joints using plain films and suggest that MRI is the method of choice in detecting these lesions, not only because of its high sensitivity but also because of the use of contrast-enhanced scans to provide physiological characterization of these lesions.

Patterns of carpal disease in rheumatoid arthritis

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Plain radiographs of the hands in 106 consecutive patients with rheumatoid arthritis (RA) were reviewed to assess the pattern of disease in the carpus and hand. Each radiograph was scored by two radiologists for joint space narrowing, erosions and loss of alignment. 98 patients had carpal disease. The commonest site for disease, 73% of cases, was between the capitate and hamate. The first carpometacarpal (CMC) joint was most frequently spared, with 80% having a normal joint. The fifth and second CMC joints were diseased in 64% and 56% respectively, the third and fourth less frequently involved. In 15% of patients radiological changes were more severe in the hand than in the carpus, in 18% the changes were of equal severity and in 65% carpal changes were more severe than those in the hand. 2% of patients had normal radiographs. 25% of patients had radiological changes in the carpus with very minor or no change in the hands. It is important that radiologists are aware of the frequency of carpal disease in RA and the common variations in disease pattern.

Vertical atlanto-axial subluxation in rheumatoid neurological disability

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Subluxation patterns have been reviewed on CT intrathecal contrast myelographic examinations of the craniocervical junction in 180 patients with rheumatoid disease. The emphasis of the study was to examine patterns of vertical subluxation rather than the already well described patterns of horizontal and rotatory subluxation. All patients had suspected myelopathy of the upper cervical spine. 38% showed evidence of vertical subluxation. In addition to features commonly noted in the literature the following observations of possible surgical relevance are made from this group. Vertical subluxation is always accompanied by some degree of lateral and rotatory subluxation and two distinct patterns of vertical subluxation emerge: (A) associated with forward tilting of C1 and the occiput on C2, here referred to as *atlanto-axial sagittal rotation* (65%); and (B) associated with vertical migration of C2 into the C1 ring without sagittal rotation (35%). Both types involve structural collapse rather than simple erosion of one of the lateral masses, but these patterns are different in each type. Type A involve structural collapse of the articular plateaux of C2, with the lateral masses of C1 staying intact apart from minor articular erosions. Type B involve structural collapse of the lateral masses of C1, the articular plateaux of C2 remaining largely intact in the majority (70%).

"Diabetic feet as they stand"—CT versus MR

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Foot disorders remain the commonest cause of diabetic hospital admissions, requiring more bed days than all the other complications of diabetes combined. This prospective study was undertaken to assess the value of computed tomography (CT) and magnetic resonance (MR) imaging in diabetic foot problems. 28 feet in 21 patients with a diabetic neuroarthropathy underwent CT (axial and coronal) and MR imaging. The latter, performed on a Siemens 1 T Impact magnet, comprised a sagittal 3D FISP volume acquisition and a sagittal T_2 weighted sequence. The axial CT provided excellent detail of the bone and joint changes in the midfoot whereas the coronal images demonstrated the anatomy of the hindfoot and any soft tissue

swelling best. The multiplanar capability of the 3D FISP MR allowed for accurate assessment of the bone and joint involvement. The accompanying soft tissue changes and acquired deformity were also well visualized. Medullary low signal changes were associated with early articular involvement and there appeared to be a distinct pattern of progress of the neuropathic changes through the involved foot. Although the 3D FISP MR images, plus reconstructions, may reduce the requirement for multiple sequences in different planes, a T_2 weighted sequence is still mandatory to exclude/confirm the presence of osteomyelitis.

The MRI appearances of chondroid tumours: a pictorial essay

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While MR is pre-eminent in the local staging of bone tumours its contribution to diagnosis is limited. The exception could be said to be the chondroid tumours where the lobules of cartilage show distinctive very high signal intensity (SI) on both the T_2 weighted and STIR sequences and low SI on the T_1 weighted. The fine calcifications are visible but less well demonstrated than on either radiographs or CT. The experience of MRI of over 30 chondroid lesions—benign, primary malignant, secondary malignant and locally recurrent—is presented. The role of MRI in differentiating benign from malignant disease is discussed, as is the value of gadolinium enhancement.

MRI in soft tissue haemorrhage in haemophilia patients

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Clinically, intramuscular haemorrhage may be apparent but the exact site and extent of the bleeding can be difficult to determine. At times, the signs and symptoms may be indistinguishable from intra-articular haemorrhage or other musculoskeletal disease, whilst bleeds into the deep muscles of pelvis or retroperitoneum may mimic a variety of medical and surgical emergencies. Imaging has an important role in the management of these patients, as the site and severity of the haemorrhage dictate the immediate therapy and subsequent rehabilitation. The aim of our study was to determine the role of MRI in the management

of soft tissue haemorrhage. 18 patients with coagulation disorders and clinical suspicion of soft tissue bleeding were scanned using a 1 T magnet. Intramuscular haematomas were demonstrated in two-thirds of the patients. One third had haematoma involving the deep muscles of the pelvis and a similar proportion had haematoma of the thigh. Half the bleeds were subacute, one third were established haematoma and the remainder acute haemorrhage. Complications identified included pseudotumour, osteomyelitis, subcutaneous haemorrhage with sinus formation and rebleeding. Follow-up scans confirmed treatment response. MRI provides early diagnosis, precise anatomical localization and details of internal architecture and temporal nature of the haematoma.

The MR appearances of the gastrocnemius rotation flap

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The preferred management for a malignancy of the proximal tibia is excision of the tumour and insertion of an endoprosthesis (EPR). The close proximity of the EPR to the skin formerly resulted in a high infection rate. In order to overcome this complication adequate soft tissue cover for the EPR is now provided by a gastrocnemius rotation flap. This MR study was undertaken to delineate the new anatomy produced by the rotation flap that, to the unwary, might be confused with local tumour recurrence. 10 patients, 1 week to 9 months after surgery, underwent MR comprising T_1 and dual echo T_2 weighted and STIR sequences. Image artefacts were least apparent on the axial images. The "new" anatomy and signal changes observed in flaps of differing ages are presented.

The incidence and significance of synovial plicae on CT arthrography of the knee

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We aimed to correlate features of synovial plicae on CT arthrography (CTA) of the knee with arthroscopic findings. 236 consecutive double contrast CTA of the knee were

retrospectively reviewed. The plicae were classified, the status of the patellofemoral articular cartilage assessed, and any maltracking recorded. There were 90 (34%) medial patellar plicae. Of these, 42 (54%) were associated with suprapatella plicae, while in 33 (43%) the dimensions of the plicae promoted mechanical dysfunction of the chondromalacia (17%) and erosions (45%), with adjacent cartilage abnormalities in the medial femoral condyle in 12%. Associated bony alterations were seen in 16% of patients, with evidence of patellar maltracking in 32 patients (12%). The low incidence of plicae mentioned in the arthroscopic findings (15%) was directly related to the arthroscopists' interest and not to the overall true incidence. When present there was good correlation with the CTA findings. We conclude that CTA of the knee is reliable in demonstrating synovial plicae and associated patellofemoral articular dysfunction. Its value however depends on the orthopaedic surgeon's interest and beliefs concerning the "plica syndrome".

The Magnetic Resonance (MR) appearance of giant cell tumours of tendon sheaths (GCTTS)

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Giant cell tumour of the tendon sheath (GCTTS) is the second most common soft tissue tumour of the hand. Pre-surgical diagnosis is often difficult and there is a high recurrence rate post-excision. The role of Magnetic Resonance (MR) in diagnosis and planning of surgery is discussed and the clinical literature reviewed. Three cases of histologically proven GCTTS were imaged using T_1 , T_2 and post-gadolinium spin echo (SE) sequences using a 1.5 TGE and 0.35 T Disonics Imager. The MR images show a low to intermediate signal intensity on T_1 and T_2 SE sequences. The tumour enhances homogeneously post-gadolinium although some susceptibility effects due to haemosiderin or calcium may be seen on T_2 and gradient recalled images. In poorly defined tumours, enhancement may define the extent of the tumour and its relationship to the surrounding neurovascular structures. A combination of clinical history of a slow growing, painless tumour with radiographic features of a soft tissue mass, with or without adjacent pressure erosion of the bone and typical MR appearances as described, may be highly suggestive of GCTTS. The extent of the tumour can also be shown, which is often helpful in planning surgery.

Ultrasonography of the tibialis posterior tendon in rheumatoid arthritis

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Our objective was to assess the frequency of frank rupture of the tibialis posterior tendon (TPT) in rheumatoid arthritis and to determine if other pathology in the tendon can be correlated with foot deformity. Clinical, radiographic and ultrasonographic signs of TPT pathology were assessed bilaterally in 28 patients with rheumatoid arthritis and hindfoot involvement. The single-heel-rise test and the tibiocalcaneal angle were assessed clinically. The talometatarsal angle was measured on lateral weight-bearing radiographs. Tendon continuity and thickness were noted on sonography. The TPT was significantly thinner in those with an abnormal single-heel-rise test ($p < 0.001$). The mean thickness in those with a normal test was 2.3 mm while the mean thickness in those with an abnormal test was 1.6 mm. Thinning of the tendon was significantly correlated ($r = 0.33$, $p < 0.05$) with heel valgus as assessed by the tibiocalcaneal angle. It was also significantly correlated ($r = 0.31$, $p < 0.05$) with pes planus as assessed by the talometatarsal angle. Only one case of frank rupture of the TPT was identified in the 56 tendons studied. We conclude that TPT attenuation in rheumatoid arthritis is associated with heel valgus and pes planus. These findings are consistent with the hypothesis that rheumatoid tenosynovitis causes TPT dysfunction and contributes to hindfoot deformity. Frank rupture of the TPT is a rare event in rheumatoid arthritis.

Detection of Achilles tendon xanthomas in heterozygous familial hypercholesterolaemia: comparison of sonography with Magnetic Resonance Imaging

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Our purpose was to compare state-of-the-art sonography with magnetic resonance imaging (MR) in the detection of Achilles tendon xanthomas in patients with heterozygous familial hypercholesterolaemia (FH). 12 Achilles tendons in six patients with FH were evaluated both with 7.5 MHz linear array sonography and T_1 and T_2 weighted MRI (eight tendons were evaluated at a field strength of 0.5 T, four tendons at a field strength of 1.5 T). Sonographically, intratendinous hypoechoic regions felt to represent xanthomas (ranging from hypoechoic nodules to diffuse, heterogeneous, hypoechoic tendon enlargement) were seen in all tendons. MR detected tendon enlargement (as did sonography), with the appearance ranging from almost completely homogeneous low signal to predominantly low signal with subtle areas of higher signal intensity scattered throughout the tendon on T_1 weighted images. Sonography was clearly superior to MR in the identification of xanthomas in FH Achilles tendons. It is concluded that state-of-the-art, high-frequency, linear array sonography, rather than MR, is the examination of choice in the identification and follow-up of tendon xanthomas.

2.15 –3.45

Teach In: Dental Imaging Advances

Seminar Suite I

New imaging in dental radiology

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Digital imaging has established its significance in general radiology for several years now. In dentistry digital radiology as a routine procedure is still in its infancy, but the feasibility of computer based imaging systems has been demonstrated in a great number of clinical studies. Applications include subtraction radiography, tomosynthesis, automated lesion detection, quantitative image analysis and geometric image reconstruction in order to decrease the need for a rigid fixation of the patient during subtraction radiography. Small intraoral X-ray sensors are now on the market to capture digital radiographic images in real time. Software to control and manipulate the images is still incomplete, but it is evident that this situation is very rapidly changing. New programs will offer procedures for image archiving and retrieval, including loss less image compression, image enhancement, image reconstruction, and task-dependent automated image analysis to provide support for clinical decision-making. Other features include teleradiology and provisions for direct consultation of experts at a distance. The declining costs of computer equipment and peripherals have brought digital imaging within reach of the dental profession. The introduction of these systems in dental practice will strongly improve image interpretation, thus increasing the reliability and the efficacy of the diagnostic process.

The radiology of osseointegrated dental implants

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The use of titanium implants into the jaw is now becoming an accepted and widespread procedure amongst dentists

and oral surgeons for the treatment of partial and total edentulism. Consequently it is highly likely that many radiologists will soon be asked by their colleagues in these specialties to image the maxilla and mandible in order to assess the bone stock available for these implants. The methods for doing this will be presented and the role of CT and specialized software programs will be emphasized.

Temporomandibular joint imaging

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There are several methods of imaging the temporomandibular joint (TMJ): plain radiography (PR), conventional tomography (CNT), dental panoramic tomography (DPT), computerized tomography (CT), radionuclide bone scanning (RN), arthrography (AR), and Magnetic Resonance Imaging (MR). Simple fractures involving the TMJ can be demonstrated with a DPT and a PA mandible view. Complex facial trauma which may involve the TMJ is probably best imaged by CT. Developmental abnormalities such as condyle hyperplasia will be demonstrated by PR or DPT but to determine whether a condyle is still actively hyperplastic RN studies are required. CT, especially with 3-D reconstruction, is invaluable in the surgical planning for complex developmental conditions and for neoplasms that can involve the TMJ. The DPT is a useful screening view for patients with suspected degenerative disease or rheumatoid arthritis but sagittal CNT will demonstrate minor structural changes better. Patients presenting with TMJ "dysfunction" should be screened with PR or DPT to exclude sinister pathology. In the minority of patients who fail to respond to simple conservative treatments and in whom TMJ surgery is contemplated it is useful to image the position of the meniscus. This can be achieved with AR, preferably in conjunction with videofluoroscopy, or with MR if available.

2.15 – 3.45

Radiobiology Study Day II

Seminar Suite II

Radiosensitivity syndromes: implications for radiology

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The autosomal recessive cancer-prone syndrome ataxia-telangiectasia (A-T) provides the classic example of a syndrome with associated radiosensitivity. Radiosensitivity can be demonstrated at two levels, with the patient and in cells, where it is manifest as increased susceptibility to cell killing and clastogenic damage. Management at radiotherapy has proved straightforward and is achieved by reducing applied doses by a factor of three, reflecting the distinction from normal individuals in tests of cellular radiosensitivity. In the same way, having recognized their A-T status before reaching the clinic, any diagnostic radiological procedures should be minimized to take hypersensitivity into account. Within A-T, "variants" have been reported with less cellular hypersensitivity, suggesting genetic heterogeneity. Evidence for the existence of other syndromes which were sought following the discovery of radiosensitivity in A-T is conflicting and may reflect greater heterogeneity within such syndromes, insecure clinical diagnosis and the quality of any tests for radiosensitivity. However, the evidence for *individuals* with radiosensitivity, both with the syndromes and the normal population, is convincing. The implications for radiology must surely provide impetus for the development of rapid reliable tests to permit tailoring any procedures to the defined radiosensitivity of the individual.

The radiation stress response

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Sub-lethal exposure of mammalian cells to ionizing radiation, UV, heat and some other physical or chemical treatments can elicit a variety of cellular or subcellular transient responses. These so-called "stress" or adaptive responses can be accompanied by transient increases in resistance to

higher doses of the same, or other, agent. In particular, these stress agents, including radiation, can induce increased transcription of a range of proteins, some of which appear to be associated with cellular signalling mechanisms involved in the processes leading up to cellular proliferation. Upregulation of transcription at the mRNA level of members of the protein kinase family has been observed following low doses of radiation and other agents. Several literature reports indicate radiation-induced expression changes in various genes or oncogenes. These include the early response genes C-fos and C-jun which are involved in "switch-on" of other genes relevant to growth regulation. This paper will review aspects of radiation stress response as reported in the recent literature and arising from studies in our own laboratory. These include effects on cell growth and resistance, transcriptional changes for various proteins, including cell adhesion molecules, and the evidence for some homology between radiation- and other stress responses.

Is the time factor important in achieving local control of squamous carcinoma of larynx by radiotherapy?

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Over the past five years there has been a growing interest in the effect of the length of time of treatment scheduled on achieving local control of tumours in larynx, oral cavity and, more recently, bladder. Of 600 cases of carcinoma of larynx treated in Glasgow from 1968 to 1977 reviewed, 343 with glottic tumours with no clinical evidence of nodal involvement have been analysed. They were treated by one of six dose-fraction-time schedules. In consideration of actuarial local control curves and graphs obtained by mathematical modelling using the linear quadratic equation, we conclude that: (a) the treatment of small volumes in the head and neck region requires a beam-

directed shell; and (b) local tumour control is improved if the treatment time is short and there is no break in treatment.

Radiotherapeutic implications of genetic instability of tumour cells

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Genetic instability is a well recognized property of tumour cells which may underlie emergent chemoresistance by clonal selection. No evidence exists for comparable processes in radiotherapy, though clonal selection of radioresistant mutants has been demonstrated in a few laboratory models. However, tumour cells of differing phenotype grown in culture may differ dramatically in radiosensitivity. It seems reasonable that mutational conversion from one phenotype to another must occur, though possibly with low frequency. A mathematical model has been used to explore the radiotherapeutic implications of genetic instability. It is shown that a small fraction of mutants may profoundly affect optimal treatment schedule structure, especially for radiosensitive tumours currently deemed suitable for treatment by hyperfractionation. In some cases, the analysis favours hypofractionation, or biphasic schedules comprised of hypofractionation and hyperfractionation in sequence. The theoretical superiority of these novel schedules should be most apparent from local radiocurability of macroscopic tumours. It may not be seen in the adjuvant setting or where short-term criteria such as tumour regression are used as end-points. Brachytherapy preceding external beam radiotherapy might also be a situation where mutational emergent resistance could be significant. These considerations may be important in relation to treatment schedule design based on the properties of the majority tumour cell type.

The use of fine needle aspiration and the measurement of proliferation indices by flow cytometry in predicting the response and relapse of breast tumours to tamoxifen

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Change in tumour size is a crude and insensitive method of detecting whether or not a breast tumour is or is not responding to primary tamoxifen therapy. It may also be a late event in the history of the disease. Therefore to be able to pick up relapse before it becomes clinically apparent has important therapeutic implications. In a prospective study on 20 patients with primary breast cancer, treated initially with tamoxifen, we have determined the changes which occur in both cellularity and proliferation in sequential fine needle aspirates (FNAs) analysed by flow cytometry over a period up to 18 months. Our results show that in 6/9 cases which eventually achieved a complete response (CR) to tamoxifen there was a reduction in s-phase fraction (SPF) of > 50% which preceded clinical CR with a mean lag time of 4 months. In the remaining three cases a repeat FNA after only 3 months of tamoxifen failed to detect any malignant cells. In 7/11 of the remaining cases no response to tamoxifen with eventual disease progression (PD) was observed. These tumours were all shown to be aneuploid and repeat sequential FNAs showed no change in SPF or DNA Index (DI). In 3/4 of the remaining cases an analysis of a pretreatment FNA confirmed that the tumours were diploid and a partial response was obtained to tamoxifen. However a change in DI from diploid to aneuploid was detected in the repeat sequential FNAs taken from these three cases and preceded eventual clinical PD with a mean lag time of 7 months. We conclude that changes in cellularity and proliferation may predict how a tumour is likely to respond to tamoxifen even before changes in clinical size are evident.

4.15 – 5.30

CT Comes of Age III

Argyll I

Quantitative dynamic CT: the challenge of perfusion

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Even today, there is no simple non-invasive method of measuring regional tissue perfusion, whether defined as flow per unit volume or mass. Our ability to assess and understand many common conditions, such as vascular disease of the heart, brain and kidneys, would be greatly enhanced if we could combine such measurements with the anatomical detail of CT. In theory, by using fixed-level dynamic scanning after a contrast bolus and analysing parenchymal and vessel time density curves, this should be possible for most solid organs. Unfortunately, the need for larger contrast boluses, recirculation (both complicating the mathematics), scanner speed limitations, problems of dosimetry and beam hardening all complicate the situation, particularly at high flow rates. Nevertheless, impressive results have been achieved over the last decade, notably (but not exclusively) using ultrafast CT. This paper will survey from a practical aspect the methods used, the means to validate them and the continuing improvements taking place. The advent of faster conventional scanners opens the possibility of a wider application of these methods, notably in the solid abdominal organs to which particular emphasis will be given. The potential for colour flow imaging will also be considered.

Quantitative dynamic computed tomography in the assessment of liver perfusion: differences between right and left lobes

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Quantitative dynamic CT following an intravenous bolus of contrast medium enables separate evaluation of hepatic

arterial and portal perfusion. The differences in these parameters between right and left lobes were studied in four control patients, four patients with hepatic metastases and 10 patients with diffuse liver disease. Using a Siemens Somatom Plus CT system, single location dynamic sequences were performed following a 50 ml bolus of iopamidol 300 mg ml⁻¹. Time density curves were constructed from regions of interest over right and left hepatic lobes and spleen. The time of peak splenic enhancement allowed separation of hepatic arterial and portal phases. Overall, arterial perfusion was higher in the left lobe (mean 0.54 ml min⁻¹ ml⁻¹ versus 0.33 ml min⁻¹ ml⁻¹). Right lobe arterial perfusion was higher in patients with liver disease and metastases, and portal perfusion correlated with splenic perfusion. In eight patients, left lobe arterial perfusion was at least twice right; six of these latter patients had focal abnormalities of the liver. Transient regional differences in enhancement are sometimes observed on dynamic CT and these can be accounted for by regional differences in perfusion. Possible causes include focal liver lesions affecting regional perfusion and streaming of blood within the portal vein.

Splenic blood flow studied with ultrafast CT

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We studied overall and regional splenic perfusion using ultrafast CT (Imatron C-100). 20 patients without spleno-portal disease (controls) and six patients with portal hypertension undergoing routine enhanced abdominal CT were studied. 25 ml of iohexol 300 mg ml⁻¹ (followed by a 15 ml saline chaser) was given at 10 ml s⁻¹ through a size 16 peripheral venous cannula. 20-30 0.4 s scans were performed at one level through the spleen from 0 to 60 s after

injection. The scans were assessed for regional heterogeneity. Time density curves for regions of interest over the spleen and aorta were analysed. Perfusion (flow/volume of tissue) was calculated as the ratio of peak parenchymal enhancement to the area under the aortic curve after correction for recirculation. Mean splenic perfusion ($1.20 \text{ ml min}^{-1} \text{ ml}^{-1}$) was close to that predicted from xenon studies ($1.02 \text{ ml min}^{-1} \text{ ml}^{-1}$). Splenic perfusion was reduced in cirrhotics ($0.90 \text{ ml min}^{-1} \text{ ml}^{-1}$). Total splenic blood flow (estimated from splenic volume on CT) was increased in portal hypertensives (1108 ml min^{-1} vs. 189 ml min^{-1}). Marked heterogeneity was observed in 43% of spleens, but by 2 min splenic enhancement was uniform. Flow calculations suggest at least a 2:1 ratio of perfusion in well and poorly perfused zones of these spleens. Inhomogeneity was seen both with and without portal hypertension. In conclusion UFCT shows promise in studying splenic blood flow, encouraging further study of portal and hepatic disease.

Assessment of splenic microcirculation using quantitative dynamic computed tomography with perfusion imaging

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Quantitative dynamic computed tomography following an intravenous bolus of contrast medium allows measurement of tissue perfusion and other flow parameters. If the analysis is performed pixel by pixel, functional images displaying regional variations in perfusion can be created. Transient inhomogeneity of splenic enhancement has been observed with dynamic CT but quantitative analysis of this phenomenon and its relation to the splenic microcirculation has not previously been reported. Using a Siemens Somatom Plus CT system, single location dynamic sequences were performed following a 50 ml bolus of iopamidol 300 mg ml^{-1} for seven normal spleens and 13 spleens in patients with diffuse liver disease. The data was used to create quantifiable functional images of perfusion and time to maximum enhancement. Regional variations in splenic perfusion were seen in all cases. Two circulation pathways were demonstrated; a high perfusion, rapid transit pathway which appears to correspond with lymphoid follicles and a lower perfusion, slower pathway corresponding with the sinusoids. The appearances of normal spleens and those in patients with liver disease were compared. The combination of functional information and high spatial resolution afforded by CT perfusion imaging enables accurate anatomical localization of these separate pathways.

Interobserver variation in the identification of pattern type in fibrosing alveolitis on CT and chest radiography

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In fibrosing alveolitis the CT pattern predicts histological appearances from open lung biopsy, actuarial survival and likelihood of response to therapy. In order to have widespread clinical application the level of interobserver agreement compared with the more readily available chest radiograph (CXR) needs to be assessed. Four observers (two "experienced", two "inexperienced") analysed 126 CT scans (3 mm on 10 mm sections) and 108 concurrent PA chest radiographs for the pattern and extent of disease. The pattern was assessed using three categories (1 = ground-glass, 2 = mixed, 3 = reticular) with a level of confidence score. Calculation of the interobserver agreement for pattern was performed using the κ coefficient. The raw data demonstrated a higher level of agreement for pattern type on CT than on CXR and this was confirmed by the κ coefficient (0.48 vs. 0.16 respectively). In all instances paired κ values showed higher agreement for CT than for CXR. Observer variation increased and observer confidence decreased with limited disease. Confident observations were associated with a predominant reticular pattern. We conclude that interobserver agreement is higher for CT than for CXR; the difference between observers reflects different levels of experience.

The role of computed tomography in the management of abdominal sepsis in Intensive Care Unit patients

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Sepsis is a major complication of abdominal surgery. In intensive care unit (ICU) patients, ultrasound can be technically difficult and the number and nature of the fluid collections may be difficult to determine. The aim of our study was to assess the role of CT in the management of abdominal sepsis in these patients. Contrast enhanced CT scans of the abdomen and pelvis were performed in all post-operative ICU patients suspected of abdominal sepsis. Drainage procedures were performed as appropriate. Over a two year period, 45 scans were performed in 20 patients (13 men and seven women) with an age range of 25-72 years. All patients had abdominal surgery (nine for a perforated viscus, three for pancreatitis, two for aortic aneurysms and six for other surgical procedures). Five patients were treated with an "open" abdomen. Abdominal collections were identified in 18 patients, multiple collec-

tions in 10 cases. 25 CT guided drainage procedures were performed in 15 patients. The overall mortality was 30%, with four ICU deaths. CT allowed the accurate identification and drainage of abdominal collections in 75% of the patients studied, avoiding the need for surgical intervention. There were no complications or deaths during patient transfer to the CT unit.

Computed tomography of the retroperitoneum in patients presenting with femoral nerve signs

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Pathological processes of the retroperitoneum are often overlooked in the assessment of patients presenting with symptoms and signs of femoral nerve disease. This study diagrammatically reviews the cross-sectional anatomy of the femoral nerve and traces its course and anatomical relations from anterior primary rami at the L2, L3 and L4 levels through the retroperitoneum to the anterior thigh. The computed axial tomograms of retroperitoneum of 12 patients presenting with pain in the distribution of the femoral nerve between June 1991 and June 1992 have been reviewed and the scans of five patients with femoral nerve signs due to retroperitoneal disease (psoas myxosarcoma; psoas metastasis from lung carcinoma; psoas infiltration by lymphoma; post-traumatic iliacus haematoma; iliopsoas metastasis from upper limb rhabdomyosarcoma) are presented, pathologies being grouped into those affecting the psoas space and those affecting the iliacus space. CT screening of the retroperitoneum allows differentiation of

intrinsic femoral neuropathy (diabetic, poliomyelitis etc.) associated with psoas muscle atrophy and femoral neuropathy secondary to compression or infiltration by pathological disease.

Computed tomography dosimetry audit in the Northern Region

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As part of Regional Audit in Diagnostic Radiology, a study has been carried out of patient dose from common CT examinations, at each scanner in the region. A questionnaire was sent to the staff at each location, to collect details of the techniques used for typical scans of the head, chest, abdomen, lumbar spine and pelvis. Data on the numbers of patients scanned in each category were also taken. Measurements of central axis dose were made on each scanner, for each slice width, and from these the CT dose indices were deduced. Organ doses were calculated using the National Radiological Protection Board Normalized Organ Dose data, and from these the Effective Dose Equivalent for each examination determined. The doses from different scanners were then compared. A wide range of doses was found, but the majority compared well with those found in the recent national survey. The majority of the differences in dose could be linked to the varying techniques used. The study provides much-needed information on the radiation risk from CT examinations in the Northern Region, and highlights some potential areas of dose reduction.

4.15 – 5.30

Angioplasty and Atherectomy

Seminar Suite I

Angioplasty and chronic critical limb ischaemia; is the consensus document correct?

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The results of the treatment of critical lower extremity ischaemia by percutaneous transluminal angioplasty (PTA) have indicated an initial technical success rate of between 75% and 90%. However limb salvage at six months is only 50%. We have evaluated our recent results following improvements to catheter and guidewire technology and limb surveillance. PTA was performed on 14 critically ischaemic limbs in 13 patients (nine restpain, two ulcers, three combined). Multiple procedures were performed on six patients. Four patients were diabetic. Altogether 11 stenoses were dilated (mean 75%) and there were 10 occlusions (mean length 6cm). A single research registrar followed up all patients clinically and by measuring the ankle brachial pressure index (ABI) and toe brachial pressure index (TBI). Angiographic appearance improved in 13 limbs of 14 patients. ABI increased from an average of 0.47 (range 0.18–0.68) to an average of 0.67 (range 0.58–0.92) at one month. At six months the ABI had dropped slightly to an average of 0.62 (range 0.23–0.84). In no case was surgery precipitated by PTA or were any patient's surgical options limited by the catheter procedure. We intend to follow our patients for six months and present the clinical results, with a discussion of the recommendations of the European Consensus Document on critical limb ischaemia.

Monitoring activated clotting times during coronary angioplasty

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Complication rates during coronary angioplasty (PTCA) have been shown by other workers to be significantly lower when the activated clotting time (ACT) is kept above 250 s.

It is common practice to give a loading dose of heparin assuming that this will raise the ACT above 250 s, but this practice may be unreliable. Our practice keeps the ACT above 300 s throughout the PTCA. 200 consecutive patients undergoing coronary angioplasty had ACT measured following administration of a loading dose of 10 000 IU of heparin. Heparin was given as required to keep the ACT above 300 s throughout the procedure. Doses of heparin required to raise the ACT to over 300 s varied from 10 000 to 22 500 IU. The total amount of heparin required during PTCA varied widely. Major ischaemic complications occurred in 16 of the 200 patients. In 12 cases vessel dissections were identified as the primary cause. In the other four cases no definite aetiology was identified but in no case was thromboembolism demonstrated. Reliance cannot be placed on a loading dose of heparin to achieve or maintain adequate anticoagulation. ACT should be monitored to minimize the risk of thromboembolism and its sequelae during PTCA.

The effect of vasodilators on the haemodynamic changes following percutaneous transluminal angioplasty (PTA) of the lower limb

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J A Dormandy and N D P Marchbank
*Departments of Vascular Surgery and Radiology,
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Recent work has indicated an unexplained delay of up to one month in the maximum improvement of ankle and toe brachial indices following successful PTA of the lower limb. Although vasodilators are often given empirically during these procedures, it is not known whether they influence haemodynamic changes in the long term. 38 patients undergoing technically successful PTA of the lower limb were prospectively randomized to receive a single intra-arterial bolus of either 150 mcg glyceryl trinitrate (GTN) or saline immediately after completion of the procedure. Toe brachial indices, laser Doppler fluxmetry and transcutaneous oximetry were performed during the first 24 hours and repeated at 1 week, 1 month and 6 months. The group given saline ($n = 19$) showed no haemodynamic improve-

ment for 6 hours following PTA, after which the toe brachial index increased slowly after one month. The group given GTN ($n = 19$) showed an immediate improvement which subsided over 6 h. Toe brachial indices then increased again in the GTN group and were consistently greater than those achieved in the saline group over the next six months. We have shown that there is a 6 h delay in the toe brachial index rise following successful PTA. The increase at 6 months is greater in patients given an intra-arterial bolus of GTN immediately following the procedure. There was a similar pattern in the assessments of the microcirculation.

Is there a role for femoro-popliteal angioplasty in severe limb ischaemia?

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Percutaneous transluminal angioplasty (PTA) is established in the treatment of short isolated lesions in claudicants although its role in critical ischaemia is controversial. 50 patients underwent PTAs to the femoro-popliteal segment for critical ischaemia between July 1983 and July 1987. All patients had ankle pressures below 60 mmHg. 20 had distal gangrene, 13 persistent foot ulcers and 17 rest pain. Criteria for success were a rise of 0.1 in the ankle brachial pressure index and symptomatic improvement. Patients were seen and regularly assessed in a vascular studies unit. Angiograms were independently reviewed and scored by radiologists. Primary and secondary limb salvage at two years were 51% and 66% respectively. Patients with long lesions and poor run-off had a high failure rate. Of 23 long occlusions dilated, 22 failed. Of 14 patients with successful results at six months, 13 had short lesions dilated. Overall, angioplasty had a low chance of long term success; however, selected patients obtained limb salvage from a minimally invasive procedure. On the basis of this series, angioplasty of long lesions is associated with high complication and failure rates and should be reserved for those with short lesions.

Colour flow Doppler is an accurate method of assessing the superficial femoral and popliteal arteries for angioplasty

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If an accurate non-invasive method of assessing the superficial femoral and popliteal arteries can be identified,

patients may be selected for percutaneous transluminal angioplasty (PTA) without first undergoing formal aorto-arteriography. To assess this accuracy, we have compared colour flow Doppler (CFD) with angiography undertaken within 24 h. 149 unselected patients had CFD assessment of the common, deep and superficial femoral and popliteal arteries. 168 limbs were assessed. 672 arterial segments were compared. Segments were assessed as normal, stenosed (more than 50%) or occluded. There was agreement between CFD findings and arteriographic appearances in 623 segments (92.7%). Of the 49 differing assessments, 15 concerned the profunda. Of the remaining 34, 20 were false negatives and 14 false positives. With regard to intention to treat, only the false positive results are relevant, and of these only those in the SFA and popliteal ($n = 8$). Five of these eight patients had lesions suitable for PTA at a different site from that identified on CFD. In only three cases would an inappropriate referral for PTA have occurred. CFD is an accurate method of assessing the femoro-popliteal segment and may be used to select patients for PTA.

Percutaneous transpopliteal angioplasty

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The conventional approach to iliac and/or femoral angioplasty (PTA) is via the common femoral artery (CFA). If this site of access is precluded, e.g. CFA occlusions or superficial femoral artery (SFA) origin occlusion, dilatation may still be attempted via the popliteal artery. The anatomy of the popliteal fossa precludes a direct puncture in the anteroposterior plane. This is owing to the popliteal vein lying posterior or posterolateral to the artery. To avoid puncturing the vein and artery therefore creating an arteriovenous fistula a Doppler needle was used and the artery approached from the medial aspect site. 15 patients underwent PTA using the above technique. All (100%) patients had successful accessing of the popliteal artery. 11 (73%) patients had a successful PTA. One (7%) patient developed a popliteal A-V fistula. There were no other complications. Catheterization of the popliteal artery is not technically difficult, has a high success rate and a low complication rate. Transpopliteal angioplasty should be considered for certain iliac and femoral lesions when the usual routes of access are unavailable or have been unsuccessful.

Electrocardiographic changes during non-cardiac angiography and angioplasty

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Electrocardiographic (ECG) changes are well recognized during the course of cardiac angiography but it is not known what ECG changes occur during lower limb vascular studies. An examination of ECG recordings was made in patients undergoing percutaneous transfemoral aortography (PTFA) and percutaneous transluminal angioplasty (PTA) of the lower limb vessels. 50 patients were fitted with ambulatory ECG recorders two hours prior to PTFA/PTA. The ECG was analysed before, during and for two hours after the PTFA/PTA procedure. The heart rate was unchanged during the study period. Runs of bigeminy/trigeminy increased in three patients during the procedure, to a maximum of 91 episodes per hour. Ventricular ectopics increased in 16 patients during the procedure, to a maximum of 538 episodes per hour. Supraventricular ectopics increased in 27 patients during the procedure, to a maximum of 314 episodes per hour. A total of four patients developed either pauses or couplets. In total, rhythm disturbances increased in over 50% of patients undergoing PTFA/PTA. In some cases this increase was dramatic. Consideration should be given to monitoring patients during PTFA/PTA, especially if the patient is known to have a cardiac rhythm disturbance.

Low dose peripheral intra-arterial thrombolysis in a small district general hospital

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Peripheral intra-arterial thrombolysis has increasingly been introduced into the modern management of the acutely ischaemic "threatened" lower limb. We describe our experience in a small (350 bed) district general hospital over a period of 1990-1992. Low dose tissue plasminogen activator was used via an intra-arterial catheter infusion of 0.5-1 mg h⁻¹ in 20 thrombolytic procedures on 19 patients (13 male and 6 female, with an age range of 49 to 93 years; average age 68 years). Thrombolysis was achieved in 17 of the procedures but a successful clinical result obtained in only nine patients of whom two required additional vascular surgery and six required angioplasty. Thrombolytic therapy alone is unlikely to produce a successful outcome in the acutely ischaemic "threatened" lower limb. Close cooperation between the radiologist and the vascular surgeon is essential for effective management.

Evaluation of Amplatz Thrombectomy Device

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We report clinical and experimental results in the evaluation of the Amplatz Thrombectomy Device (ATD). The ATD is a mechanical thrombectomy device which consists of an 8F catheter that contains a distal rotor housing in which a small-diameter recessed impeller is attached to a stainless steel drive shaft. The shaft is attached to a disposable high speed air driven motor. The ATD is designed to recirculate and homogenize thrombus. *In vitro* thrombectomy was performed with human clotted blood aged between 2 days and 4 weeks. The ATD was activated for varying periods of time and the range of particle sizes was determined by filtration. Clinical experience is limited to three patients at present; the main indication for use is failure of thrombolysis. Rapid thrombectomy was achieved *in vitro*, but a greater proportion of larger particles were found in older thrombus. Particle size did not exceed 1000 µm and the majority were less than 15 µm. Clinical success was achieved in all cases with no procedural complications. We conclude that mechanical thrombectomy is feasible with the ATD and the resulting particle size does not appear to present a clinical problem in the peripheral circulation. This device is a useful alternative for the patient who does not respond to thrombolysis.

Treatment of peripheral vascular disease with the pullback atherectomy catheter — assessment by intravascular ultrasound and angiography

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We assessed the clinical utility of a new atherectomy device. 19 patients with superficial femoral (24), popliteal (4) and tibial (3) stenotic lesions were treated using the Arrow Fischell Pullback Atherectomy Catheter. The 2.5 mm catheter was used initially in all patients, and in three patients the 3.0 mm device was then used. Lesion morphology and end results were assessed in nine patients using intravascular ultrasound (IVUS), and in six patients angiography was also used. Intravascular imaging demonstrated the presence of calcification in all femoral and two popliteal lesions. Angiography revealed some surface ulceration with thrombus in seven lesions. There were 19 eccentric and 12 concentric lesions. Following atherectomy the mean ankle brachial index rose from 0.69 to 0.86. IVUS

and angiography revealed smooth atherectomized segments confined to the intima in all but three lesions. Exposure of the media occurred on the opposite surface to the two calcified eccentric lesions and in one calcified concentric lesion. There were no dissections or perforations. We

conclude that the pullback atherectomy catheter can cut plaque cleanly and has the potential to be a precise endovascular treatment device. Cutting can be controlled by the degree of external compression, depth of blade and number of passes.

4.15 – 5.30

Clinical Oncology: Current Practices and Developments

Seminar Suite II

Adjuvant treatment of bowel cancer

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Novel ways of scheduling surgery, radiotherapy (XRT) and chemotherapy (chemo) have improved Therapeutic Ratio (TR) in bowel cancer. Re-operation and CT scanning have given accurate information on sites of recurrence and reasons for treatment failure. Recurrences within the operative or XRT field suggest a need for XRT dose escalation, or XRT with concomitant infusional chemo. Recurrences outside the field suggest a need for more extensive surgery or XRT fields, or for sequential chemo. Perioperative XRT has improved local control and survival in ano-rectal cancer, and current US trials in colorectal cancer exclude surgery-only arms. This has not been the case in stomach, pancreatic or biliary tract cancer. Possible reasons for the difference include XRT dose-compromisation because of the risk of small bowel damage, difficulties in defining local control and statistical limitations due to the rarity of resected patients fit enough for postoperative treatment. In future, TR will improve by better patient selection and clinical staging, better drug schedules and reductions in treatment morbidity. Preoperative XRT or chemo is less toxic than postoperative. Better infusional pumps will reduce the need for bolus chemo and encourage chemomodulation of 5-fluouracil by folinic acid or biological agents, using the intravenous or intrahepatic route. XRT toxicity will be reduced by three-dimensional planning and the use of growth factors.

External radiotherapy for inoperable colorectal cancer: analysis of 86 cases

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Our analysis presents a group of 86 patients with unresectable colorectal cancer who were treated with radical or

palliative external beam radiotherapy from 1979 to 1989 at the Radiation Oncology Department of the Greek Anticancer Institute, St. Savvas Hospital, Athens. The dose to the tumour-bearing area was 20–50 Gy in 2–6 weeks. A CAT-scan guided boost field portal to the primary tumour bed and immediately adjacent nodes has also been used. Irradiation was given with a ⁶⁰Co unit or a 6 MeV linear accelerator using a two, three or four field technique. Complete symptomatic relief was achieved in 90% of patients with rectal bleeding, 63% with pain and 37% with mucous discharge. Although the majority of our patients received a radiation dose higher than 40 Gy, we have seen symptomatic relief in 2–3 weeks in up to 90% of patients treated with 20–30 Gy. However the duration of improvement concerning the symptomatic relief of our patients was better for those who had been given higher doses or radiation therapy. The radiation dose was adequate to relieve symptoms in 40 patients (46.5%) for more than 12 months and in 20 patients (23.2%) for 8–12 months.

Clinical radiobiology of malignant melanoma — the National Hospital experience

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Due to the current controversy regarding the radiotherapy of malignant melanoma, a retrospective clinical radiobiological analysis was carried out on 116 lesions treated at the National Hospital between 1966 and 1990. The vigorous statistical analysis of radiation effects in both tumour and normal tissue included frequency distributions, regression analysis, the chi-squared test and Fischer's exact test. Treatment variables analysed included total dose, dose per fraction, treatment time and field size for various levels of tumour response. The predictive abilities of time-dose models (TDF, CRE and LQ) were also analysed. Both dose per fraction and treatment time influenced the outcome of treatment. Fractions > 600 cGy were more effective and radiotherapy should be completed in 21 days. The Bloemfontein melanoma α/β value is 4.06 Gy and target ETD for complete response 84.35 Gy. Late normal tissue effects (necrosis, fractures and fibrosis) occurred in 14.66% of the

treated lesions. Iso-effect tables for the fraction range 600–900 cGy have been developed, together with the expected normal tissue effects using SRE and D_0 values.

Bone mineral density after craniospinal irradiation

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Bone mineral density (BMD) reaches at approximately 30 years of age, and may be influenced by radiotherapy prior to completion of skeletal maturation. Regional BMD has been measured using Dual Energy X-Ray Absorptiometry (DEXA) in adults following craniospinal irradiation for medulloblastoma between ages 4 and 19, receiving doses of 3500–4000 cGy to the brain and spinal cord. Lumbar spine (LS) and femoral neck (FN) BMD measurements were compared to normal age and sex matched control values. There was failure to achieve normal adult BMD at both LS and FN, with a mean reduction at LS of $12.1\% \pm 2.4\%$ ($p < 0.01$) and a mean reduction at FN of $14.3\% \pm 3.4\%$ ($p < 0.01$). Mean body mass index (BMI) was also reduced compared to a standard population ($21.8\% \pm 1.5\%$), as were mean standing and sitting heights. No relationship was found between reduction in BMD at either site and age at irradiation, time elapsed since irradiation or BMI at time of scanning. Biochemical and endocrine markers including corrected calcium, alkaline phosphatase, sex hormones and IGF-1 were normal in all seven patients. The reduction in BMD outside the irradiated area suggests that indirect factors may be important in this effect. Further studies were needed to address these issues, in conjunction with the role of hormone replacement combined with counselling.

Radiolabelled methylene blue for diagnosis and therapy of disseminated melanoma: human and animal studies

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Almost random metastatic dissemination of melanoma causes main difficulties in the neoplasm's management. Systemic treatment selectively directed at melanoma, such as targeted radiotherapy, seems to be the most promising option among those presently available. Since melanoma is

a pigmented tumour, melanin constitutes a suitable target for a radioisotope's carrier to be addressed to cells of the tumour. Methylene blue (MTB) possesses exceptionally high affinity to melanin and, therefore, if labelled with appropriate radioisotopes, reveals both a diagnostic and therapeutic potential in melanoma. [^{211}At]-MTB (α -particle emitter) injected intravenously effectively prevents dissemination of human melanoma in animal model systems by inhibiting growth of cutaneous lesions and scavenging melanoma cells circulating with blood (*Cancer Res.*, 52, 4385–4390 (1992)). The results justified an introduction of the treatment to clinical trials. Bio-distribution studies in melanoma patients using [^{125}I]-MTB, as well as a measurement of radioactivity content in biopsies of cutaneous lesions, confirmed a high and stable uptake of MTB in melanoma metastases (tumour/surrounding tissue ratio = 9 at 19–26 h after [^{125}I]-MTB i.v. injection) and a lack of retention of the compound in normal tissues. A whole-body monitoring with γ -camera and more detailed brain studies with SPECT enabled the diagnosis not only of an unsuspected metastasis subsequently verified by X-ray radiography, but also of a brain lesion which was revealed five months before the CT camera enabled detection of the tumour.

Correlation of skull base invasion with Epstein-Barr virus detection in tumour tissues of nasopharyngeal carcinoma

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Computed tomographic (CT) evaluation of skull base invasion is valuable in the planning of the treatment protocol of nasopharyngeal carcinoma (NPC) clinically. While the mechanism of the oncogenesis of NPC is still not clear, biochemical and immunological evidences suggest that Epstein-Barr virus (EBV) may play an important role in its oncogenetic process. This study is aimed to clarify whether the skull base invasion of NPC is related to the presence of EBV genome in the tumour tissue. In the study of 22 NPC biopsies, polymerase chain reaction (PCR) detects the presence of EBV genome in all the WHO Type 3 samples, and half of WHO Type 1 and Type 2 samples. CT findings of these cases are retrospectively studied. All the cases with skull base invasions are of the WHO Type 3 group, but the amount of EBV DNA in these tumour biopsies is not significantly different from those tumours that are less invasive. However, the amount of viral genome in the biopsy samples is related to the differentiation state of the tumour.

Clearance kinetics of mIBG

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The recent rise of interest in treatment with [¹³¹I]-mIBG (meta-iodobenzyl-guanidine) has increased the need for accurate dosimetry data, which are required to predict the toxicity of unsealed radionuclide therapies and to advise staff and patients on radiation protection. Retention measurements were obtained following 50 therapies with (¹³¹I)-mIBG. A simple mathematical model was formulated which assumes a continuous decline in the rate of clearance. As the rate of whole body clearance decreases, the mean effective half-life increases from 5 h at 1 h post-injection, to 50 h at 3 days. Whole body doses, corrected for differences in body weight, were calculated. Typically, a 70 kg adult received a whole body dose of 0.1 mGy MBq⁻¹ of administered activity (50% of the dose is delivered in the first 60 h). These results indicate that administered activities as high as 11.1 GBq (300 mCi) would give whole body doses well below the tolerance level of 2.5 Gy. The model can be used to predict safe levels for resuming normal activities; the "no restriction" 150 MBq level would be reached, on average, 10 days after injection of 7.4 GBq of mIBG.

Protein derangement in cancer patients and its significance

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The hypothesis that cancer can impose characteristic abnormalities in the host protein metabolism, and consequently alter its free amino acids profile, has been long recognized but has received little systematic investigation. To verify this hypothesis, we have measured the level of 18 amino acids (asparagine, glutamine, serine, aspartic acid, glutamine acid, cysteine, glycine, threonine, alanine, histidine, lysine, proline, methionine, arginine, tryptophan, phenylalanine, leucine and isoleucine) in the urine of patients ($n = 22$) with different types of cancer (breast, lung and lymphatic system). Healthy volunteers ($n = 10$) served as control subjects. The levels of amino acids were determined using the technique of high performance liquid chromatography and the data were compared using Student's *t*-test. Compared with control subjects, only arginine, leucine and isoleucine levels were higher in patient groups than normal volunteers. For the rest of the amino

acids there was a general decrease in the levels in patients compared to normal volunteers. With the exception of histidine and methionine, the decrease was significant on Student's *t*-test ($p < 0.05$). For the normal volunteers ($n = 10$) and patients ($n = 22$) the total concentrations of all urinary amino acids in nmol cm⁻³ were 492.1 ± 225.2 and 284.2 ± 172.2 , respectively. The difference was significant at $p < 0.05$. Although no startling breakthrough has occurred during the past few decades on exploiting the phenomena of protein derangement in cancer patients for diagnostic purposes, small but important leads are appearing and perhaps with further research in the future a breakthrough will be forthcoming.

Urinary modified nucleosides as potential tumour markers: analysis by gas chromatography-mass spectrometry

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Elevated levels of nucleosides in the urine of cancer patients have attracted much recent interest, particularly in respect of the potential of modified nucleosides in the urine as biological markers for the early diagnosis of tumours, since the modifications appear to arise as a result of abnormally high turnover of tRNA. Several previous studies have utilized HPLC for the routine analysis of urinary nucleotides, with the identification of individual compounds based upon chromatographic behaviour. Better evidence is produced by combined gas chromatography-mass spectrometry (GC-MS), which has provided unambiguous identification of several modified nucleosides and identified one novel nucleoside in human urine. Here we report preliminary data from GC-MS analysis of urine samples, obtained prior to treatment, from 10 cancer patients. Samples were purified by solid-phase chromatography, then converted to the trimethylsilyl (TMS) derivatives prior to GC-MS analysis. Positive identification of 14 nucleotides was achieved, and quantitation revealed that several of the modified nucleotides were present at elevated levels in comparison to those in control urine samples. The modified nucleotides found to vary included 2-methylguanosine and 1-methylinosine; the preliminary data obtained from a small number of patients support the view that these compounds may prove to be useful tumour markers, and a larger scale survey is now being initiated.

Assessment of liver metastases complicated by hepatic steatosis

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Hepatic steatosis may occur in patients receiving chemotherapy and this can make assessment of the response of liver metastases to treatment difficult on CT. We retrospectively analysed the CT scans of 120 consecutive patients with hepatic metastases from colorectal carcinoma receiving either 5F-fluoracil (5 FU) alone or 5 FU and interferon. We found that in 16% of patients there was transient hepatic steatosis which resolved on cessation of therapy. The incidence was equal in both treatment groups. As oncology patients have frequent scans during the course of their treatment we elect to follow patients with obvious metastatic liver disease with unenhanced scans. In those patients who developed hepatic steatosis, we found that hypodense metastases became isodense or hyperdense relative to the surrounding liver as the fatty change evolved only to become hypodense again when the density of the liver parenchyma returned to normal. Such camouflage effect caused difficulties in assessing treatment response or progression. Technical aspects of overcoming these problems and the relationship of CT to clinical evaluation and serial CEA levels in the monitoring of treatment will be discussed.

Audit reduces the reluctance to use single fractions for painful bone metastases

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We used audit to reduce the number of fractions used to treat painful bone metastases. We present the findings of three retrospective audits undertaken from June to August 1990, June to August 1991 and November 1991 to January 1992 to assess the number of patients, total number of fractions and mean number of fractions per patient. Following the initial audit, single fractions were agreed as the appropriate management for painful bone metastases. Spinal cord compression, retreatments and skull base involvement were considered appropriate indications for multiple fractions. The three quarterly audit intervals identified 133, 149 and 148 patients treated with totals of 538, 520 and 335 fractions respectively. (Mean number of fractions per patient with ISEM 4.1 ± 0.27 , 3.5 ± 0.24 and 2.3 ± 0.17 respectively). The guidelines were reinforced after the second audit and this resulted in a significant change in practice. Detailed analysis of the third audit showed that 31% of the multifraction schedules used were inappropriate. This study illustrates the importance of continued surveillance of clinical practice if audit is to modify clinicians' behaviour. A further follow-up audit is to be undertaken to assess maintenance of this change.

Wednesday 19 May

9.00 – 10.15

Joint Disease

Argyll I

Different types of joint prosthesis

I W McCall

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Arthroplasty of the hips and knees is now a commonplace operation with the time of hospitalization down to a matter of days. The technology has developed over many years. The initial hip replacement was of an uncemented femoral component used primarily in cases of fractured necks of femur, which use the normal acetabulum but lead to extensive wear of acetabular cartilage and were not appropriate for cases of osteoarthritis. The main development for patients with osteoarthritis has been the Charnley cemented arthroplasty replacing both the acetabulum and femoral sides of the joint. The femoral component is made of inert metal and the acetabular component of polyethylene. The cement provides a good interface between bone and prosthesis and, despite some reservations about the use of cement, the long term follow-up of these hip replacements has stood the test of time although minor changes have occurred in cement quality and cementing technique. The trochanter may be removed and rewired or the replacement undertaken without a trochanteric osteotomy. The posterior approach does not require trochanteric osteotomy but the exposure is less clear. Non-union has been a problem with those using the trochanteric osteotomy. While numerous wear particles occur within the joint, and as it was thought that the cement was the main problem, uncemented prostheses were developed. These prostheses were either of metal, with irregular surfaces to enable the bone to grow onto the surface of the prosthesis, or were made of ultra-high molecular weight polyethylene, which was isoelastic with bone and provided flexibility. Ceramic prostheses have also been used but been found to be too brittle. Great advances have also been made recently in total knee replacements. Initially, minor resurfacing procedures were performed, using an inserted Mackintosh prosthesis. These had a limited role but were moderately

satisfactory. A number of hinged prostheses were then developed, which have not proven to be entirely successful owing to the substantial stress on the hinge system and the extensive bone removal required for these types of prosthesis. The key to the prosthesis stability is careful alignment and strengthening of the quadriceps and collateral ligaments. Re-alignment may be performed by soft tissue releases. In these circumstances surface replacements have proved to be very satisfactory. Some surface prostheses rely on cement between the prosthesis and bone, whereas others are porous coated and require ingrowth of bone into the prosthesis. While wear particle remains a problem, the overall results of the latest systems of both knee and hip are extremely good.

Imaging of complications of joint replacement

I Beggs

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Abstract not received.

High resolution ultrasound of the shoulder in rotator cuff tear

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High resolution ultrasound (US) of the shoulder joint has been described as a technique for evaluation of the rotator cuff. The aim of the study was to determine the accuracy of this technique using arthrography for comparison and to establish the place of ultrasound of the shoulder in the evaluation of the rotator cuff. High resolution US and single contrast arthrography were performed on 40 patients (24M, 16F, age 17-80) referred to our department for investigation of suspected rotator cuff tear. 24 (60%) were

negative at US and 18 (75%) of these were confirmed as true negatives by arthrography. 16 (40%) were positive at US, and 15 (94%) of these were confirmed as true positives by arthrography. In our department, high resolution US of the shoulder has a sensitivity of 75% and a specificity of 94%, with an overall accuracy of 83%. Since the technique is so specific, we feel that no further investigation is required following a positive result, unless improved anatomical delineation is required. In these cases, MRI may be the imaging technique of choice. A negative US should be followed by arthrography or MRI if clinical suspicion remains high, or if conservative management fails.

Integrated imaging of the shoulder

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Madrid 28034, Spain*

Currently MRI, and to a lesser extent conventional radiography and ultrasound (US), are the main imaging tools used in the evaluation and detection of anatomical abnormalities of the shoulder. We have evaluated the diagnostic value of US and MRI in 50 patients with suspected rotator cuff tears. The patients were first evaluated by US, and after with MRI. In the results, US was useful in evaluating impingement, tendinitis, bursitis and rotator cuff tears, being of value in the initial assessment of cuff rupture, often resulting sufficient. MRI was also useful in the evaluation of impingement, being superior to US in differentiating lesions of rotator cuff and other structures of the shoulder, but it was considerably more expensive. For these reasons, US, if performed by an experienced sonographer, is the next study performed after conventional radiography. In this exhibit, we will illustrate examples of these features for a variety of clinical conditions.

Loss of "adhesive capsulitis" as a diagnosis in shoulder MRI

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MRI of the shoulder has replaced double contrast shoulder arthrography as the investigation of choice at the Royal National Orthopaedic Hospital Trust. MRI alone is unable to assess shoulder joint distensibility and volume restric-

tion. A retrospective review was undertaken to determine the effect of the introduction of shoulder MRI on the radiological diagnosis of "adhesive capsulitis"/"frozen shoulder". 45 arthrograms in 45 patients in the year prior to MRI installation and 87 shoulder MRIs in 75 patients in the subsequent year were analysed. Prior to MRI, arthrography in 45 patients revealed 11 (24%) to have "adhesive capsulitis" as assessed by significant volume reduction and lack of distensibility. As predicted, no (0%) patients from 87 MRI examinations were diagnosed as adhesive capsulitis. Our ability radiologically to diagnose this common condition, which accounts for almost one quarter of arthrographic diagnosis, appears to be lost. The consequences of this loss to the clinician and ultimately patient management are under further study.

MRI of the shoulder in sickle cell disease

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In a recent clinical and radiographic assessment of the shoulder in sickle cell disease we found an overall incidence of 28.3% for humeral head involvement. The present study was undertaken to evaluate the MRI findings in 10 symptomatic shoulders which had normal radiographs. Ten asymptomatic shoulders were also examined as a control group. The asymptomatic shoulders were either the opposite shoulder in a patient with one symptomatic shoulder (six) or both shoulders of an asymptomatic patient with sickle cell disease (four). There was no difference between the two groups in age and sex. 80% demonstrated extensive amounts of haematopoietic marrow in the proximal humeral shaft, with 60% of humeral heads showing moderate or extensive amounts of haematopoietic marrow. This finding was the same in the control and study groups. Infarcts were detected in two symptomatic shoulders and four asymptomatic shoulders. The relationship between infarcts and previous shoulder crises is discussed. In four patients evidence of acromioclavicular joint degenerative change was seen on MRI. No evidence of associated supraspinatus tendinitis was present in any case. Three of these shoulders were symptomatic and one was asymptomatic. Although MRI does demonstrate abnormalities in sickle cell shoulders, which are radiographically normal, the correlation with symptoms is weak.

9.00 – 10.15

MR Technology II

Argyll II

From morphological images to quantitative MRI: A technical challenge for MR tissue characterization

J D de Certaines

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Although MRI is quite good at representing normal and abnormal anatomic structure in soft tissues, quantification for tissue characterization and representation of functional information have been up to now more difficult to obtain. In addition to the routinely available T_1 , T_2 or N(H) weighted images, there are flow, diffusion and IVIM, magnetization transfer, texture, magnetic susceptibility, calculated T_1 , T_2 or N(H) images of each nucleus and chemical shift. Progress in quantitative MRI (QMRI) has profited from development in MRI Quality Assessment (MRIQA) as for instance expanded under the auspices of the EEC programme COMAC-BME on Tissue Characterization by MRI and MRS (1984–1992) with Eurospin test-objects and protocol. The Eurospin procedure has now been used in nearly 200 NMR units in Europe, providing a good technical basis for QMRI. Accurate QMRI allows tissue characterization to be performed by image segmentation and identification of clusters for pathology, texture analysis and histological image synthesis as TTI (Tissue Type Imaging). Furthermore MRIQA is a preliminary request for multimodality image processing. The final goal of QMRI is not only to estimate the potential of new automated MRI methods for medical use. It is to integrate them into diagnostic algorithm for improvement of specificity, otherwise they will remain of academic interest only.

A novel MRI sequence providing T_2 contrast that depends on the exchange properties of water

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A novel MRI sequence is described, providing images in which contrast gives information on the exchange properties of water. This sequence is based on the observation that

measured values of transverse relaxation times (T_2) can depend markedly on the experimental conditions used in their determination. Spatially heterogeneous systems contain regions of varying magnetic susceptibility that give rise to magnetic field gradients. The diffusive exchange of water molecules through these gradients may result in multi-exponential transverse relaxation and cause the measured value of T_2 to depend on the value of the pulse-spacing (2τ) used in the T_2 determination. Chemical exchange can also confer a pulse-spacing (2τ) dependence to T_2 . When 2τ is long compared to the exchange rate (k), the exchange causes a dephasing of spins and hence enhanced relaxation. Conversely, when 2τ is short relative to k there is no exchange contribution to dephasing and measured relaxation times are relatively longer. As cellular systems tend to be heterogeneous and often contain solutes with exchangeable protons, then T_2 contrast can be manipulated by varying the pulse spacing used in the imaging sequence. This is demonstrated using a novel MRI sequence in studies of some samples of biological origin, including human tissue.

Development of information theory in MRI sequence evaluation

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The quantitative comparison of different MRI sequences or scanners is complicated by the virtually infinite number of sequence parameter variations available. The use of standard image quality measurements such as signal-to-noise ratio (SNR), uniformity and resolution gives an indication of the performance of the scanning hardware but cannot answer such questions as: "When is it more effective to use 3D acquisition as opposed to 2D multi-slice?", or "Is 512×512 acquisition better than 256×256 ?" A method for quantifying the totality of information produced by an acquisition is required. Information theory presents one route forward. The information content (in bits per unit area or unit volume) can be derived from straightforward measurements using test objects. Also important is the

information content per unit scan time and the effective information content normalized to square root time. These parameters, it is argued, are more relevant to MRI and examples illustrate how the new parameters function in practice. From this approach a general figure of merit for a given acquisition can be calculated. This figure reflects the amount of information generated by the sequence with regard to the sources of image degradation (noise, ghost artefacts, uniformity, spatial resolution and slice thickness).

The development of a Magnetic Resonance Imaging motion test object: ultrasound quantitation of respiratory motion

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Respiratory organ motion produces serious artefacts in abdominal magnetic resonance imaging (MRI) and other imaging techniques where image acquisition time exceeds breath-hold capabilities. Despite the importance of organ movement there is limited quantitative information available. A quantitative study of respiratory organ motion was undertaken on 10 healthy volunteers using ultrasound, in order to design an MRI motion test object. Total organ displacement was measured during quiet respiration and deep inspiration with a linear array ultrasound transducer. A motion-made scan taken with a sector scanner enabled organ displacement during the respiratory cycle to be followed; the velocity and acceleration were also calculated. Results demonstrated that there were considerable inter-subject variations in the displacement, velocity and acceleration of various organs. The average quiet respiratory cycle time was 4.5 s, with an average maximum displacement of 12 mm for the diaphragm and 10 mm for the upper liver. The average maximum displacement after deep inspiration was 43 mm for the diaphragm and 37 mm for the liver. The results have been used in the development of a motion test object which should prove useful in developing techniques for reducing motion artefacts in MRI.

The development of a Magnetic Resonance Imaging motion test object: design and operation

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Artefacts caused by organ motion can limit the diagnostic value of an image, particularly in magnetic resonance

imaging (MRI). The MRI motion test object (MTO) is designed for assessing respiratory organ motion effects on MRI image quality and for future use in the evaluation of manufacturers' techniques for reducing or compensating for motion induced artefacts. The MTO motion parameters are derived from ultrasound studies of abdominal organ movement. The MTO, constructed of non-metallic material, is driven pneumatically and has a "cycle" time controlled by an electronic switch. It is designed to allow a range of horizontal displacements (5–40 mm) and vertical components (0–26 mm). The movement of the MTO has been validated to correspond to typical respiratory motion. Results have been obtained of the validation of test object movement and the appearance of artefacts for typical imaging sequences which are described in the following abstract, by J P Bean et al (this page). The MTO simulates respiratory organ motion, can be used for assessing the effects of such motion on image quality, and with improvements may be useful as an MRI quality assurance test object.

Analysis of motion artefacts and motion artefact correction techniques: their effect on image quality

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Motion artefacts seriously affect image quality in MRI, particularly so in imaging of the abdomen and thorax. This has led manufacturers to utilize techniques that overcome motion artefacts, for example: fast imaging sequences, special ordering of the phase encode cycle to minimize the effect of the respiratory cycle, and post-processing of the data to remove artefacts. It is the function of MAGNET, the magnetic resonance National Evaluation Team, to quantitatively compare the imaging performance of MRI systems from different manufacturers. To assess the success of the motion correction techniques and the effect on image quality, a performance assessment test of motion artefact and correction techniques is needed. For this purpose a motion test object has been developed (see preceding abstract, above) Images have been obtained to compare the image quality, using typical abdominal imaging sequences with the test object (a) stationary and (b) moving. Analysis of image quality using spatial and Fourier domain techniques is presented comparing the two cases. Results to date indicate that the approach adopted here to assess image quality in the presence of motion artefacts is an important performance assessment test.

Quantitative dynamic studies of contrast uptake in intracranial tumours using ultra high speed IR-EPI

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The overall effects of intravenous gadolinium DTPA on tissue signal in intracranial tumours are complex, depending on dosage, time of administration, pulse sequence and the micro-architecture of the component tissues. In a group of 14 patients with intracranial tumours it has been possible to examine both vascular uptake and diffusion across the blood-brain barrier in a single experiment by using the IR-MBEST echo-planar technique which combines the advantages of strong T_1 weighting with high temporal resolution. The amount of blood flow to a tissue and richness of the vascular bed determine the "wash-in" phase and are major determinants of the "wash-out" phase. The rate and amount of contrast medium accumulating in the extracellular space are determined by the degree of breakdown of the blood-brain barrier. The uptake curve for an individual tumour reflects these different processes and by modelling them mathematically it has been possible to abstract an index of both tissue vascularity and permeability of the blood-brain barrier. These indices could have important clinical applications, both in tumour staging and assessment of response to treatment.

Vertebral body blood supply on gadolinium enhanced Magnetic Resonance Imaging

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A retrospective study was performed to see if bone blood supply can be assessed on gadolinium enhanced magnetic resonance imaging. Lumbar spine MRI scans of 40 patients attending for post-laminectomy examination were reviewed (23 males, 17 females, mean age 46 years, age range 23-84 years). Each study included sagittal T_1 weighted spin echo sequences pre- and post-gadolinium. Regions of interest were drawn within the L3 vertebral body from a parasagittal and midline sagittal slice from each sequence. Signal intensity (SI) values were obtained and the percentage increase in SI was calculated. For each patient, changes in receiver gain for pre- and post-gadolinium images were corrected by an image scaling factor. In all cases, a measurable increase in SI was found (mean 16.5%, SD 10.3%, range 5.3-56.5%), due to bone vascularity. The results give no indication of the quality or timing of blood supply but provide a basis for further work.

Observations on the *in-vivo* measurement of temperature using MRI

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We continued our studies designed to optimize the use of MRI for the *in vivo* monitoring of tissue temperature. Changes in T_1 (Dickinson et al, 1986) and the diffusion coefficient (Le Bihan et al, 1989) have been proposed as methods of *in vivo* monitoring of tissue temperature changes, primarily for monitoring hyperthermia, but also for advanced MR techniques such as magnetization transfer, and proton decoupling in spectroscopy. Temperature changes were created in volunteer calf muscles by using bags through which water at a controlled temperature was circulated. Temperatures were monitored using implanted and surface mounted thermocouples. The tissues were imaged at 0.15 T with various sequences. The most effective method of monitoring tissue has been to observe changes in T_1 (Hall et al, 1990). This has previously been measured using one reference sequence, and many rapidly acquired data sets. However we now find that T_1 changes less than earlier results suggested, though there are significant changes in the effective proton density, partly, at least, due to changes in the blood signal. The method of temperature measurement previously favoured still seems that which offers the simplest, least complicated experiment. Its mechanisms are, however, complex, and calibrations of temperature from one tissue to another may differ.

References

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NMR microscopy of single isolated neurons: the properties of cellular water

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We examined the characteristics of single cells using NMR microscopy on a neural cell model. The T_1 , T_2 , diffusion and magnetization transfer (MT) contrast characteristics are reflective of the cell structure. Studies were performed on an 8.5 T Bruker spectrometer using a home-built micro-imaging probe. The L7 neuron was isolated from *Aplysia*

and placed in a 600 μm capillary. T_1 , T_2 diffusion and MT image data sets were collected ($20 \times 20 \times 100 \mu\text{m}$) and analysed on a SUN computer as a two-compartment system. The T_2 and diffusion coefficients were several times shorter in the cytoplasm than the nucleus. Cytoplasmic T_2 tripled after cell death indicating a loss of the cell membrane integrity. MT is similar to T_2 contrast. We found that relaxation, diffusion and MT data sets can be obtained on single cells in acceptable acquisition times. The nuclear

and cytoplasmic compartments are very different and their characteristics change with perturbations, inferring structural changes within the cells. MT images confirm that the T_2 changes are due to real water restriction and not susceptibility effects. These data indicate the importance of including a nuclear compartment when interpreting NMR characteristics of macroscopic assemblies of cells, *i.e.* human tissues.

9.00 – 10.15

Paediatric Imaging

Argyll III

Modern imaging of spinal dysraphism in children

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Spinal dysraphisms include a wide variety of malformations such as spina bifida, tethered cord, spinal lipoma, diastematomyelia and other rare conditions. MRI is the examination of choice for the diagnosis and presurgical work-up of such malformations. More than 300 were studied in the Enfants Malades during the last three years with MRI. Spina bifida is less and less often seen in our institution thanks to prenatal diagnosis. Antenatal MRI helps to diagnose associated malformations. Spinal lipoma associates low attached cord with an intradural lipoma. It can be classified into two types depending on the relationship between the lipoma and nerve roots. Diastematomyelia is probably due to an incomplete duplication of the neural arch of the spinal canal. A new understanding of this unique malformation will be given. Other rare malformations will be presented as well.

Evaluation of the MR appearances in patients following surgery of spina bifida anomaly

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A retrospective review of patients imaged following surgery for spina bifida was undertaken to assess the amount of associated intraspinal abnormality. 27 patients, age 9 months to 57 years, who presented with local pain or progressive sensorimotor disturbances were referred for further assessment by Magnetic Resonance (MR) imaging. Sagittal and axial T_1 weighted spin echo (SE 500/25) images, with a slice thickness of 3–5 mm, were used. Other sequences were used only if indicated. Children under 6–7 years required general anaesthesia. Only five patients had MR scans pre- and post-surgery. The surgical level was:

cervical in four, thoracic in five and lumbar in 18. Associated Arnold-Chiari malformations were present in six and vertebral body anomalies in 13. A tethered cord was present in association with a low lying conus in eight. In 15 patients local tethering of neural tissue was observed at the site of surgery. Intrathecal masses (11), lipomata (12) and syrinxes (12) were detected. MR is a non-invasive and relatively rapid method to demonstrate residual spinal lesions in this highly selected group of patients. In patients with spina bifida significant intraspinal lesions requiring follow-up or consideration for further surgery may be identified.

“True FISP” MR Imaging in spinal dysraphism

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Magnetic Resonance (MR) Imaging is of established value in the assessment of spinal dysraphism. Conventionally, 2D-FT Spin Echo (SE) images are obtained but multiple acquisitions are frequently necessary to provide full demonstration. The 3D-FT “true-FISP” sequence (TR = 14, TE = 4, FA = 40) offers multi-planar imaging from a 3D data set, improved resolution, and myelogram-equivalent contrast with low susceptibility to CSF flow artefact. A 3D “true-FISP” sequence, and conventional T_1 weighted sagittal SE images (TR = 500, TE = 15), were performed in 10 patients (ages ranging between 6 months and 50 years) who had lower spinal dysraphic syndromes. Examination time (on a 1.0 T Siemens Magnetom 42 SP imager) totalled approximately 15 min. A spectrum of dysraphic abnormalities was clearly demonstrated by 3D “true-FISP” imaging in combination with a single T_1 weighted sagittal SE sequence. Illustrative examples of the case material are presented, highlighting particularly the value of multi-planar reformation in the assessment of complex anatomical derangement. 3D “true-FISP” imaging in combina-

tion with a conventional T_1 weighting sagittal acquisition allows a fast and complete assessment of spinal dysraphism and can replace sequences traditionally used.

Radiographic features of limb lengthening in children

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Bone lengthening procedures using gradual callus distraction (callotaxis) have become a reliable and predictable means of correcting limb length discrepancies. We report our experience in plain radiographic imaging of limb lengthening procedures using callotaxis for congenital limb length discrepancy using a monoaxial external fixator (Orthofix). 17 patients completed 21 bone segment lengthening procedures using this device. Seven femora (average discrepancy 9.8 cm), 11 tibiae (average discrepancy 6.5 cm) and four ulnae were lengthened. Age at operation ranged from 5.7 to 17.7 years (average 10.8 years). Serial radiographic examination was employed in all patients. Progressive evidence of consolidation of the newly formed bone was assessed and graded. The healing index was quite different in the three bony segments lengthened, with the femur averaging 28.9 days cm^{-1} , the tibia 35.8 days cm^{-1} , and the ulna 38.3 days cm^{-1} . Amorphous abnormal bone development was seen in four patients. The commonest radiographic abnormality seen was a periosteal reaction around the pin sites which occurred in 81% of patients. Pin loosening was present in 57% of children. Angulation was detected in 52% of patients in the AP plane. Six patients developed a ragged radiolucent region through the newly forming bone. Problems and complications of the technique are presented.

Magnetic Resonance Imaging of fibrous dysplasia of the skull vault

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Fibrous dysplasia is a relatively common benign developmental disorder, in which normal bone is replaced by a fibrous stroma containing variable numbers of poorly formed trabeculae of woven bone. The incidence of craniofacial involvement is approximately 10% in the monostotic form of the disease, but rises to over 50% in patients with polyostotic forms. We describe the Magnetic Resonance (MR) appearances in two patients with fibrous dysplasia of

the skull vault. There have been few descriptions to date of the appearances of fibrous dysplasia on MRI and to our knowledge this report is the first to describe the MRI appearances of fibrous dysplasia of the craniofacial bones. MRI is a useful modality to show the extent of fibrous dysplasia involvement in the cranium. It is also excellent at demonstrating distortion of the underlying brain and related structures, and its multiplanar imaging capacity makes it superior to CT in this respect. However, MRI appearances are not specific for fibrous dysplasia and the diagnosis must be made by combining the history, examination findings and appearances on other radiological imaging modalities. Biopsy is however rarely required for making the diagnosis.

Parotid calcification in childhood – calculi or haemangioma?

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The most common cause of salivary gland calcification in adult patients is calculus formation, usually secondary to infection, sialectasis and ductal stasis. Calculi are uncommon in childhood, and diagnostic confusion can arise, particularly in children but also in adults, with salivary gland haemangiomas containing calcified phleboliths. Haemangiomas tend to undergo spontaneous thrombosis, which may result in episodes of pain and swelling, adding further to diagnostic difficulty. We present three cases of parotid haemangioma in children, in which initial radiographs showed calcification. The correct diagnosis was made in these cases using ultrasound with colour flow mapping, computed tomography and magnetic resonance imaging. Diagnosis depends on the demonstration of a mass lesion containing abnormal blood vessels and vascular spaces, and characteristic change in the size of the lesion with posture is also helpful. Awareness of this entity in childhood is important in order to avoid inappropriate investigation and surgery.

Doppler ultrasound in Pelviureteric Junction Obstruction (PUJ) in infants and children

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Renal arterial Doppler studies have proven useful in adults in differentiating obstructive from non-obstructive kidneys.

We proposed to assess the potential diagnostic use of renal Doppler in infants and children with proven PUJ obstruction. We carried out a prospective study of eight children (age range 3 weeks–6 years, mean 4 years). Three arterial Doppler signals were obtained from each kidney before and 10 min following intravenous frusemide. Resistance indices (RI) were calculated. Each study was correlated with the DTPA examination using frusemide and the surgical findings. In three children the Doppler study was repeated 1 week post-pyeloplasty and correlated with a nephrostogram. Initial RIs for all kidneys were within the normal range (< 0.75). Following i.v. frusemide the RIs in obstructed kidneys increased to > 0.75 and the difference between the obstructed and non-obstructed side was > 0.01 . In one case (3 weeks old) the resting RIs were high and following frusemide diastolic flow was absent in the obstructed kidney. Following pyeloplasty kidneys which did not drain at nephrostogram had high post-frusemide RIs (> 0.75). We conclude that renal arterial Doppler studies are of value in confirming a diagnosis of PUJ obstruction in children. They may also provide another role to assess the results of pyeloplasty.

Vanishing simple renal cysts and vesicoureteric reflux in children

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Until recently solitary simple renal cysts were considered extremely rare in children. Review of the world literature reveals only 33 cases reported prior to 1979, mostly presenting as an abdominal mass. Latterly, with increasing use of ultrasound, asymptomatic simple cysts are being recognized more commonly. A review of abdominal ultrasounds performed at this centre revealed 10 cases during the last five years. This represents a 0.15% frequency. The investigation of these children is discussed, particularly the role of intravenous urography, with reference to the important differential diagnoses of obstructed duplication abnormalities and calyceal diverticula. The majority of cysts remain unchanged in size at follow-up. Only two cysts reduced considerably in size; this occurred in the only children in whom vesicoureteric reflux had been demonstrated. The occurrence of simple renal cysts in children with vesicoureteric reflux has been documented in at least two cases, as have cysts spontaneously reducing in size. The possibility of an association between simple renal cysts which become smaller and vesicoureteric reflux has not been reported previously. The natural history of simple childhood cysts is unknown at present. Intervention is unlikely to be necessary in asymptomatic children. Long term ultrasound follow-up is recommended.

Renal Doppler ultrasound in normal infants and children

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Doppler ultrasound studies have found an increasing role in the assessment of the adult kidney. Because of its safety and lack of known risks, ultrasound is an ideal method of imaging in paediatrics. It is invalid to assume that normal values in adults can be transferred to paediatric studies. We have performed Doppler studies to assess normal arterial waveforms in infants and children. All children referred for a DMSA study also had a renal Doppler study performed within 24 h. Those with an abnormal DMSA study were excluded from the study. Arterial signals were obtained from upper, mid and lower portion of each kidney and resistance indices (RIs) were calculated. In normal infants the RIs are high (0.8–1.0). From age 2–10 years the upper limit of normal is 0.75. After the age of 10 the RIs are equivalent to those in adults (< 0.7).

The paediatric bladder revisited

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Enuresis is a common paediatric condition but can be a difficult, socially debilitating, problem. Careful ultrasound assessment of the bladder in these cases can identify abnormalities, select those who would most benefit from more invasive techniques such as urodynamics, or suggest normality in those who are suspected of having primary psychosocial problems. We describe the techniques involved in the careful assessment of bladder contour, bladder wall thickness, bladder neck, trigone, and insertion of distal ureters as part of the routine ultrasound examination of the renal tract in enuretic patients. The results of the examination of 200 enuretic patients over a 2 year period will be presented and typical appearances of the unstable bladder, neuropathic bladder and structural defects will be illustrated with selected cases.

Imaging in non-obstructive chronic renal failure of unknown aetiology in young children

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Children who are in established non-obstructive chronic renal failure (CRF) which is not part of the clinical features of a named syndrome nor secondary to any precipitating

cause will probably be labelled by the clinicians as having renal dysplasia. This study is a retrospective review of the nuclear medicine, ultrasound and radiology in this group of children in an attempt to define their imaging characteristics and to establish the relative value of the different techniques. Between 1980 and 1990, 53 children under the age of 2 years presented at the Hospital for Sick Children with stable non-obstructive CRF, and of these there were 27 in whom the aetiology of renal failure was unknown and

who were included in the study. Characteristic ultrasonic features were found (small, bright kidneys with loss of corticomedullary differentiation and, in a third of cases, small cortical cysts), suggesting that ultrasound holds the key to the diagnosis of the aetiology of renal failure in this group of children. MCU demonstrated reflux in 52% and in these cases usually also demonstrated a dysplastic pelvicalyceal system. DMSA scanning was of limited value. DTPA scanning and IVUs were of no value.

9.00 – 10.15

The Barium Enema Examination

Seminar Suite I

Patient factors that contribute to a successful bowel preparation for a barium enema examination: A review of 100 patients

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Inadequate bowel preparation remains a problem in barium examinations of the large bowel despite many different laxative preparations. A prospective study of 100 patients, in the form of a questionnaire, was undertaken to ascertain the patient factors which determine the success of bowel preparation. Information recorded from the questionnaire included normal bowel habit, normal dietary fibre, fluid consumption prior to the procedure, amount of laxative actually taken and subsequent frequency of bowel action. The barium enemas were divided into four groups depending on the amount of faecal material present. 24% of the patients admitted to taking less than the required amount of laxatives and attributed this to the effects of the first sachet. 44% had impeccable preparation and 22% had gross faecal contamination. A positive correlation between bowel cleanliness, high fluid intake and number of bowel actions was established (> 10 times had the best results, < 2 the worst). Patients on a high fibre diet normally had better bowel preparation. Those with > 3 daily bowel actions normally were more likely not to take the preparation and have poor bowel preparation. We conclude that patients with frequent bowel actions need to persist with the prescribed laxatives and the number of bowel actions on the day prior to the procedure is the best predictor of the quality of the examination.

How do requests for outpatient barium enemas compare between general practitioners and hospital physicians?

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Currently, general practitioners (GPs) have restricted access to barium enemas (BEs) in many centres. The changes in

the structure of the Health Service with a purchaser/provider emphasis and the formation of GP fund-holding practices may provide pressure for this current restriction to be reviewed. We have analysed a comparable number of consecutive GP and out-patient based hospital physician (HP) BE requests, reviewing and correlating indications and outcome. Over a six month period HPs requested 179 BEs (mean age of 58 years). The indications were felt to be good in 59.7%, moderate in 13.4% and poor in 26.8%. Significant large bowel pathology was demonstrated in 10.6%. Correlating indication to outcome showed that if the indication was moderate/good there was approximately 13% probability of significant disease while with a poor indication only 4%. 143 GPs requested BEs (mean age of 56 years). Indications were good in 40.5%, moderate in 21% and poor in 38.5%. Significant large bowel pathology was demonstrated in 23%. Correlating indication to outcome showed that if the indication was moderate/good there was a 25-30% probability of demonstrating significant disease while there was only an 18% probability with a poor indication. The study has reaffirmed the importance of scrutinizing requests from all sources rather than limiting primary care access.

Retrospective audit of barium enema referrals to colonoscopy

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We wished to assess the accuracy of routine barium enema (BE) reports. Consecutive BE reports over four months were reviewed and results compared with colonoscopic findings. Of 228 BEs, colonoscopy was definitely or probably indicated in 87. 57 subsequently underwent colonoscopy. Three further patients with normal BEs underwent colonoscopy. An abnormality shown at BE was confirmed by colonoscopy in 21 patients (16 polyp/cancer, two IBD, one benign stricture, one lipoma and one pseudo-obstruction). In two of these patients, three additional polyps (2, 2

and 4 mm) were also seen. Colonoscopy concurred in two of the three patients with normal BEs. In 31 patients a possible abnormality was reported, or else the barium study was felt to be technically inadequate (usually because of preparation difficulties or severe diverticular disease); in four of these, five small polyps (3, 4, 5, 5, 7 mm) but no other significant lesions were detected on colonoscopy. In six patients there was disagreement between the BE and colonoscopy. Three reported polyps and two aphthoid ulcers were not detected at colonoscopy. In one patient reported as normal, angiodyplasia was discovered. Overall, eight polyps (all 7 mm or less) were missed in six patients by BE. We conclude that: 1. a confident BE report of a lesion is reliable; and, 2. in BE patients who subsequently undergo colonoscopy, missed polyps are likely to be 7 mm or less.

Is there still a role for double contrast barium enema (DCBE) in the detection of colonic polyps?

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It is established that colorectal carcinoma arises from adenomatous polyps in which the risk of malignant change is related to polyp size and histology. It is therefore important to identify patients with colonic polyps. The aim of this study was to compare DCBE and colonoscopy in the detection of colonic polyps. Between 1986 and 1991, 104 patients noted to have polyps at one examination subsequently underwent the alternative test. DCBE was the initial investigation in 73% of patients. There were 60 males and 44 females with a mean age of 64 years. Their presenting complaints were blood pr (36%), change in bowel habit (27%), abdominal pain (23%), anaemia (9%) and weight loss (5%). 176 polyps were identified and 116 (65%) were documented by both DCBE and colonoscopy. 44 polyps were missed radiologically (false negative rate: $44/176 = 25\%$) and 16 were missed by colonoscopy (false negative rate: $16/176 = 9\%$). 17 patients had multiple polyps and there was malignant transformation within the polyps in eight patients. Of the 92 polyps which were < 5 mm diameter, 28 were missed by DCBE (30%) and 12 were missed by colonoscopy (13%). No polyp > 10 mm diameter was missed by either procedure. There were 148 left-sided and rectal polyps and 44 (29%) were missed by DCBE and seven were missed at colonoscopy (5%). DCBE detected all of the 28 polyps in the transverse colon and the right colon. Colonoscopy, however, missed nine (32%) of these. This study suggests that DCBE and colonoscopy are

complementary procedures in the detection of colonic polyps. Whereas small left-sided polyps are best detected by colonoscopy, polyps proximal to the splenic flexure may be better evaluated by DCBE.

Is the quality of indications for a barium enema and subsequent outcome superior for the specialist gastroenterologist?

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350 barium enemas (BE) were reviewed, comparing a mixture of inpatients and outpatient referrals from hospital specialists. The indications and outcome of the BE examinations were analysed and correlated with the specialist nature of the referring doctor. Indications were classified into three categories: good, moderate and poor, determined by the clinical details on the request form. 238 BEs were requested by physicians or surgeons with a specialist gastrointestinal interest. The indications were good in 155 (65%), moderate in 26 (11%) and poor in 57 (24%) BE requests. 58 (24%) revealed significant large bowel pathology. Correlating indication to outcome showed that there was a 33% probability of finding significant disease with a good indication, only an 11.5% probability with a moderate indication and an 8% probability with a poor indication. 110 BEs were requested by physicians or surgeons without a particular gastrointestinal interest. The indications were good in 96 (87%), moderate in seven (6.5%) and poor in seven (6.5%). 33 (30%) revealed significant large bowel pathology. Correlating indication to outcome showed that there was a 30% probability of finding significant disease with a good indication and only a 14.2% probability with a moderate indication. This study suggests that BE requests should be scrutinized primarily by the indications provided, with only minor regard for the specialist interest of the referring physicians and surgeons.

The barium enema in the investigation of anaemia

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Chronic blood loss from the gastrointestinal tract accounts for up to half of the cases of iron-deficiency anaemia, and double contrast barium enema (DCBE) is a routinely

requested examination in such patients. A prospective study was performed to evaluate the abnormal yield of DCBE in patients with anaemia. DCBE was performed on 1854 patients during the course of one year. 124 patients had anaemia and formed the study group. A control group of 124 patients known not to be anaemic was randomly obtained from the remaining patients. The study and control groups were subdivided according to the absence or presence of bowel symptoms. The demonstration of a carcinoma or a polyp greater than 1 cm in diameter was considered a significant abnormality. There were 12 abnormal DCBEs (9.7%) in the study group (eight carcinomas, four polyps) and two abnormal DCBEs (1.6%) in the control group (both carcinomas). All lesions were histologically proven. This was a statistically significant difference (p approximately 0.01). Of those patients with anaemia, there were no significant lesions in cases of macrocytic anaemia or in patients with normal or raised serum ferritin. The presence of iron-deficiency anaemia is an important finding requiring investigation by DCBE.

A pilot study of an orally administered gut-selective antispasmodic in barium enemas

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Intravenous antispasmodics are a well accepted adjuvant to barium enema examinations but have unwanted systemic side-effects. A placebo-controlled pilot study of a novel orally administered gut-specific antispasmodic Zamifenacin (Pfizer Ltd) in a dose of 30 mg has been carried out in two parallel groups of 25 patients attending for routine double contrast barium enemas. Objective bowel measurements from standardized overcouch radiographs were undertaken by two independent observers using computerized planimetry. The observers also made subjective assessments of bowel spasm. Subjective patient side-effects were assessed by visual analogue scoring and standardized questionnaires. Bio-chemical and haematological parameters were monitored before and five days after the dose. Whilst the subjective evaluation of bowel spasm proved unreliable, the computerized bowel planimetry was highly reproducible, with negligible inter- and intra-observer variation. The technique will be described in detail. No statistically significant differences were demonstrated between the patient groups in respect of objective bowel measurements; however, there was a trend towards pain score reduction with Zamifenacin which did not reach statistical significance. There were no significant effects on biochemical or haematological parameters in either group.

Randomized blinded prospective trial of Citramag versus Picolax in bowel preparation for barium enemas

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The use of combination purgatives like Picolax, containing an osmotic agent, magnesium citrate and a surface-coating agent (sodium picosulphate), is commonplace in preparation for barium enema. The use of a single-agent laxative, magnesium citrate, as Citramag, has been suggested as an adequate alternative. The aims of this study are to compare patient acceptability and the effectiveness of both products. A total of 205 patients were randomized to receive either a single dose of Citramag ($n = 100$) or two doses of Picolax ($n = 105$). Age and sex distributions were similar. 170 patients were assessed for compliance, acceptability and side-effects on arrival. All examinations were scored for cleansing, barium coating and faecal residue, using blinded assessment by a consultant radiologist. Patient compliance and acceptability were excellent in both groups. Normal activities were inconvenienced more significantly with Picolax ($p < 0.001$). There was no significant difference in bowel coating or image quality between products, but bowel preparation was poorer after Citramag ($p < 0.001$) with significantly more cases having faecal residue ($p < 0.001$). Citramag is an acceptable alternative to Picolax when a small amount of faecal residue does not impair diagnostic quality and when patient convenience is considered.

Barium enema preparation: low residue diet, Picolax and Kleen-Prep

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A prospective, randomized three-arm trial of 150 consecutive patients attending for double-contrast barium enema was undertaken. This compared Picolax (a combined stimulant and osmotic agent), Picolax following a 3-day low-residue diet, and Kleen-Prep (a polyethylene-glycol osmotic agent). Faecal clearance, mucosal coating and colon fluid were scored in four colonic segments by two radiologists working independently and without knowledge of the preparation used. Analysis of an elderly sub-group and of patient side-effects was performed. Low-residue diet conferred no benefit to Picolax preparation, which was satisfactory (ability to exclude 5 mm polyps) in 80% of

patients. Kleen-Prep failed to achieve adequate preparation in 46% of patients due to excess fluid and poor mucosal coating. Kleen-Prep caused significantly more patient nausea, abdominal bloating and pain than Picolax. Patients 70 years and older ($n = 35$) had equal preparation quality to younger patients according to the method used. Low-residue diet need not be used in addition to Picolax. Kleen-Prep is not recommended for barium enema preparation.

Comparison of sodium picosulphate (Picolax) and magnesium citrate (Citramag) as bowel preparation in barium enemas

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Many bowel preparations are available for barium enema examination. This study was conducted to compare sodium picosulphate and magnesium citrate. 80 consecutive patients attending the Radiology Department at King's College Hospital were randomly allocated to sodium picosulphate or magnesium citrate, thereby forming the largest published series comparing these drugs. The barium enema films were assessed for diagnostic quality, with particular reference to faecal residue and coating, by two radiologists who were unaware which preparation had been used, and the patients were given a questionnaire to assess patient acceptability. The results, in terms of diagnostic quality and ease of following the preparation protocol, showed no significant difference between the two preparations. Depending on the criteria by which patient acceptability is

judged, each preparation had its own advantages and disadvantages. In conclusion, patient acceptability must be the parameter by which choice of preparation is judged, as no difference has been shown in diagnostic quality.

A comparison of single and combined laxative for bowel preparation

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A study to compare colon cleansing ability of bowel preparation using Picolax (magnesium citrate and sodium picosulphate) and Citramag (magnesium citrate alone) was done by randomly assigning 50 patients into two groups of 25 patients who underwent an outpatient double contrast barium enema examination. Three radiologists independently scored the cleansing of each site of the colon (right, transverse, left and rectum/sigmoid) in the resulting radiographs using a scoring system for bowel cleansing (Lee, 1984). In both subgroups the right side of the colon tended to receive the lowest scores and the transverse and rectum/sigmoid sites tended to receive the highest scores. There were consistent variations in scores between radiologists. There was no difference in bowel cleansing between the two subgroups. It was concluded that there was no significant difference in bowel cleansing between the preparations in this group of patients.

References

LEE J R, 1984. Combinations of laxatives for bowel preparation: Are they necessary? *Clin. Radiol.* 35, 461-462.

9.00 – 10.15

Oncological Imaging

Seminar Suite II

Preoperative staging of oesophagastric cancer — a prospective comparative trial

E Fitzgerald and G O'Sullivan

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Patients with oesophagastric cancer who have metastases outside the field of resection have a poor prognosis and rarely benefit from resection. To define the relative merits of current preoperative staging techniques we prospectively compared the accuracy of laparoscopy, computed tomography (CT) and ultrasonography (US) in the same patient group. 102 consecutive patients who had no evidence of metastatic disease clinically were studied. All of these were felt to be fit for surgery on anaesthetic review and had lesions distal to the upper pericardium. The investigators were blind to each others' findings and all positive results were verified by histology. Of the 102 patients studied 34 had metastatic disease outside the field of resection; laparoscopy detected 32 of these, CT 25 and ultrasonography 14. While laparoscopy is the most accurate method of detecting disease in these patients it is also invasive and requires general anaesthesia. As CT compares quite favourably with it we therefore recommend that these patients be staged initially with CT. Laparoscopy can then be done as a pre-operative procedure in the remaining group to detect those who have small transcelomic deposits not detectable on CT.

Comparison of computed tomography and visceral angiography in the assessment of resectability of pancreatic cancer

M E Roddie, N Jonker, J E Jackson, V Wood, R C N Williamson and A Adam

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One of the major contraindications to resection of pancreatic carcinoma is involvement of the extrahepatic splanchnic vessels. The purpose of this study was to

compare the ability of contrast-enhanced computed tomography (CT) and visceral angiography to assess vascular involvement by carcinoma of the pancreas. 44 patients with known pancreatic carcinoma underwent both abdominal CT (sequential table incrementation in 38 and volume scanning in six) and visceral angiography. The two studies were reviewed independently by two radiologists to compare the ability of each modality to predict irresectability on the basis of vascular involvement. Nine patients proved to have resectable disease at surgery, all of which were correctly predicted by both angiography and CT. 33 patients had irresectable disease, determined either at laparotomy (four patients) or by pre-operative imaging (29 patients). Angiography correctly predicted irresectability in 20/33 because of major vessel involvement, increasing to 21/33 when evidence of distant spread was included. CT correctly predicted 24/33 as irresectable because of vascular involvement but this increased to 29/33 when evidence of distant spread was included. We conclude that there is no longer a role for visceral angiography in the routine pre-operative assessment of patients with pancreatic carcinoma.

Treatment of liver metastases with interstitial laser photocoagulation: clinical update

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We present an update of our clinical experience using interstitial laser photocoagulation (ILP) to treat liver metastases. 74 liver metastases (median size 3.0 cm) have been treated in 27 patients. One to eight 0.2 mm optical fibres were inserted percutaneously into each tumour, via 19G needles, under ultrasound guidance. 2 W per fibre was delivered by a Nd:YAG laser for 500 s. Treatment effects were monitored in real-time with ultrasound, and extent of tumour necrosis evaluated 1–3 days later using dynamic CT and MRI. Thermal changes during ILP were seen with

ultrasound. Dynamic CT clearly showed laser-induced necrosis after ILP as a new area of non-enhancement; this was also seen on MRI using gadolinium-enhanced T_1 weighted sequences (fast spin-echo and gradient echo). Greater than 50% necrosis of tumour volume was achieved in 85% (63 out of 74) of the tumours treated, and 100% necrosis in 54% (40 out of 74). Life survival analysis gave predicted 1 and 2 year survivals of 84% and 74%, respectively. In conclusion, ILP may offer a practical and minimally invasive alternative to major surgery for treating patients with small volume liver metastases. Improvements are still needed, particularly with accurate monitoring of thermal damage during ILP.

The computed tomographic features of granulosa cell tumour of the ovary and its role in management

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Pure granulosa cell tumours of the ovary account for less than 1.5% of ovarian malignancy and their CT features have hitherto remained undescribed. The clinical and radiographic files of 15 patients with pure granulosa cell tumour seen at the Marsden Hospital have therefore been reviewed and the imaging features of these tumours have been identified. The radiological pattern of relapse has been assessed and correlated with clinical progression in order to establish the role of CT in the clinical management of patients with these tumours.

Ultrasonographic diagnosis of metastatic melanoma of the gallbladder: A retrospective study and review of the literature

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900 ultrasound examinations of the upper abdomen performed over a three year period (1.3.89-1.3.92) on 464 patients diagnosed as having malignant melanoma were reviewed. Of these patients 23 (5.2%) were found to have hyperechoic polypoidal or nodular material projecting from the wall of the gallbladder either at initial or follow-up examinations. In view of the fact that autopsy studies have confirmed the incidence of gallbladder metastases from malignant melanoma to be 15-20%, it is advocated that a careful study of the gallbladder by ultrasound be made when staging and following up these patients.

MR Imaging of thoraco-abdominal lymphoma

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MR Imaging is developing an increasing role in the management of lymphoma. Disease site and extent may be clearly identified, and MRI rivals high dose gallium scanning as a predictor of disease relapse following treatment. Our experience of thoraco-abdominal MRI in 64 patients (103 scans) is reviewed. The principal clinical indications for MRI, which include definition of extent of soft tissue lymphoma and assessment of activity in residual masses after treatment, are discussed. Signal intensity of active lymphoma may vary between patients and between sites of disease in an individual patient. The characteristic morphological abnormalities and range of signal changes observed in lymphoma are illustrated. MRI has proved useful in the evaluation of post-treatment residual masses and its role in assessment of disease activity and planning of further treatment is analysed. Although CT remains the primary investigation in diagnosis, staging and follow-up of thoraco-abdominal lymphoma in our practice, MRI has developed an important supplementary role in management of the disease.

Problems and pitfalls using transvaginal colour Doppler sonography (TVCDs) in the diagnosis of ovarian neoplasia

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We wished to illustrate potential pitfalls and problems in the use of transvaginal colour Doppler sonography (TVCDs) in women examined to exclude ovarian neoplasia. Sonography, clinical findings and surgical pathology are described for 16 representative women who at initial TVCDs examination had abnormal pulsatility index (PI) measurements (PI 0.35-0.98; normal > 1.0) at sites in or around adnexal lesions. All women had either resolution of abnormalities at repeat sonography or benign surgical pathology. Abnormal but reversible PI during TVCDs examinations was from corpus luteum activity in six women with unreliable (peri-menopausal) or unpredictable (post-hysterectomy) menses. Endometrial thickness of 7-11 mm at initial examination reduced to 2-4 mm immediately following menstruation with normal PI values at follow-up (PI 1.44-3.26). Similar reversible findings occurred in three high-risk women whose ovaries were screened for metastasis from breast cancer. In seven women

benign neoplasms, inflammatory or haemorrhagic pathologies resulted in adnexal masses with low PI, mimicking malignant ovarian neoplasms. Abnormal TVCDs findings must not be interpreted in isolation from grey-scale and clinical findings. Menstrual haemodynamic effects should always be considered when abnormal PI values are obtained; endometrial thickness may be helpful. When low PI is the only abnormality, re-examination immediately following the next menses is advisable. In a range of benign pathologies which sonographically mimic ovarian malignancy TVCDs affords no discrimination.

Pre-operative embolization of soft tissue tumours

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Soft tissue tumours are highly vascular structures and during resection will result in a large intraoperative blood loss. This has in the past presented problems to the surgical team and pre-operative embolization has been suggested as a means of reducing the vascularity of the tumour and therefore the intraoperative blood loss. This is usually performed 24–48 h before surgery. We wish to describe the technique of pre-operative embolization of soft tissue tumours and to present three cases of soft tissue tumours where this has been performed — a case of high grade leiomyosarcoma, a case of malignant schwannoma and a case of alveolar soft part carcinoma. In each of these cases, the operating surgeon has found that pre-operative embolization has been effective in reducing the vascularity of the tumour and therefore reducing intraoperative blood loss. Pre-operative embolization of soft tissue tumours is a useful adjunct to surgery in the treatment of soft tissue tumours and is an essential part in helping to reduce intraoperative blood loss and therefore reducing the intraoperative morbidity of the patient.

Duplex ultrasound for radiation arteritis in upper limbs

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Arteritis causing ischaemia can result from ionizing radiation. Axillary radiotherapy has been used in breast cancer. The prevalence of upper limb arterial damage from such irradiation is unknown. This study used Duplex ultrasound

to assess upper limb arteries after radiotherapy. 34 arms in 17 breast cancer patients of whom 14 had received unilateral axillary radiotherapy 14–18 years previously were studied blind. With patients supine, arms adducted, Duplex ultrasound recorded velocity waveforms at brachial, axillary (in axilla), proximal axillary (infraclavicularly), and subclavian arteries — total 136 sites. Brachial blood pressures were measured bilaterally. Abnormal axillary and brachial waveforms (slow upstroke, spectral broadening, reduction in second and third components) were detected in seven irradiated arms, no mastectomy alone arms and no contralateral “normal” arms, $p < 0.05$; the latter two groups and remaining irradiated arms had normal triphasic wave forms. Asymmetrical blood pressures occurred in five patients, all irradiated, with significantly lower systolic \pm higher diastolic readings on the irradiated arm. In conclusion, abnormalities in arterial flow were detected using Duplex ultrasound in axillary radiotherapy field in 50% irradiated breast cancer patients. Furthermore, ultrasound detected more abnormal patients than blood pressure measurement. Further ultrasound studies of such arterial complications are indicated.

Radiographic appearances of the oesophagus post-chemoradiation for carcinoma

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20 patients who underwent adjuvant therapy for oesophageal carcinoma, prior to surgery, were included. The use of combined-modality therapy programmes in trials so far has shown some improvement in one and two year survival statistics. All patients had barium studies before and after the chemo-radiotherapy regime. Three of the patients had mild bone marrow depression which delayed surgery by one week. There was no increased surgical difficulty or complications in any of the patients. All cases showed an increase in luminal diameter, on average a 300% increase, and a decrease in tumour length, on average a 56% decrease. A number of patients had histological cure on pathological examination of the surgical specimen which was correlated with the overall radiographic appearance and the patient's clinical condition. In this study barium examination has proved a simple and safe method to demonstrate the dramatic result of adjuvant therapy in patients with oesophageal carcinoma prior to surgery. We also demonstrate radiological pathological correlation between the barium studies and the histology of the surgical specimens.

10.45 – 12.00

Gastrointestinal Radiology

Argyll I

Normal and abnormal closure of the airways during swallowing

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The pharynx is the common canal for swallowed bolus and inhaled air. During swallowing it is therefore important to close the airways in order not to get bolus material into the airways. Such closure is achieved on four anatomically and functionally different levels, namely the epiglottis, the sub-epiglottic and the supraglottic portion of the laryngeal vestibule, and the vocal folds. Muscles involved in this closure are internal as well as external to the larynx. Dysfunction may occur at any of these levels. Of fundamental importance is also the coordination between the oral and pharyngeal stages of swallowing. Dissociation of these events leads to a delayed elevation of the larynx and pharynx. Thereby bolus material reaches into the pharynx before airway closure. This dysfunction is the most common cause of penetration especially among the elderly and/or demented. These dysfunctions often occur together with other abnormalities in the swallowing apparatus. The radiological appearance of such airway protection will be presented, together with findings during manometry and nuclear medicine studies.

Does "a lump in throat" warrant a barium swallow?

M L Wastie

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The feeling of a lump in the throat is a common problem accounting for about 4% of referrals to an ENT clinic. The condition goes under a variety of names of which globus pharyngeus is the most frequently used. Various causes have been postulated, from Hippocrates who thought it

was due to uterine dysfunction, to hysteria, cervical osteophytes, sinusitis, temporomandibular joint dysfunction, cricopharyngeal spasm, enlarged tonsils, gastro-oesophageal reflux and psychosomatic disorder. From January 1990 to June 1992 a barium swallow was performed on 66 patients (41 females, 25 males, average age 63 years) who complained of a lump in the throat. 48 patients had a normal barium swallow. 18 patients showed an abnormality, comprising: four hiatus hernia, four compression by goitre, three prominent cricopharyngeus impression, three webs, one aberrant right subclavian artery, one benign stricture, two malignant tumours (piriform fossa carcinoma, postericoid carcinoma). Only in the patients with a benign stricture and the two patients with malignant tumours did the radiological findings affect management. These three patients gave a history of dysphagia, which is not a feature of globus pharyngeus. In those patients who give a typical history of globus pharyngeus a barium swallow is unlikely to be of great value.

Flexible fibre-optic cholangioscopy in biliary obstruction as an adjunct to percutaneous cholangiography. A preliminary report

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The purpose of this project is to investigate the feasibility of introducing a fibre-optic endoscope into the bile ducts via a sheath introduced at percutaneous transhepatic cholangiography (PTC). 16 patients have undergone the procedure which is performed using a modified renal sheath introduced along the percutaneous track to permit ready access to the common bile duct. At present the endoscope is relatively undeveloped but permits visualization of the nature of the luminal or mural pathology and acts as a guide to brush cytology and basket forceps for biopsy at a

precise level. It is hoped to be able to develop the technique and apparatus in such a way as to allow better study of the bile ducts and to ultimately develop an endoluminal laser technique to treat strictures.

Common bile duct calculi in patients selected for laparoscopic cholecystectomy—true incidence

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Since the introduction of laparoscopic cholecystectomy there has been controversy regarding the incidence and method of detection of common bile duct calculi. In this study, we define the incidence of common bile duct calculi in patients selected for laparoscopic cholecystectomy. In the 24 months from August 1990, laparoscopic cholecystectomy was performed on 295 patients aged from 4 to 82 years. Per-operative cholangiography was routinely attempted. Of the 295, 15 had open cholecystectomy. Thus 280 had an attempted cholangiogram: in 247 of these cholangiography was successful (cannulation rate 88%). 21 of these 247 were shown to have common bile duct calculi, one of 18 who had open cholangiography had a stone and no cholangiogram was obtained in 30 patients. The stone rate in those who had successful cholangiography was 8%. Our conclusions therefore are that in this group selected for laparoscopic cholecystectomy the incidence of common bile duct calculi was 8%. Pre-operative biochemical prediction was unsatisfactory, as was pre-operative ultrasound measurement of common bile duct size. Laparoscopic cholangiography is feasible in most patients and allowing the stent to remain in the common bile duct facilitates follow up studies and stone dissolution.

Pitfalls of stone dissolution — how to avoid them

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25 patients were referred for solvent dissolution of gallstones using methyl tertiary butyl ether (MTBE). All patients were assessed beforehand by ultrasound and oral cholecystography. Computed tomography was performed in 23 patients to assess stone calcification and gallbladder anatomy. Successful stone dissolution was achieved in 15 patients and partial dissolution in six patients. Failure to catheterize the gallbladder occurred in four patients. There

were four biliary leaks, two requiring cholecystectomy. The CT appearances of the gallbladder may have predicted problems with catheterization in three of the four cases and we suggest that cover of the gallbladder by the liver of greater than 50% is a favourable predictor of successful catheterization. A thick-walled gallbladder and excess fat between the liver and the lateral abdominal wall are also adverse predictors of successful gallbladder catheterization. Both tubography and ultrasound should be used to assess progress of dissolution. Newer, more effective solvents together with increased expertise in interventional techniques may encourage the more widespread use of solvent dissolution of gallstones as an alternative to surgery in a selected population.

Combined percutaneous and endoscopic stenting of biliary strictures: a four year experience

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135 patients presenting with obstructive jaundice in whom ERCP was either not possible or feasible underwent percutaneous transhepatic cholangiography with either immediate or delayed stenting of the stricture. In only five patients was some form of internal drainage unsuccessful. The complications of the procedure, level of obstruction and rates of symptomatic and biochemical relief of jaundice are presented. There is significant benefit to patients with obstructive jaundice in providing a combined radiological and gastroenterological service such that patients may have internal drainage established for the relief of jaundice.

Perineal herniation

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In a retrospective study of 800 evacuating proctograms, 37 patients were found to have a varying degree of perineal herniation. A perineal hernia is defined as an abnormal prolapse or herniation of the posterior rectal wall or whole rectum through a levator ani defect on attempted defaecation. All proctograms were performed with the patient in the left lateral recumbent position, using 100 ml of thick liquid barium to coat the anorectum. Five out of 37 patients were operated on and all were found to have either a levator ani muscle defect or severe atrophy of the pelvic

floor muscles. It is thought that the perineal defect may either be a result of traumatic childbirth or chronic straining at stool. The excessive stretching of the pelvic floor causes weakness and subsequent atrophy of the levator ani muscles.

Enteroclysis — the influence of tube design

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Enteroclysis is a valuable technique for investigating the small bowel; however, intubation with traditional 12F tubes can be unpleasant. To ease intubation 10F enteroclysis tubes have been developed. The performance and patient acceptability of three 10F tubes with different tip designs (Corsafe, Law, Silk (E Merck Ltd)) were assessed. 100 consecutive examinations using randomly selected tubes were studied. Jejunal intubation was performed via the nose following topical anaesthesia. A double contrast technique was used with injected Micropaque 100% w/v and methylcellulose 0.5% given by gravity infusion. Intubation time was recorded. Patient acceptability was assessed using a visual analogue scale. Image quality was assessed on the basis of bowel distention, double contrast effect and terminal ileal visualization using a scoring system. For completed examinations no difference in acceptability to patients was found. Failure of intubation occurred more frequently with the Law tube. Superior image quality was obtained with the Corsafe tube, this reaching statistical significance for distention and double contrast effect (Kruskal-Wallis). None of the tubes produced consistently satisfactory results, due primarily to underdistention of bowel. 10F tubes are considered unsuitable for double

contrast enteroclysis using a gravity infusion technique. The implications of tube and tip design are discussed.

Complications of the ileal pouch: the predictive value of the pouchogram

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There are several studies of radiological complications of ileal pouches in the American literature. However the value of individual features of the pouchogram in predicting complications has been little studied. Our purpose is to examine the relationship between certain pouchogram parameters and complications. We have analysed retrospectively a series of 36 pouchograms undertaken in 25 patients with ulcerative colitis at the Royal London Hospital between 1987 and 1992. We find no significant relationship between the radiological continuity of the ileo-anal stapled anastomosis and clinical evidence of pelvic leak or abscess. However there is a significant relationship between a disrupted ring and leak of contrast at pouchography ($t = 7.491, p < 0.01$). We find no relation between symptoms of ileo-anal stricture and diameter of anastomosis at pouchography (patients with stricture: mean diameter = 0.7 cm, range 0.3–1.6 cm; other patients, mean 1.4, range 0.2–2.0 cm). In our series the minimum width of the presacral space is variable in patients with leak/abscess (mean 1.6 cm, range 0.3–4.0 cm) and without sepsis (mean 1.6 cm, range 0.3–5.0 cm). This parameter is not a useful prediction for pelvic sepsis (t -test). We discuss the value of pouchography and the importance of good technique in demonstration of complications.

10.45 – 12.00

Radiation Accidents, Standards and Quality Assurance

Argyll II

Radiation accidents: the lessons to be learned

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An accident is an event that takes place without one's foresight or expectation. Following an accident there are invariably lessons to be learned and applied if the risks of similar events are to be reduced. Accidents may result from human error or machine failure. The risk of human error may be reduced by some form of secondary check procedure, and machine failure by some form of secondary back-up system or improved fail-safe mechanisms. Following an accident, among the questions to be answered is whether negligence was a factor. Clearly negligence is an important consideration in any accident and it is essential to determine that professional conduct was of a standard generally accepted by professional colleagues. The lessons include: equipment specifications being met; technical and user manuals being easy to understand; certain procedures pertaining to patient treatment to follow some form of systematic processing, including confirmation checks; quality assurance to ensure compliance with all intended procedures; monitoring patients' treatment reactions to assess that they are in line with expectations; and recording treatment machine parameters to provide verification. Only by providing traceability of all treatment procedures will accidents be properly analysed and lessons learned.

Analysis of radiotherapy accidents in Europe by the European Federation of Organizations for Medical Physics

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The European Federation of Organizations for Medical Physics represents more than 20 national medical physics organizations in Europe. In March 1991, EFOMP Scientific Committee launched a scheme which assists the national organizations to share information about accidents to patients. In the absence of intergovernmental arrangements, EFOMP and its member organizations

undertake the important role of gathering accident reports and distributing them. A preliminary analysis reveals that 1344 patients were affected by radiotherapy accidents over a 10-year period. In the case of all but 35 patients it is clear that the circumstances of the accident should have been foreseen and procedures to prevent it should have been carried out. The procedural nature of the accidents can be related to deficiencies in quantity, training or organization of the staff involved — sometimes all three. Currently these problems are being addressed through quality management systems (ISO 9000/2). However, quality management systems only implement the priorities inherent in the culture of the institution employing them. It is therefore essential to seize the opportunity to establish correct priorities at the outset and thereby to improve the culture of the institution before it becomes entangled in the formalities of quality management.

Errors and accidents in radiotherapy

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Information on errors and accidents which have occurred in radiotherapy is reviewed. They can be classified either as those potentially affecting a large number of treatments, due to general problems arising in equipment operation, dosimetry, or in the establishment of techniques or procedures; or those affecting a single patient or treatment fraction. We analyse the specific underlying causes which can be single or multiple, simple or complex. Some common themes can be identified. In addition critical points in the radiotherapy process can be identified, either where errors are prone to be introduced or where errors or accidents may have critical consequences. Human errors and equipment malfunction will inevitably occur. However quality assurance systems and procedures can be designed to take account of available experience, in ways that should minimize the incidence and the consequences of any such occurrence. Some general observations are made on some of the points which should be considered in reviewing

quality assurance systems with this aim in mind. These include: the need for good communication; defined responsibility; the implementation of rigorous check systems incorporating independent checking and redundancy in checking; and the utilization of quality audit, both internal and external, where possible.

Accidents — the role of the International Electrotechnical Commission

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The International Electrotechnical Commission writes safety and performance standards for equipment. Its Subcommittee 62C has the responsibility for preparing relevant standards for medical electron accelerators. As these standards apply to equipment, they cannot address operator errors. However the sub-committee and its working groups do seek to influence equipment design in the light of reported incidents which have harmed patients. This paper first outlines briefly the history leading to the safety measures incorporated into the current standards. Recent incidents and developments in equipment have led to the need for a complete revision of the standard. The revised draft standard has been circulated via the British Standards Institution (and other national committees) for comment and voting. The issues and safety incidents addressed in the revised draft standard are described, together with those areas where user opinion is sought.

Radiotherapeutic observation from the German Hodgkin Lymphoma Study Group

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In the German Hodgkin Lymphoma Study Group patients suffering from different stages of the disease are treated in three separate studies. One comprises radiotherapy for the early stages only, whereas in two studies the more advanced stages are treated by combined modality. Here panel observations and calculations from the radiotherapy reports are shown that give an impression of the quality control and performance in the ongoing study. The revision of the films of the patients treated by radiotherapy only gives evidence that about 30% of the patients in the multi-centre study are treated with some violations of the prescriptions in the study. The calculations from the reported radiotherapy data show that about 5% of the patients show

deviations from prescription concerning the daily dose, the overall dose and the fractionation during the study. Here the results of these and other observations are reported. It can be first shown that the violations of prescription seem to result in a significant reduction in freedom from treatment failure in the patients. In conclusion, quality control and performance stages seem to be of high importance for the interpretation of multicentre results. The continuing control has a high educative effect on the quality of treatment in this study.

Field placement errors in routine radiation therapy

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We have developed and implemented an on-line portal imaging device to measure field placement errors (FPEs) during routine clinical radiation therapy. The results are useful in evaluating set-up procedures and immobilization devices, and for selecting margins during treatment planning. The Beamview portal imager was mounted on a dual energy (6/23MV) Linac and portal images were acquired for head and neck treatments (166 fields), lung (127 fields) and pelvis (292 fields). Each portal image was compared to a digitized simulator film using operator-selected point placement and the Procrustes alignment technique. Mean systematic errors for head and neck (H&N), lung and pelvis were 1.7, 1.7 and 2.5 mm, and random errors (1σ) were 0.9, 2.1 and 2.5 mm. Mean field rotations were shown to be less than 3° . FPEs were larger in the AP/PA direction than in the lateral direction for H&N and lung, but were equal for pelvic treatments. Maximum areas of target underdose for H&N, lung and pelvis were 4.1, 16.8 and 20.7 cm². A technique has been developed for determining FPEs quantitatively using image alignment by operator-selected anatomical landmarks. Set-up errors are not isometric for H&N and lung treatments. Maximum areas of target underdose and normal tissue overdose are about double the mean values.

Prognostic factors for mucosal or bone necroses after radiotherapy of head and neck cancers

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In the period from October 1983 to September 1992 770 patients were irradiated for squamous cell cancer of the head and neck region. 18 (2.33%) got a necrosis of the

mucosa (44%) or, additionally, of the mandible (50%). Most of these patients had tumours of the cavity of the mouth (50%) or the oropharynx (39%) of limited size (T1 + T2 = 78%); there was no known invasion of the mandible. 83% had been operated on before radiotherapy. Radiation was performed with total reference doses ranging from 60 to 86.3 Gy. A univariate statistical analysis showed a prognostic significance of single and total doses, localization and stage of the primary tumour, age and Karnofsky performance status of the patient and the grade of late side-effects in the subcutaneous tissue and the salivary glands. There was no correlation with pre-treatment, chemotherapy after radiation or the acute side-effects (dermatitis, mucositis). During follow-up, the risk was increasing steadily with a plateau at 4.5 years after radiation. We can conclude that total doses higher than 75 Gy to the mandible should be avoided. Younger patients with limited tumours and favourable Karnofsky status having a high risk of necrosis because of the application of high doses should be included in a dental prophylaxis programme.

Volume effects caused by changes in dose rate in intracavitary radiotherapy

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Remote afterloading has led to an increase in treatment dose rates in brachytherapy. Since normal tissues and tumours respond in different ways to dose rate changes it is important to know how schedules should be given so that results obtained at low dose rate (LDR) can be produced at medium and high dose rate (MDR and HDR). Radiobiological considerations allow surfaces of equal effect, called iso-effect surfaces, to be defined around an insertion at LDR and these change position as the dose rate increases. This effect is demonstrated here using the linear quadratic (LQ) iso-effect model. The nature of these movements as well as the changes in enclosed volume will be discussed for MDR and HDR schedules. Iso-effect surface movements suggest that increased treatment dose-rate will not necessarily produce higher morbidity levels than those associated with LDR.

The quality assurance of dynamic radiotherapy treatments in linear accelerators

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Modern computer-controlled accelerators are capable of a range of dynamic treatments such as the "dynamic or flying

wedge" or rotational arc therapies. These are implemented and controlled by the use of computer software. This paper considers how the performance and reliability of these techniques can be assessed on a daily and weekly basis as part of a quality assurance (QA) programme. The techniques we have adopted in this centre for checking the performance of the Varian dynamic wedge will be discussed: in particular the use of specially written computer programs to check the integrity of the data files used to position the wedge mechanically and control radiation output. Dosimetric and mechanical techniques for monitoring dynamic wedge performance at different gantry angles will also be presented and the use of test patients in the record and verify system to check that the prescription parameters for wedged beams are accurately set up and delivered. Results from the evaluation of two very recently introduced commercial pieces of QA equipment will be presented — the Beamcheck linear diode detector (for radiation and light fields) and the Gard goniometry system for checking gantry angles and field alignment accurately.

The development of interdepartmental audit for radiotherapy physics

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It is generally recognized that one of the most effective methods of identifying problems or verifying the quality of a service is the regular use of audit. In order to apply this principle to radiotherapy physics a system of interdepartmental audits for external beam therapy has been formulated on the basis of one machine one modality per year. The audits are carried out on a reciprocal arrangement. The audit process comprises an examination of records and procedures for quality control together with a series of measurements of basic data. The measurements are divided into three areas: 1. The measurement of a sample of documented data; 2. a sample dosimetry intercomparison; 3. measurement of an applied treatment to a phantom for which a treatment prescription has been previously prepared. This process has been successfully applied to both proton and electron beams at Leicester and Coventry. The methodology and sample results are presented. This audit process is now being extended on a supraregional basis and will involve several radiotherapy centres.

Image registration with local distortions: quantification of guilt

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The registration of two images can be accomplished by determining the rigid-body transformation between two corresponding sets of fiducial points, A_i and B_i . Local distortions or inaccurate point placement will lead to erroneous results, and so incorrect points should be detected and deleted from the set before registration. Our approach is based on a search for anomalous metric relationships between points A_i in one image and B_i in the other. In such a case, one cannot judge which point is to blame, and a fine equal to the difference $D_i = |r(A_i, A_i) - r(B_i, B_i)|$ is imposed on both B_i and B_j . Ranking by total guilt $G_i = \sum_j D_{ij}$ permits the deletion or reduction in relative weight of the most distorted points. The algorithm has been successfully tested on simulated data sets, and on images of a radiological phantom capable of non-rigid body movements. A formula is derived for the required number of correct data points when some points are erroneous. The effect of operator error in point selection is examined, as well as the effect of out-of-plane rotation. A new algorithm for image registration in the presence of local distortions has been developed and tested. Its immediate application is in on-line verification of radiation treatments, but other registration applications are apparent.

Totally automatic quality control for electronic portal imaging devices

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Regular quality control measurements are required to ensure that an electronic portal imaging device (EPID) is operating correctly. We have designed a phantom and developed an algorithm to provide automatic verification of spatial resolution and noise level. The phantom consists of five sets of high-contrast rectangular bars with spatial frequencies of 0.1, 0.2, 0.25, 0.4 and 0.75 lp mm⁻¹. Daily

megavoltage images are acquired with the EPID, and analysed automatically to determine the noise level, which is compared with pre-determined limits of acceptability. The modulation in each set of bars is obtained from the standard deviation of pixels within a region of interest, and the frequency at 50% modulation is compared to "go/no go" decision levels. Long-term daily checks have shown that the image quality of EPIDs can be monitored automatically, and operation halted if action levels for spatial resolution or image noise are exceeded. Portal images are inherently low in contrast and spatial resolution, and subjective impressions of their adequacy can be misleading. A totally automatic, objective, quantitative procedure has been developed, which will trigger a warning if image quality drops below pre-determined levels. It is appropriate for routine daily quality control of EPIDs.

Verification of calculated absorbed radiation dose to tissue

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Radiotherapy of thoracic tumours almost always requires the radiation beams to pass through lung tissue. The presence of such a low density inhomogeneity produces much less beam attenuation than muscle or fat, and this has to be taken into account in absorbed dose calculations. In this study doses were calculated at specific points in the phantom using Bulk, Equivalent Path Length (EPL) and Power Law corrections and the results compared with measured doses at the same points. A water-filled phantom was used with inserts in which the lung equivalent materials could be placed, in this case cork and a synthetic substitute LN10/100. Absorbed doses were then calculated for a single beam of 8MV and 4MV X rays and ⁶⁰Co γ rays using CT derived attenuation data. Measurements were taken within the phantom using silicon diodes. Within the lung equivalent material, Bulk and EPL corrections overestimated the dose, especially for low energy radiation and small field sizes. The Power Law correction however gave good agreement with measurements for ⁶⁰Co radiation, but at higher energies underestimated the measured absorbed dose to the same extent as the Bulk and EPL corrections overestimated the dose.

10.45 – 12.00

Magnetic Resonance Imaging

Argyll III

A review of the clinical application of the STIR sequence

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We wished to identify the usefulness and disadvantages of the STIR sequence in various anatomical regions and pathologies. 350 MRI studies utilizing the STIR sequence were retrospectively reviewed. The conspicuity of the principal abnormality was scored from 0 (undetectable) to 5 (markedly conspicuous) in all pulse sequences. The studies were subdivided by anatomical region and type of pathology. 350 studies were reviewed; the principal abnormality was neoplastic in 252 (72%). The anatomical regions examined (in decreasing order of frequency) were the appendicular skeleton (26%), pelvis (25%), chest (16%), spine (10%), skull base and neck (9%), brain and orbits (9%) and abdomen (5%). The conspicuity of the principal abnormality on the STIR sequence was high (score: 4 or 5) in 68%, intermediate (score: 3) in 18% and low (2-0) in 14%. The abnormality was of high conspicuity on STIR sequences in 85% of chest, 84% of appendicular skeleton, 77% of abdominal, 72% of spine, 64% of skull base and neck and 45% of pelvic studies. The abnormality was of low conspicuity on STIR sequences in 39% of pelvic, 13% of skull base and neck, 13% of brain and orbit, 8% of abdominal, 5% of chest, 4% of spine and 3% of appendicular skeleton studies. We concluded that the STIR sequence remains valuable, particularly away from organs that are normally of high signal; its usefulness will be enhanced by future fast and turbo techniques.

Advice on image acquisition for MRI of the head

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This collaborative study, part-funded by the Department of Health, seeks to establish statistical, expert and image databases for advice towards MR head image acquisition in diagnosis of cerebral disease. A 3 year investigation at two centres (9 months retrospective and 6 months prospective studies at the Queen Square Imaging Centre, National Hospital, and 15 months prospective study at the Churchill Clinic) has entailed examination of some 2950 cases. A statistical database of clinical presentations (2271 cases), an image archive of 1121 cases exhibiting abnormalities, and a database of confirmed/working diagnoses (currently 830 cases, but continuing) have resulted. Follow-up information is also being utilized to categorize the usefulness of the MR examination in relation to patient management by, for example, demonstrating the causative lesion, excluding some other suspected lesion, giving valuable associated anatomical information, or otherwise influencing management. Analysis has identified 21 distinct "clinical groups" corresponding to patients with recognizable patterns of presentation suggestive of different diagnostic problems. Information from these groups is being correlated with data of confirmed/working diagnoses and MR usefulness. The results are presented and the feasibility of linking this data to a parallel study on the extraction of "expert knowledge" from published literature is discussed.

MR findings in vacuolar myelopathy

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Spinal pathology in AIDS includes, amongst others, vacuolar myelopathy which is present in more than 20% of patients who die with AIDS. The purpose of this study was to find out whether MRI can diagnose vacuolar myelopathy. 24 spinal cord specimens fixed in formalin were scanned. The specimens included vacuolar myelopathy, lymphomas, CMV myelitis and normal cords. The MRI evaluation was blinded. Transverse T_2 weighted scans (SE 2200/80) of the spinal cord specimens were obtained. To obtain high resolution scans, FOV = 10 cm, MA = 256 × 256 and NEX = 14–16. There were eight cases of vacuolar myelopathy. MR scans correctly identified the affected tracts and the correct diagnosis in five cases. In two cases the signal changes within the tracts were misinterpreted as artefacts. In one case MRI was normal. MRI findings in vacuolar myelopathy were increased signal from the affected tracts; the signal increase was present on multiple contiguous slices and was symmetrical. The other pathologies were not mistaken for vacuolar myelopathy. However, in three normal specimens increased signal intensity at the entry of the dorsal nerve was misinterpreted as abnormal and this is a potential pitfall. Vacuolar myelopathy can be diagnosed by MRI and differentiated from other abnormalities.

The prevalence of paranasal sinus disease in HIV infection on cranial MR imagingW K Chong, M A Hall-Craggs, I D Wilkinson, A Clews, M Paley, R F Miller and M J G Harrison
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We proposed to determine the prevalence and severity of paranasal sinus disease in patients with human immunodeficiency virus (HIV) infection. The cranial magnetic resonance (MR) scans of 114 HIV-seropositive patients and 42 controls were prospectively analysed by two radiologists who were blinded to the clinical and serological status of the patients. There were 93 patients who had the acquired immunodeficiency syndrome (AIDS). Disease severity was graded by the degree of sinus obliteration and by a single measure of the maximal mucosal thickness. Severe mucosal disease (more than one sinus with greater than 75% obliteration) or moderate mucosal disease (only one sinus with greater than 75% obliteration) was seen in 14/93 (15.1%) patients with AIDS and none of the 42 controls. The mean maximal mucosal thickness in the AIDS group was significantly greater than in the seropositive patients

without AIDS. Paranasal sinus mucosal abnormalities seen on cranial MR scans are greater in prevalence and severity in patients with AIDS and about one in seven would be expected to have at least one sinus largely obliterated.

Use of the Fluid Attenuated Inversion Recovery (FLAIR) sequence in MRI of the spinal cordI R Young, J V Hajnal, J M Pennock and G M Bydder
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42 patients with suspected or proven disease of the spinal cord were examined with conventional T_1 weighted and T_2 weighted spin echo sequences as well as the Fluid Attenuated Inversion Recovery (FLAIR) sequence in order to assess the value of the two approaches in lesion detection. The FLAIR sequence used an unselected 180° pulse followed at inversion time 1800–2500 ms by a multislice spin echo set with echo times of 20 and 80 ms or 30, 60, 90 and 120 ms. Conventional sequences were SE700/20 and SE2500/80. Gadolinium-DTPA (0.1 mmol kg^{-1}) was used in 26 cases. All studies were performed on a Picker HPQ system at 1.0T. Long T_1 cysts and syrinxes were shown with greater conspicuity using the FLAIR in 6/8 cases. Long T_2 components were only seen with the FLAIR sequence in cord compression in eight cases. Multiple sclerosis (MS) lesions were only seen with the FLAIR sequence in nine of 16 cases of MS. The FLAIR sequence improves lesion conspicuity and detection in the majority of cases of spinal cord disease.

Spinal MRI in lymphomaT Y K Chan, J E Husband and D MacVicar
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In a retrospective analysis of 36 patients with lymphoma referred for spinal MRI, the following clinical indications were encountered: motor dysfunction, mainly weakness of a limb (18 patients); sensory disturbance including root pain and paraesthesia (13 patients); assessment of paraspinal soft tissue masses shown on plain film or CT (two patients); and back pain with known vertebral fracture (three patients). In 27 patients, no spinal cord or root involvement was demonstrated. This included eight patients with MR evidence of vertebral marrow infiltration, and one with paravertebral lymphomatous mass. Compression of the cord or nerve root was evident in eight patients. Compression was due to epidural soft tissue mass in four patients, bony lesions in three, and degenerative disc disease in one patient. One patient showed abnormal signal within the cauda equina. The typical MR appearance of

spinal lymphoma is illustrated. In our experience, MRI has proved a suitable means of defining the pathological anatomy and will distinguish between the different possible causes for neurological symptoms.

Potential applications of the FLAIR sequence in MRI of the abdomen and pelvis

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The Fluid Attenuation Inversion Recovery (FLAIR) sequence was invented by Professors Graeme Bydder and Ian Young for applications within the CNS. The main purpose of this sequence is to suppress signal from bulk fluid, such as CSF, and by retaining T_2 -weighting in the tissues to improve lesion conspicuity. This occurs by introducing a 180° inversion pulse 2000–2500 ms prior to a spin echo sequence, during which time the fluid recovers to its null point, while the tissue has recovered most of its longitudinal magnetization. This allows a long TE to be implemented, without generation of artefacts. Current studies of the CNS with FLAIR imaging show improved conspicuity of lesions with greater sensitivity in detection of disease. As yet there has been no description of the use of FLAIR outside the CNS. At Bristol, we have begun to use the FLAIR sequence in the pelvis to suppress signal from urine within the bladder to try to improve detection of bladder involvement in pelvic malignancy. A serendipitous finding has been that signal from bowel contents also appears to be suppressed whilst retaining signal in the bowel wall. This has implications for MR imaging of the abdomen, for instance in trying to distinguish lymphadenopathy from bowel, and may assist in the demonstration of bowel wall tumours. We present our early findings from patients examined with the FLAIR sequence, including cases with bladder carcinoma and previously treated pelvic tumours.

Dynamic contrast enhancement in MRI of upper abdominal pathology

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Previously we described a technique for abdominal MRI with sequential breath-holding acquisitions after contrast injection. In this study we have measured the rate and degree of enhancement of normal and abnormal tissues following intravenous injection of Gd-DTPA. 50 patients with upper abdominal disease were studied first using axial T_2 weighted SE imaging (TR2000/TE45/90), then using

serial multislice TurboFLASH sequences (TR = 100, TE = 4) each acquired during a single breath-hold period of 19 s. Images were obtained before, during and up to two minutes after bolus injection of Gd-DTPA. The signal intensities of the lesions, and of normal liver and pancreas, were measured for each acquisition in the dynamic series. We also measured the contrast to noise ratios of lesions shown on each acquisition. In all cases lesions were best seen during either the first (33/50) or second (17/50) post-contrast acquisitions. The range of contrast to noise ratios of the first and second TurboFLASH acquisitions was less than the range of contrast to noise ratio of T_2 weighted SE images. The enhancement curves of normal and abnormal tissues converge as the equilibrium phase develops, indicating that optimum technique requires completion of data acquisition in the pre-equilibrium phase.

Dynamic contrast-enhanced MRI in acute pancreatitis — correlation with CT

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The introduction of breath-hold sequences in MRI enables imaging of the entire pancreas at the first pass stage of enhancement during a single breath-hold period, such that MRI may now provide an acceptable non-invasive alternative to CT. 10 patients were examined using axial T_2 weighted spin echo imaging (TR200, TE45/90) and a multislice turboFLASH sequence (TR100/TE4) in axial and coronal planes. 11 slices were acquired during a single breath hold period of 19 s before, immediately after and over a period of two minutes following bolus injection of Gd-DTPA. The MR results were compared with those of a contemporary dynamic contrast-enhanced CT scan. Contrast-enhanced MRI was as good as CT in distinguishing viable pancreatic tissue from areas of necrosis. Peripancreatic fluid collections and inflammatory changes were equally well assessed by MRI and CT. MRI was superior in characterization of complex inflammatory lesions and detection of intrapancreatic haemorrhage.

Comparison of MR and ultrasound contrast hystero-graphy for localization of uterine leiomyomata

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Recent development in the medical and surgical management of uterine leiomyomata have led to a need for

accurate pre-treatment tumour localization to plan appropriate therapy. We have compared the efficacy of magnetic resonance (MR) with pelvic ultrasound combined with ultrasound contrast hystero-graphy (UCH) for the detection and localization of fibroids. Seven patients were imaged by transvaginal and transabdominal ultrasound following intrauterine injection of negative (saline) and then positive (Echovist®) contrast media. MR scans were performed on a 1 T scanner and dual-echo and T_1 -weighted SE sequences before and after intravenous gadolinium were acquired. Three patients were imaged after injection of intrauterine saline. Five patients underwent hysterectomy. The number,

size, and location of the fibroids and the degree of submucosal distortion of the endometrium were assessed on the MR and US studies and compared with the histopathology. MR was more sensitive than ultrasound for the identification of fibroids. However UCH, by causing distension of the uterine cavity, showed the degree of submucosal distortion more accurately. Intrauterine saline improved the localization of the endometrial cavity by MR. We conclude that MR is more accurate for the diagnosis of uterine leiomyomata; however, UCH is a quick and accurate method for delineating submucosal fibroids.

10.45 – 12.00

Veterinary Radiology

Seminar Suite I

All creatures, great and small; veterinary radiology practice

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Among the major differences between human and veterinary diagnostic imaging are the wide range of species and conformational variations with which veterinary surgeons deal. As an example, there is considerable disparity between

the alimentary organs of the various species; indeed to a veterinary radiologist, the human abdomen looks more like an immature goat or equine abdomen than that belonging to man's best friend. The presentation will attempt to show that whilst the training and equipment is similar, veterinary radiologists are confronted with patients which are often very reluctant to be imaged and yet the information that can be acquired is crucial to the management of animals that are valuable in both a financial and emotional sense to their owners.

10.45 – 12.00

Genitourinary Imaging

Seminar Suite I

An assessment of combined ambulatory pyelo-manometry and antegrade renal pressure/flow studies

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Despite antegrade upper tract pressure flow studies (PFS) the cause of renal pain or ureteric dysfunction remains unexplained in some patients. PFS studies are conducted over a short period and patients with intermittent symptoms may be missed. Ambulatory pyelo-manometry (AP) provides a method for recording the intrapelvic pressure for longer times under more physiological conditions, with the patient free to perform those activities which provoke the symptoms. To assess the contribution made by AP to the diagnosis, 14 patients with suspected upper tract obstruction or ureteric dysfunction were investigated with AP immediately after standard PFS. Recording times ranged from 5h to 16h, during which period the patient was normally active. For eight of the 14 patients there was agreement between the two tests (five normal, three with obstruction). In two patients a positive PFS was not confirmed by AP. One of these had a mobile renal stone which obstructed only at the high perfusion rate of PFS. In four patients AP made a significant diagnostic contribution, by demonstrating intermittent obstruction in one patient, and raised intrarenal pressure during voiding in three patients, two of whom had ureteric reflux. It seems that AP has a valuable role as a follow-up to an equivocal or negative PFS.

Effect of diatrizoate on the non-filtering rat kidney

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Interaction with the tubuloglomerular feedback (TGF) system has been proposed to explain the depression of renal

function induced by high osmolar contrast media. In the isolated kidney, glomerular filtration can be prevented by increasing both the tubular hydrostatic pressure and the perfusate oncotic pressure. The non-filtering kidney can therefore serve as a useful model in which to examine a role for TGF in the renal effects of contrast media. Kidneys were removed from the anaesthetized rat by a non-ischaemic technique and perfused *ex vivo* with a Krebs-Henseleit solution containing albumin (6.7% filtering model; 11% non-filtering model). In addition, in the non-filtering group the ureter was occluded prior to kidney removal. The presence or absence of filtration was established using lissamine green and viewing surface nephrons. Control kidneys were perfused without the addition of contrast media. In the filtering kidney, diatrizoate 20 mg/ml decreased perfusate flow by 35% ($p < 0.001$, $n = 9$). In control filtering kidneys, perfusate flow increased with time by 11% ($n = 6$). In the non-filtering kidney the response to diatrizoate 20 mg/ml was markedly reduced, decreasing renal perfusate flow by only 12% ($n = 4$). In control non-filtering kidneys, renal perfusate flow decreased with time by 4% ($n = 4$). The results suggest that the TGF system may be involved in the renal effects of diatrizoate in the isolated rat kidney.

Identifying "at risk" patients with chronic pyelonephritis

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Chronic pyelonephritis (CPN) is a disease which starts in early childhood but is often first detected in adult life. Most adults with CPN have an excellent prognosis but nephrologists need to be able to identify "at risk" groups for detailed follow-up. A cohort of 232 adults with CPN diagnosed by excretion urography has been studied to identify renal morphological and clinical factors which indicate a poor prognosis. The extent and distribution of renal scars have been correlated with renal function, hyper-

tension and proteinuria at initial presentation. Some of these patients have been the subject of a previous similar analysis from this centre. 133 patients had unilateral and 99 bilateral disease. Scarring was commonest in the right kidney, and in both unilateral and bilateral disease it was found in decreasing frequency from above down. There was no statistically significant association between hypertension and renal function in either unilateral or bilateral disease. However, proteinuria was statistically significantly associated with poor renal function in both unilateral ($p < 0.001$) and bilateral disease ($p < 0.001$). Whilst this association might be expected with bilateral severe scarring the association with often minimal unilateral disease is surprising. Possible mechanisms for this finding will be discussed.

Renal parenchymal volume and renal function in patients with chronic pyelonephritis

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Chronic pyelonephritis (CPN) is characterized by caliectasis and juxta-papillary cortical scarring. Accurate quantitative assessments of renal parenchymal loss in this disease by imaging methods such as intravenous urography, radio-nuclide scintigraphy and ultrasound are limited. An off-line image processing technique for the calculation of renal parenchymal volumes from X-ray computed tomography data has been compared with measurements of individual renal function by ^{99m}Tc DTPA renography in 49 kidneys in a group of patients with CPN. Measurements were made by two independent observers. Parenchymal volumes showed positive correlation with glomerular filtration rate (GFR) such that large kidneys have high GFRs, small kidneys low GFRs and intermediate-sized kidneys intermediate GFRs. Observers demonstrated identical correlation coefficients (r) of 0.89, indicating that the method is accurate and reproducible. The technique will be described and its significance in the management of patients with CPN discussed.

Localization of the impalpable undescended testis

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Recent literature suggests laparoscopy may be the investigation of choice in the patient with an impalpable undescended testis. However, the results of these studies suggest that up to 50% of impalpable undescended testes may be truly absent. It would therefore seem desirable to identify

these cases by less invasive means, sparing the patient a general anaesthetic and the recognized complications of laparoscopy. Radiological techniques for preoperative localization include CT, ultrasound, MRI, spermatic venography and testicular angiography. We have found that angiography is the most accurate technique for identifying the site of arrested descent. We present a series of 33 consecutive patients with a total of 36 undescended testes who had angiography performed preoperatively. The testicular artery was identified and satisfactory angiograms were obtained in 33 cases. In the cases with surgical correlation, there was total agreement between surgical and angiographic findings. A critical review of the literature suggests this technique is superior to other modalities for identifying the site of arrested descent and also for identifying the nature of the residual testicular tissue. This may help to avoid unnecessary surgery, particularly in cases of true testicular agenesis.

Herniography in unexplained groin pain

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Many patients present with pain in the groin for which no obvious clinical cause can be found. In some, inguinal hernia may be present but not detected by clinical examination. 150 patients were examined using herniography, a simple outpatient procedure where low-osmolar non-ionic contrast medium is injected into the peritoneal cavity percutaneously. Radiographs are taken in the semi-erect position in anteroposterior and oblique projections with the patient at rest and with Valsalva manoeuvre. Complications of the procedure have produced no long-term sequelae. Syncopal attacks do occur and also needle puncture of bowel without complication. Herniography detects hernial sacs not palpable clinically and may demonstrate sacs on the asymptomatic side. Where no sac is demonstrated surgical exploration is avoided. The results, complications and long term outcome are discussed and the role of herniography assessed in the light of these results. We conclude that if herniography fails to demonstrate hernial sac then surgical exploration can be avoided.

The investigation of apparent "groin strain": the role of herniography in 37 patients

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Clinically palpable hernias present no problem of clinical diagnosis but the young sportsperson presenting with

“groin strain” whilst having no palpable abnormality may still have an inguinal hernia as the cause of pain. Non-ionic contrast medium instilled into the peritoneal cavity followed by pre and postexercise films permits an elegant demonstration of inguinal anatomy, normal and abnormal. 37 consecutive herniograms have been performed in the last

six months and the results of these investigations are presented and correlated with operative findings. In this selected group of patients herniography has a vital role in selecting those patients with groin strain who will benefit from hernia repair before the hernias become clinically recognizable.

10.45 – 12.00

Therapeutic Use of Radiopharmaceuticals

Seminar Suite II

Dosimetric considerations in ^{131}I -mIBG therapy

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Ten years or so after its clinical introduction, ^{131}I metaiodobenzylguanidine (mIBG) has established its place in the treatment of neuroendocrine tumours. The uptake and retention of this compound in the body and tumour are such that therapeutic tumour doses can be delivered with the concomitant whole body dose being not more than 2–3 Gy. Administered activities have ranged from 2.4–15 GBq. Dosimetric considerations, particularly with regard to normal tissue, become important when mIBG therapy is combined with whole body external radiation, as in treatment of childhood neuroblastoma, or when repeated therapeutic administrations are required. Raw data, from which radiation doses are derived, are somewhat limited, usually consisting of a sequence of three to four radio-nuclide images of the whole body (to obtain organ and tumour uptakes) and a sequence of dose rate measurements at a fixed distance from the patient (to obtain whole body retention). Studies in children with neuroblastoma receiving treatment doses of up to 12 GBq have produced estimated doses of 0.7–2.6 Gy to the whole body, 1.6–11.3 Gy to the liver, and 18–38 Gy to the urinary bladder. Estimated tumour doses ranged from 2–53 Gy. Radiation doses may have to be revised in light of the new MIRD dynamic bladder model. One patient with adult neuroblastoma, known to the author, has received six therapeutic doses of ^{131}I -mIBG (5.4–6.9 GBq) over a period of five years with good response in terms of reduction in tumour mass. Whole body doses to the patient have ranged from 0.7 Gy to 1.1 Gy, whilst tumour doses have been of the order of 60 Gy.

Combined antibody targeted radiotherapy with external beam irradiation for locoregional tumour control

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Immunoscintigraphy and biodistribution studies have demonstrated successful tumour targeting by radiolabelled monoclonal antibodies (MABs). Tumoricidal radiation doses can be delivered; this however is the exception rather than the rule as only a small fraction of the injected antibody is taken up by the tumour. The uneven antibody distribution and the low radiation dose rate decrease their therapeutic potential still further. Targeted radiotherapy may however deliver a useful radiation dose if given synchronously with external beam irradiation (EBR). The radiation dose response curve for tumour control from EBR is thought to be steep: a 25% increase in radiation dose could have a dramatic effect on tumour control if this was targeted to the tumour cells and not the surrounding normal tissue. Present antibody technology allows us to deliver a radiation dose of 15–20 Gy to tumour deposits. The surrounding normal tissue and bone marrow can be expected to receive 5 Gy and the liver and kidney 10–20 Gy. All these radiation doses (delivered at a low dose rate) are within normal tissue tolerance. If tumour deposits and surrounding tissue are irradiated concurrently by external beam irradiation then the tumour will receive 70 Gy over 5 weeks without normal tissue tolerance being compromised. Targeted radiotherapy is often thought of as a systemic treatment. It may however have a more important role in the treatment of locoregional tumours.

WEDNESDAY

Simultaneous surgery and implantation for brachytherapy

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In the 1930s as a Radium Officer I found that with the correct dose, uniformly distributed, a local cure without undue radiation damage could be expected. I found early that implantation of radium needles in the plane of excision at the time of removal of mixed parotid tumours was uniformly successful in preventing recurrence and tried to extend the method to other types of tumour. The logistics made it difficult to get the cooperation of surgeons to use the method and after I retired the method tended to fall

into disuse in the Oxford centre. In the USA however, I was able to persuade surgeons at the Memorial Sloan Kettering to adopt the method to the extent that the results of clinical trials have been published vindicating it. The necessity for consultation and decision on the extent of operation and therefore the amount of radioisotope to have available is stressed. The principles of technique and dosage calculation are discussed. Some statistical results are available and some illustrative cases are described. In addition the question of radiation danger will be dealt with. Tumours which may be suitable for this method of treatment include parotid, breast, metastatic lymph nodes and soft tissue sarcoma.

12.15 – 1.15

3M Mayneord Memorial Lecture

Argyll I

Proton magnetic resonance imaging and spectroscopy of brain disease in childhood

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Magnetic resonance imaging (MRI) and spectroscopy (MRS) can provide new insights into the structural, biochemical and functional abnormalities associated with brain disease in childhood, as illustrated by our studies of epilepsy and of inherited metabolic disease that are in progress at the Hospital for Sick Children, Great Ormond Street. In children with intractable temporal lobe epilepsy, MRI commonly reveals abnormalities of the hippocampus, while proton MRS provides further information about temporal lobe pathology through the detection of reduced signals from N-acetylaspartate (NAA). Since NAA is

believed to be located primarily within neurons, this signal loss is interpreted in terms of neuronal loss or damage. The combined use of MRI and MRS should lead to a better understanding of the pathological basis of epilepsy and of the functional deficits in these children, and should contribute to early treatment decisions. Proton MRS is also of value in the investigation of children with inherited metabolic disease, showing abnormal brain chemistry in a range of disorders, including Canavan's disease, lactic acidoses and urea cycle disorders. It has recently been shown that functional activation of the human brain can be visualized non-invasively using MRI. We have used a conventional 1.5 T MRI system operating in a routine clinical environment to map regions of the brain that are activated with visual and motor tasks, and it is apparent that there will be widespread applications of functional MRI in many areas of neuroscience, clinical neurology and neurosurgery.

2.15 – 3.45

The Prostate

Argyll I

Transrectal ultrasound of the prostate

W R Lees

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Transrectal ultrasound of the prostate is about to undergo an explosion in popularity, mainly driven by the success of serum prostate specific antigen (PSA) as a screening test for cancer. Our understanding of the role of digital rectal examination and PSA in benign and malignant disease is now extensive, and less than 20% of patients with clinically significant prostate cancers will have a normal PSA. There have been dramatic improvements in the technology of transrectal ultrasound in the past few years, with high resolution probes and colour Doppler imaging all now being widely available. Abnormalities can be detected in the majority of patients with prostate cancer, and guided biopsy via the transrectal route is now standard practice. Staging biopsies are now possible, targeting the invaginated extra prostatic space (IES), seminal vesicle, neurovascular bundles and full thickness of the capsule. Transrectal ultrasound is also of proven value in male and female urodynamics and in male infertility. Staging prostate cancer by transrectal ultrasound is of value but tends to underestimate the distribution of the disease within the gland and extra-capsular spread on the scale of 1–2 mm. Conventional body coil MRI is no more accurate but endorectal coil techniques show great promise. Prostate cancer kills 6000 men a year in the UK and although much of the disease is clinically insignificant, detection and adequate treatment in the 50–70 year age group is important. As PSA and digital rectal examination become widespread, the time is ripe to establish a large screening trial in the UK.

Colour Doppler transrectal ultrasound in prostatic inflammatory disease

A King and D Rickards

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Many appearances of the prostate on transrectal ultrasound (TRUS) in patients with prostatic inflammatory

disease have been described. It is a difficult diagnosis to make clinically, to treat and to monitor and is focal in nature. Grey-scale ultrasound is of little value except in the chronic case where calcification and an abnormal echo pattern are likely. Colour Doppler can provide a lot of additional information in such cases and is of immense value in acute prostatitis. 140 patients (age 19–67, mean 34 years) with a clinical diagnosis of acute prostatic inflammatory disease have been studied with transverse axial and sagittal colour Doppler TRUS. Biopsy was performed on 64. Analysis of the TRUS scans shows: 1. no abnormality on TRUS in 45 in whom random perineal biopsy was also normal in 13 and abnormal in four, with evidence of prostatitis; 2. no abnormality of grey scale TRUS, but diffuse increase in blood flow throughout the peripheral zones of the prostate gland in 33; biopsy confirmation of prostatitis was obtained in 13; 3. abnormalities in echo pattern on grey scale and increased blood flow on colour Doppler TRUS in 62 in whom confirmatory biopsy evidence was obtained in 28, with six biopsies being normal. It can be concluded that the clinical diagnosis of prostatic inflammatory disease may not be supported by TRUS. In nearly 50% of the patients scanned, the only abnormality was in the blood flow within the gland. Where there are abnormalities in grey scale that are described in prostatic inflammatory disease, abnormalities in blood flow were seen in all. Colour Doppler TRUS has a large part to play in the diagnosis of prostatic inflammatory disease.

Transrectal ultrasound in male patients with urethritis

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Urethritis is a common problem in patients attending a Department of Genito Urinary Medicine. Previous studies have reported prostatic abnormalities seen on transrectal ultrasound (TRU) in patients with prostatitis. The aim of this study was to identify, with TRU, prostatic abnormalities occurring in patients with symptoms and signs of urethritis. 42 male patients presenting to the Department of

Genito Urinary Medicine were assessed. 17 patients were controls, having a previous history of sexually transmitted disease. Six had gonococcal urethritis, nine chlamydial urethritis, two mixed infection of gonococcus and chlamydia, and eight had non-specific urethritis. All TRU examinations were performed by a single radiologist blind to the clinical and microbiological features. The results of TRU were not disclosed to the referring clinician. 21 patients demonstrated prostatic abnormalities on TRU. None of the patients with gonococcal urethritis had abnormal scans and only five of the control group, of whom only three had a previous history of chlamydial urethritis. Of the patients with active chlamydial infection, eight had abnormal scans. These findings suggest that there is a high prevalence of prostatic abnormality in patients with chlamydial urethritis, and the abnormalities may persist. Long term follow-up may be considered in these patients.

The endourethral spiral as an alternative to the indwelling catheter in the treatment of prostate hyperplasia

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Micturition difficulties due to prostatic hyperplasia often lead to treatment by indwelling catheter. An alternative is treatment with an endourethral spiral. In an initial study it was found that a correct positioning of the spiral in relation to the sphincter is of great importance. A modified positioning technique was studied on 36 patients aged between 64 and 95. Control of the function and position of the spiral was done at three occasions after insertion; after 1 week (X-ray and ultrasound examinations) and after 1 and 3 months (urology examination). After 6 months the patients were contacted and asked about the function of the spiral. After 1 week 77% of the spirals functioned well, while 23% of the patients had difficulties (incontinence or urine retention). The stents functioned well in 74% of the patients after 1 month, in 64% after three months and in 49% after 6 months. Within the six month period, the spiral had to be removed in 41% of the cases, either in connection with surgical treatment or because of malfunction. The endourethral spiral will not replace surgical treatment but it is an excellent alternative to catheter treatment for patients who are inoperable or waiting for operation.

Sphincter stricture following TURP — radiological evaluation of patients treated with a permanent urethral and Brantley Scott prosthesis

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Transurethral resection of the prostate gland (TURP) involves removal of the bladder neck mechanism as well as prostatic tissue surrounding the posterior urethra. Urinary continence then depends solely upon the distal sphincter mechanism. Distal sphincter strictures are a recognized complication of TURP, occurring in 5% of cases. They are primarily treated by dilatation and/or limited urethrotomy. The danger lies in compromising the distal sphincter and thereby rendering the patient continually incontinent. Should this occur, treatment is with incontinence devices. Seven patients with sphincter strictures that defied conventional treatment have been treated with insertion of a Wall stent endoprosthesis across the distal sphincter stricture to keep the stricture open and insertion of a Brantley Scott prosthesis to produce urinary continence. In all seven patients, urinary flow rates improved (preoperatively mean 3.4 ml s^{-1} ; post-operatively 16 ml s^{-1}), there was complete bladder emptying in all and satisfactory continence was achieved in four. Two patients had urge incontinence due to detrusor instability and in one, the Brantley Scott prosthesis failed to provide a sufficient obstructive urethral pressure. Although this treatment is expensive in terms of hardware, it is successful in achieving a good result from an iatrogenic disease.

Ejaculatory duct stones — transrectal ultrasound appearances, clinical significance and treatment

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Ejaculatory duct stones are a cause of infertility, pain with ejaculation, or haemospermia or are asymptomatic. 73 patients are presented in whom ejaculatory duct stones were found on transrectal ultrasound (TRUS). In 15 patients, stones within the ejaculatory duct were causing obstruction to the genital tract with dilatation of the seminal vesicle: 10 patients had a low sperm count, seven were infertile and five complained of pain on ejaculation; two were treated with perineal aspiration of the stones under TRUS control with an improved sperm count in one. Of those with infertility or a low sperm count, eight underwent deroofting of the verumontanum, with improved fertility in six and a successful pregnancy in two. Aspiration of the stones under TRUS control was attempted in three

of those complaining of pain on ejaculation, with resolution of their symptoms in two. In 29 patients, stones within the ejaculatory ducts were associated with haemospermia, but without TRUS evidence of obstruction to the genital tract. No treatment was undertaken. In another 29 patients, stones within the ejaculatory ducts were found in normally fertile men without haemospermia. The presence of stones within the ejaculatory ducts associated with evidence of obstruction to the genital tract and infertility requires careful assessment and treatment. No patient in that series had haemospermia. Those with haemospermia and stones can be assured that there is nothing sinister to account for this alarming sign. Stones frequently occur in asymptomatic and normally fertile men. Some men with stones and pain with ejaculation may respond to transperineal aspiration of the stones.

Volume-adjusted prostate-specific antigen compound with transrectal ultrasound guided biopsy as a predictor of prostatic disease

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The diagnostic performance of predicted volume-adjusted prostate-specific antigen (VPSA) against transrectal ultrasound (TRUS) guided prostatic biopsy was assessed in patients with clinical and/or TRUS suspicion of prostatic malignancy. 98 men (age range 52–89 years, mean 69.2 years) underwent TRUS guided biopsy over an 18 month period. A prostate ellipse volume calculation was used and the predicted VPSA level taken as TRUS gland volume $\times 0.2 \text{ ng ml}^{-1} \text{ g}^{-1}$. Abnormal PSA levels were arbitrarily taken as an actual PSA level equal to or greater than twice the predicted VPSA. In the 37 patients with newly diagnosed prostatic adenocarcinoma on histological examination, 34 (91.9%) would have been diagnosed by VPSA alone. In the 14 patients with previously treated prostatic malignancy, five of the six men with positive current biopsy (83%) had a VPSA within normal limits. All three patients with histologically proven prostatitis had a significantly

raised VPSA and, contrary to previous studies, all patients with normal prostatic biopsies using these criteria had a VPSA within normal limits. There was no significant correlation between VPSA and the patient's age. We conclude that VPSA is a good predictor of normality in a patient who has not received treatment for previous prostatic malignancy.

Guidance of cryoablation of the prostate — a new application of ultrasound

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Cryoprostectomy, the use of subzero temperatures to destroy prostatic tissue, gained favour in the 1960s due to its rapidity and low blood loss. It fell from use because the inability to monitor the extent of tissue damage caused by freezing process led to a high incidence of local complications. We assessed the feasibility of monitoring the freezing process in 12 patients transrectally. Transurethral cryoablation was performed using a Cooper Cryosurgical System, and intraoperative transrectal monitoring was via a 5 MHz transaxial sector scanner. Ultrasound allowed maximum ablation of the prostate without breaching of the prostatic capsule. Following cessation of freezing the patients were catheterized and received bladder washouts. At one and three months urine flow studies and ultrasonographic appearances were assessed. Intraoperatively the freezing process was easily visualized as a well defined iceball with distal acoustic shadowing, and allowed freezing to be continued until it was seen to be abutting the prostatic capsule. In comparison to conventional surgery, operating times were reduced ($p < 0.05$) and hospital stay was similar. There were no major complications and 92% of patients gained symptomatic relief. At three months there was a significant rise in urine flow rates ($p < 0.05$) and repeat scans showed a significant cavity formation. These results show that it is possible to monitor cryoablation of the prostate with ultrasound. This should significantly reduce the local complications that were previously encountered.

2.15 – 5.30

Workshop: The Role of Radiology in Women's Healthcare

Argyll II

Methods of bone mass measurement

J E Adams

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Several methods for non-invasive bone mineral density measurements (BMD) are now available. These include single photon absorptiometry (SPA), dual energy X-ray absorptiometry (DXA) and quantitative computed tomography (QCT). All can provide clinically useful measurements with good precision and low radiation dose. The techniques measure different types of bone (cortical, trabecular or integral) in various sites of the skeleton (lumbar spine, forearm, femoral neck and whole body) and may, therefore, provide complementary information in the study of effects of disease and therapy on the skeleton. There are established clinical uses for bone densitometry (confirming radiographic osteopenia; identifying women at the menopause who would benefit most from hormone replacement therapy; assessing the effect of corticosteroids, hyperparathyroidism and therapy on the skeleton), but the cost effectiveness of population screening at the menopause remains controversial. A more recently introduced technique is broadband ultrasound attenuation (BUA) which is generally applied to the calcaneum and provides information on not only bone density but also bone structure. The clinical role of this method has yet to be established.

Preventive strategies for osteoporosis — the role of bone densitometry

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Osteoporosis is a major public health problem because the condition leads to skeletal fragility and an increased risk of fractures. An estimated 50 million Europeans are at risk of fracture by virtue of low bone density and many of these fractures result in disability or death. Furthermore, the burden posed by these fractures is likely to increase over the next 50 years, as a result of the ageing of the population as

well as secular increases in the incidence of certain fractures. The epidemiology of fractures is heterogeneous. The patterns of incidence for the three most frequently involved sites (hip, distal forearm and spine) show differences which provide a challenge for aetiological research. It has been clearly established that bone density plays a major role in the pathogenesis of all three fractures. The relative contribution of other factors, however, such as the risk of falling and neuromuscular impairment, remains uncertain. Longitudinal data are now available on the changes in bone density with ageing, and these provide increasing information on the determinants of peak bone density and subsequent loss rate. Although numerous studies have shown statistically significant associations between these risk factors and both low bone density and fracture, the strength of the association is insufficient to help predict future fracture risk. How then do we identify individuals at increased risk of fractures? Prospective studies have now shown that bone density measurement is effective in predicting future fractures at the hip, spine and several other sites. Furthermore, limited analysis of the cost-effectiveness of such a high-risk preventive strategy for targeting oestrogen replacement in post-menopausal women suggests that this might be a reasonable use of health care resources. The alternative strategy of directing preventive measures at the whole population is more appropriate to the use of educational measures regarding diet, exercise, smoking and alcohol. Serious difficulties regarding the effectiveness, compliance and cost of these strategies have to be resolved, however, before either approach can be fully evaluated and implemented. This provides a focus for urgently required research.

Risk estimation in familial breast cancer

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It is now well accepted that 4–5% of breast cancer is caused by a dominantly inherited genetic fault. Until recently no specific tests to identify these faults were possible. Risk

estimation depended on a combination of familial and other risk factors. The number of relatives with breast cancer, particularly if onset is at a young age or bilateral, influences the likelihood of there being a genetic predisposition. Where an affected sister and mother have developed the disease at around 30 years of age, the relative risk to first degree relatives at this age exceeds 40 times. There is also evidence that if a genetic predisposition has not manifested itself by 60 years the person at risk is probably not at much greater risk than the general population. It is clear that for some women the major period of risk is from 30 to 50 years rather than after 50 years. Now that specific predictive genetic tests are available for a limited number of women whose families have been shown to have abnormalities in the p53 gene or to be linked to a gene on the long arm of chromosome 17, a more accurate way of targeting screening is becoming available. Other ways of defining those at risk at a young age are being developed and this only highlights the need for evaluation of screening in high risk individuals under 50 years of age.

Controversies in breast cancer screening

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The National Health Service Breast Cancer Screening Programme has now been in operation for almost 4 years, and currently 96 screening centres in the 14 English regions, Scotland, Wales and Northern Ireland are in operation. The programme has not been without critics from its inception and these criticisms centred mainly on the question as to whether the programme would be successful in its object of reducing mortality from breast cancer, the cost of the programme in financial terms and in terms of radiation hazard to the well woman population and in terms of anxiety, pain and discomfort imposed on the screened population. All these issues are discussed and the attempts made by the screening programme to address them are described.

2.15 – 3.45

Management, Teaching and Audit

Argyll III

Better data management in CT

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To coincide with the installation of CT and MRI scanners at our institution, a database has been set up using an IBM-compatible personal computer and commercially available database software. Data from each examination is entered onto a worksheet by the radiographers and a radiologist, and includes: basic patient information including postcode; referring consultant and hospital; type of examination; any special technique used; contrast usage; total mAs; code for prospective research projects; indications for scan; diagnostic code (using the American College of Radiologists classification); suitability for teaching museum; and a short synopsis of the examination. This information is entered onto the PC at the end of the day, usually by the radiographic staff. The powerful retrieval capabilities of the software allow rapid access to data for audit, research, cross-charging, costing and teaching purposes. The potential of the system will be demonstrated. In the absence of expensive management systems this package, which is readily available and relatively inexpensive, is of great practical value in small well-defined units.

The use of barium studies in Asians by Tower Hamlets general practitioners

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The largest ethnic groups in Tower Hamlets (East London) are the white population (64.4%) and South Asians (25.7%) of which the vast majority are Bangladeshi. The purpose of this study is to examine the frequency of referral for, and diagnostic yield of, barium studies in the Asian population. In the year from October 1991 834 barium meals and swallows were requested by general practi-

tioners. The proportion requested in Asians (34%) is significantly greater than in the remainder of the population ($\chi^2 = 59.5, p < 0.01$). However the proportion of positive results in Asians (43%) is significantly less than in the rest of the population (66%) ($\chi^2 = 12.1, p < 0.01$). This is reflected in significantly lower rates of major abnormality, e.g. peptic ulcer ($p < 0.05$) and suspected malignancies ($p < 0.01$). Within Asian and other racial groups there is a trend towards lower diagnostic yield in female patients ($p < 0.05$) and patients less than 45 years ($p < 0.01$). The yield in young Asian females is very low, only 26% of tests being abnormal. We discuss explanations for these differences and means to improve the diagnostic yield of such referrals.

Analysis of general practitioners' referrals for barium meal examinations in the Northern Region

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There has been a steady decline in requests for upper gastrointestinal barium studies but the proportion from general practitioners (GPs) has increased. We present an audit of 757 consecutive GP referrals for barium meals and swallows at eight hospitals in the Northern Region. 674 (89%) attended for the procedure and 60% of the reports were abnormal. Patients under age 40 years usually had normal reports whereas two-thirds over 40 years had at least one abnormality. The abnormalities encountered will be described and classified; the commonest findings (50%) were gastro-oesophageal reflux and hiatal hernias. Oesophageal and gastric neoplasms accounted for only 2.8% of the abnormalities. Completed questionnaires were returned for 532 (70.3%) of the 757 patients referred. The commonest presenting symptoms were identified and will be described. Most patients complaining of a bloated feeling, dysphagia, anorexia or weight loss had symptoms for less than six months. Nearly 80% of patients were on medica-

tion, with one-third on H₂ receptor antagonists and one-third on drugs acting on the cardiovascular system. 30% of patients had some other co-existing major disease process. 17% had a previous barium meal and 5% a previous endoscopy.

Are old radiographs helpful?

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In today's hospitals storage space is at a premium and there is increasing pressure to destroy old radiographs. We have, therefore, carried out a prospective study of 500 open-access GP requests for chest radiographs with the aim of assessing the importance of old films. On attendance, patients were asked about previous chest X-rays. If the patient had had previous films an attempt was made to retrieve them. When the consultant radiologist reported on the current film, this was classified into normal and abnormal, and the previous films were assessed as helpful or not. 42% of our patients were classified as having an abnormal chest film. 40% had had a previous chest radiograph at some stage in their lives. Of these 75% were retrievable, three-quarters of which were judged to have been helpful in the assessment of the current film. These figures indicate that previous radiographs are of considerable benefit in the assessment of the current films. This may have implications for the future storage of radiographs.

Reducing unnecessary investigation of dyspepsia by general practitioners: are guidelines the answer?

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In October 1991 the gastroenterologists at the Royal London Hospital introduced an open access endoscopy service for general practitioners (GPs) and circulated guidelines for its use. We examine the effect of this on rates of referral for investigation for dyspepsia. For five months prior to this service the mean number of barium studies requested per month was 85.6 (± 19.3). The number of barium requested for the same period one year later was 67.6 (± 19.1). This is not significantly different ($t = 1.87$, $p > 0.05$). However, endoscopy requests have risen and the rate of barium plus endoscopy requests for the latter period was 115.4 (± 19.1), significantly greater than the barium request rate prior to endoscopy ($t = 3.01$, $p < 0.05$). Furthermore there is no significant difference in the proportions of patients referred for either test aged less than 45 for

the year since endoscopy began ($\chi^2 = 1.99$, $p > 0.05$). These findings suggest that open access endoscopy, even with accompanying guidelines, has not reduced unnecessary investigation in younger patients or even reduced radiation dose to this group. We conclude that any optimism about the value of guidelines for implementing change in the hospital/GP relationship needs qualification.

Implementation and evolution of outpatient multi-testing in the department of radiological sciences

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In the 90s radiology services will be facing numerous challenges. There will be an increasing emphasis on evaluation of existing practices, with a view to reducing unnecessary testing while maintaining quality of care. The Toronto Hospital introduced a service with four main objectives: 1. to coordinate multi-testing in a compressed time frame, as an outpatient (OP); 2. to effectively reduce the pre-treatment length of stay; 3. to provide an optimum standard in patient care; 4. to ensure prompt reporting of all studies within a 24 h period. This programme was established in August 1991. A collaborative approach was undertaken between the radiologists, the referring service and technical management to evolve a change in the philosophy of OP management for multi-testing. This resulted in a reduction in pre-treatment (in-patient) days; the logical testing and appropriate availability of results allowed effective consultation between radiologists and referring services. This often resulted in the elimination of unnecessary testing, thereby ensuring cost savings and patients' appreciation of their management. Dr D Rollo, of the Humana Group in the USA, suggests that "the single most important department in the entire hospital system is Radiology, which can have a greater impact on the length of stay and any cost than any other department". Consultative excellence reduces costs and ultimately provides the most integral method of managing the patient (*Radiology Today*, January 1991).

Objective evidence for dual coding of our memory for radiological appearances

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The following experiments suggest that information underlying our memory for radiological appearances is encoded in both a spatial and verbal mode, each handled through a separate physiological channel. Five subjects each per-

formed two different decision tasks from memory on two separate occasions: firstly, reporting their responses verbally and secondly, by pointing to a board containing rows of "yes" and "no". In the first task, subjects were shown a chest radiograph with a single artificial nodule in one or more of the six lung zones for 15 s. They then reported whether each zone contained a nodule following a prescribed random search pattern covering all zones. In the second experiment, subjects learned a list of descriptors appropriate to a series of nodular lung lesions. They were then shown a series of radiographs, containing a lung nodule for 15 s and afterwards reported whether each feature in the list was present or absent taken in serial order. In the first task, the average time was 6.6 s for a verbal response and 14.4 s for a pointing response. In the second, the times were 8.5 s and 5.4 s respectively. Since overt responses by one method only interfere with recall of information in the same mode, we may conclude that visual and spatial information are handled through different channels.

A digital X-ray teaching library: what it can do and how much it costs

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Traditional film museums do not serve modern radiology teaching very well. They tend to be incomplete, hard to use, and not reflect current practice. In our centre a personal computer (PC) based system has been developed which can digitize and store any size of radiological image with very high spatial and contrast resolution, but is based on low cost components from the business PC market. A large number of images from the Royal College of Radiologists' conventional museum have been scanned, and the system is shown working as if in a teaching session. The system is costed in several variations and there is a look forward into the future to consider how institutions could share their image collections.

Imlink and continuing education

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We describe the use of Imlink*, a new personal computer based image storage and transfer system, as an educational tool. This system, installed in over 90 hospitals, uses public telephone lines for image transfer. Much used in clinical practice, we hoped Imlink might increase the availability of teaching material. We organized a weekly transmission of

CT and MRI neurological cases to district general hospitals. Based at the regional neurosurgery centre we could provide histological confirmation in most cases. New software, designed for the project, allowed automatic down-loading of scans to each hospital. These could then be viewed at leisure. Each week, along with further scans, diagnoses and comments on the condition/radiological signs were available. In the light of recently announced intentions of the Royal College of Radiologists to introduce a programme of continuing medical education (CME), in line with Department of Health policy, this study is of some interest and suggests potential difficulties in the proposals. The use of teleradiology for education is an interesting additional facet in the whole issue of PACS and digitization. The paper describes briefly the technology of Imlink, the organization and uptake of the course and comments of radiologists involved.

The Clinical Terms Project in radiology

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The Clinical Terms Project is an initiative funded by the NHS Management Executive and co-ordinated by the NHS Centre for Coding and Classification (CCC). The aim of the project is to develop a thesaurus of clinical terms and to classify the terms into a nomenclature which can be used to describe and record events taking place in clinical practice. The end-product will be a clinical terminology which is coded, computerized, user-friendly and dynamic, with facilities for updating entries every three months in order to retain flexibility. The first objective of the Radiology Working Group is to deliver a comprehensive list of radiological and imaging procedures. The second objective is to develop diagnostic coding for reports of radiological and imaging procedures. To this end the American College of Radiology classification is being mapped into the existing Read codes. (Details of progress with this have been submitted as a separate poster.) Subsequent steps will include an assessment of the proportion of reports which can be coded using the existing classifications, and the development of prototype coding systems for those areas in which the current classifications are unusable.

A proposed clinical data set for radiology departments

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The object of the clinical data set is to provide a structure which will describe the interactions between patients and

healthcare providers. Patients' contacts with radiology departments might be described by the answers to the following four questions:

1. Why did the patient attend? — the answer will be a symptom, a sign, a diagnosis (known or suspected), a requirement for exclusion, or a combination of the above.

2. What procedure was done? — the answer will lie within a list of radiological and imaging procedures.

3. What was the result of the procedure? — the answer will lie within a list of coded diagnoses and other pathological terms together with additional terms to describe those radiological features which cannot be directly equated with pathology. Recording levels of uncertainty would also be helpful.

4. What was the outcome in the patient? — the answer would be derived from a general enquiry regarding outcomes for all other clinical interventions.

The nomenclature for answering the second and third questions lies within the current objectives of the Clinical Terms Project Radiology Group. The answer to the first question should lie within existing Read terminology. Answers on outcomes are as yet largely undeveloped.

Reliability of diagnostic coding in X-ray departments

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Many radiology departments operate some form of diagnostic coding for research, teaching, audit and case-mix. As part of the development of the Read classification for use in radiology the effectiveness of the commonly used American College of Radiology (ACR) classification was reviewed in 200 X-ray examinations. All reports are compulsorily coded with two digits of Anatomy and at least two of Pathology. Up to 10 codes may be used. The codes entered were compared with the diagnoses made using the definitive ACR coding book. Of the 111 abnormal exam-

inations, the wrong code was used in 12% and the correct one in 69%. Though an acceptable code was applied in 17%, this was not the major diagnosis mentioned in the report. In 9% of the 111 this was because a "Miscellaneous" code was used, though in 3% the major feature was not codable using the ACR classification. In addition, 4% of codes were transcribed incorrectly when checked against the code put in the report text. The error rate in diagnostic coding is unacceptable for use in audit or research. Ways in which the Read classification may improve this are discussed.

Correlation of Read codes with the American College of Radiology diagnostic index

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Read coding is expected to be widely adopted as the standard for computer recording of clinical activity, but in its current form the Read terminology is unsuitable for coding radiology reports. Most departments which use report coding rely on the American College of Radiology (ACR) index or upon modified versions of it. It is clearly desirable to develop enhancements to Read coding which will allow their effective use in radiology. We here describe progress with the mapping of ACR terms into the Read nomenclature. Read contains about 85 000 terms, and the ACR index contains about 717 anatomy terms and 5300 pathology terms. In an initial sample of one-tenth of the ACR index, close matches with Read terms were found in a high proportion of cases and partial matches were found in most of the remainder. Some entries could not be matched. Specific areas of concordance and discordance between the ACR and Read coding systems will be described and further progress with the matching exercise will be reported.

2.15 – 3.45

ENT Imaging

Seminar Suite I

Cerebrospinal fluid fistulae through the skull base

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Meningitis and cerebrospinal fluid rhinorrhea are the commonest presenting features of CSF fistulae through the skull base. The underlying causes are congenital malformations, trauma and post-operative states as well as erosion by tumours. The petrous temporal bone is a common site for a fistula but CSF otorrhoea will not occur if the eardrum is intact. Seven patients with a specific deformity of the inner ear characterized by a dilated basal cochlear turn and sac presented with meningitis; the fistulous communication was confirmed at surgery or post-mortem. Other less obvious inner ear deformities may result in a slow flow of CSF only as a result of surgical interference and the concept of "gushers" and "oozers" will be explained. Concise thin section bone imaging of the skull base is the most important primary assessment for a suspected fistula and this is best achieved by coronal CT. Dehiscences in the floor of the anterior cranial fossa, inner ear deformities, fluid levels and dependent soft tissue masses suggestive of meningo-encephalocoeles are revealed. MRI can help to confirm the latter. Further information about the route of the fistula can then be obtained if necessary from intrathecal contrast or isotope studies.

Computed tomography (CT) of inflammatory sinus disease with bone destruction

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CT is the method of choice for the evaluation of the paranasal sinuses in both malignant and benign disease. Differentiation of malignant from inflammatory bone destruction remains problematic. Since most para-nasal tumours are relatively hypovascular the use of i.v. contrast

is thought to be of little value except where intracranial extension is suspected. We have performed pre and post-contrast CT in 52 patients with known or suspected malignant sinus disease since February 1986. In four of these patients the presence of a soft tissue mass within the sinus and associated bone destruction led to a diagnosis of antral carcinoma, which was not confirmed on subsequent histology or clinical follow-up of 6–18 months. In three of these cases CT demonstrated a serpentine line of contrast enhancement in the soft tissue within the sinus, overlying the bone destruction. Histology in these cases showed chronic inflammatory tissue and in the fourth case aspergillosis. The enhancing line seen on contrast-enhanced CT in three of four patients is thought to represent sinus mucosal enhancement. We suggest that unbroken mucosal enhancement crossing a region of bone destruction makes a diagnosis of malignancy of mucosal origin unlikely and a chronic inflammatory cause should be suspected.

A comparison of plain radiography and sonography in the diagnosis of maxillary sinus disease

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This study compares the findings of plain radiography and ultrasonography in patients with suspected maxillary sinusitis. 20 patients with symptoms compatible with acute or chronic maxillary sinusitis are included in this study. Radiography includes occipito-mental, occipito-frontal and lateral projections. Sonography is performed in the longitudinal and transverse planes using a 5 MHz linear array probe (Acuson 128). With the patient sitting, a transverse scan is performed from the orbital floor to the alveolar margin. The probe is then swept longitudinally from the turbinates to the lateral wall of the maxillary antrum. The signs of abnormality on ultrasound are de-aeration of the sinus, presence of echoes from the posterior wall of the antrum and mucosal thickening. Both the radiographs and

sonographs are reported independently. Seven of the radiographs are reported as normal, with which ultrasound shows 100% concurrence. 13 radiographs are reported as showing abnormal opacification or mucosal thickening of one or both maxillary sinuses; ultrasound shows 77% concurrence. Three radiographs showing minor local mucosal thickening are reported as sonographically normal. Our findings suggest that ultrasound is sensitive in detecting diffuse mucosal thickening. Ultrasound may be useful in the follow-up of patients with recurrent maxillary sinusitis, reducing exposure to ionizing radiation.

Incidence of normal variations in screening sinus CTs

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There is a wide range of normal variations in nasal anatomy. This is becoming increasingly significant in the light of expanding numbers of nasal endoscopies. A minor radiological variation — for instance, low position of fovea ethmoidalis — may have profound clinical significance, as the unwary endoscopist may find themselves unexpectedly in the anterior cranial fossa. The incidences of some variations, e.g. concha bullosa, are known. However, there are many well recognized variations, whose incidences are as yet uncalculated. We assessed all sinus CTs performed in Dudley Road Hospital from May 1991 to date for 12 normal anatomical variations. We present our findings and discuss the implications.

Functional endoscopic sinus surgery (FESS): pre-operative assessment with computed tomography

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Functional Endoscopic Sinus Surgery (FESS) is a new minimally invasive surgical technique used in the treatment of a range of sinus diseases. It allows treatment to be

accurately directed at the cause of sinus disease by direct miniature endoscopic vision. CT is required preoperatively to establish normal anatomical variants, and to provide a safe route map for the endoscopist. We describe our experience in 60 consecutive cases. The CT technique is described and the normal detailed anatomy of the sinuses relevant to the endoscopist illustrated by means of annotated images. Selected pre and postoperative scans are presented that illustrate a range of pathologies and successful FESS treatments. The pathologies encountered include simple inflammatory disease, multiple polyposis, transitional cell papillomas, osteoblastic papillomas and encephalocoeles. A case of post-traumatic CSF leak repair is also presented. This paper demonstrates the correct CT technique, normal anatomy and pathology encountered in CT scanning of patients undergoing functional endoscopic sinus surgery.

Are three-dimensional CT reconstruction images of value in the evaluation of orbital fractures?

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Modern CT scanners now offer rapid three-dimensional (3D) images, which can form part of the assessment of complex orbital fractures. We studied 25 consecutive cases with orbital fractures. Images were acquired in the coronal plane, with a modified protocol of 5 mm slices at 4 mm increments which allowed more accurate 3D reconstruction. Images were inspected by two radiologists and one maxillo-facial surgeon. Coronal CT, 3D images and the combination of coronal CT with 3D images were compared and scored for information regarding demarcation of fractures, distribution of displaced fracture fragments and evaluation of the size of the orbital floor defects. Experienced radiologists found coronal CT to be more sensitive than 3D images in detecting undisplaced fractures of the orbit (due to partial voluming effect). However, 3D images were useful in demonstrating the distribution of displaced fracture fragments and in the assessment of orbital floor defects. The maxillo-facial surgeon found 3D images with displaced fracture fragments more representative of what he would see at surgery than coronal CT images. We believe that 3D images of orbital fractures should be routinely inspected on the display console and selected images captured for the clinician.

Deafness, genetics and imaging the ear

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Recent advances in genetics have made it possible to identify the offending gene in some types of genetic deafness. Specific deformities of the petrous temporal bones and other soft tissue lesions can be shown by imaging in some cases. These deformities, correlated with genetic studies, help to distinguish one syndrome from another in which the phenotype is similar. Treacher-Collins syndrome and hemifacial microsomia are an example. We have used CT correlated with genetic studies to define specific imaging features for the following syndromes: Treacher-Collins [5q 31–33], branchio-oto-renal [8q 13–21], Pendred [8q 24], X-linked with stapes gusher [Xq 13–21], oto-palato-digital type I [Xq 26–28], Waardenberg type I [2q 37], neurofibromatosis type I [17q 11], neurofibromatosis type II [22q]. In X-linked deafness genetic studies have shown that there is a deafness locus on the long arm of the X chromosome. This causes a specific abnormality of the petrous temporal bone, but there is another type of X-linked deafness that has a normal CT scan. This would seem to confirm a different gene locus or an allelic form. Specific imaging features are now identified for the two types of neurofibromatosis involving chromosome 17 (NF1) and chromosome 22 (NF2). We conclude that imaging can aid the progress of genetics when such correlation is used.

Anatomy and pathology of the facial nerve tract: CT and MRI appearances

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The purpose of this paper is to illustrate graphically the anatomy of the facial nerve and its upper tract origins. The range of pathologies that cause facial nerve paralysis is large and the clinical presentation will vary with the position of the pathology along the facial nerve tract. We present 15 cases where facial nerve symptoms were the predominant clinical feature, and imaging by CT, MRI or both provided the diagnosis. The range of pathology includes: a small meningioma, brain stem tumour, facial nerve neuroma, facial nerve teratoma, cholesteatoma, acoustic neuroma, temporal bone metastasis and parotid adenoid cystadenocarcinoma. The paper emphasizes normal anatomy as well as pathology and demonstrates the merits of CT and MRI in particular cases and particular anatomical locations. Specialized scanning techniques are also considered.

Colour flow ultrasound: a new technique in central retinal vein occlusion?

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Central retinal vein occlusion is a common cause of sudden visual loss. Accurate diagnosis is essential as separation into ischaemic and non-ischaemic forms has prognostic significance. Colour Doppler ultrasound can visualize the retrobulbar vessels, the central retinal artery and vein being easily identifiable. We conducted a prospective trial and compared 20 age-matched healthy volunteers with 20 patients with central retinal vein occlusion, the ultrasonologist being masked to the clinical diagnosis. No difference in velocity from the central retinal artery was detected between the patient's affected eye or unaffected fellow eye, or the normal control eyes. A marked reduction in venous velocity was recorded from the central retinal vein from the affected eyes when compared to the fellow and control eyes ($p < 0.001$). There was no difference in venous flow between the fellow and control eyes. These initial results suggest colour flow imaging may have a diagnostic role in central retinal vein occlusion. It is easy to perform, well tolerated by patients and allows the potential of temporal assessment.

The value of the STIR sequence in the MRI of extraocular muscles

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Magnetic resonance is the investigation of choice for imaging orbital contents. The orbit is unusual in that the background stroma is composed mainly of fat which has a characteristic appearance on conventional spin echo (SE) sequences. The short tau inversion recovery (STIR) sequence suppresses signal from fat and summates T_1 and T_2 effects, highlighting both normal orbital structures and orbital lesions, the majority of which are water-containing. The advent of fast and Turbo STIR sequences permits the acquisition of STIR images in a very short time period and will therefore increase the use of this technique. Disease processes such as thyrotoxicosis result in swelling and inflammation of extraocular muscles with an increase in their water content. The change in morphology is well seen on T_1 weighted SE but changes in water content are best appreciated by using STIR. This was demonstrated in a group of 20 patients with thyroid eye disease and in a single patient with myositis. The increased signal on STIR

sequences was then compared with clinical parameters of disease activity. The use of STIR sequences is recommended in the investigation of this group of patients and may have a role in selecting those cases that require anti-inflammatory therapy.

Salivary duct balloon dilatation — an initial experience

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The traditional treatment for the obstructed salivary gland is generally surgical. Recent reports of balloon dilatation for duct strictures and calculus disease have opened new horizons. We describe our initial experience using a 3 mm balloon on a wire in Stensen's and Wharton's duct. In 10 patients with a typical history of parotid or submandibular duct obstruction, sialography confirmed calculi in six and strictures in four. The wire negotiated the obstruction in all but one case, whilst the balloon was mostly unable to be pushed beyond the lesion. However, except for the single failed case, all the patients improved symptomatically even though the radiological images did not appear to change significantly. Our initial impression suggests that this is a

useful technique and the procedure, complications and pitfalls are further discussed.

Interventional sialography using digital imaging

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The advent and development of digital subtraction vascular imaging has allowed the successful application of this technology to other organ systems, including the salivary glands. Digital imaging allows dynamic visualization and image manipulation, expanding sialography from a static image at a particular moment to a dynamic technique with high contrast resolution. The digital subtraction of bone affords better demonstration of duct detail, particularly non-opaque calculi. These advantages allow the transfer of interventional vascular techniques to the parotid gland. Very small low profile angioplasty balloons may be passed down the parotid (Stensen's) duct either to dilate focal stenoses or to retrieve calculi. Other vascular implements such as the retrieval snare may also be used for sialolith removal. It is the intention of this paper to present our experience with these techniques and discuss the pitfalls and modifications that can be made to avoid them.

2.15 – 3.45

Treatment Planning

Seminar Suite II

Relationships between dose distributions and tumour control probability: consequences for clinical dosimetry

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Dose-effect information on tumour control probability (TCP) and on normal tissue complication probabilities, forms the basis of current recommendations on overall dosimetric precision in radiotherapy. In addition to variations in the dose to the specification point, variations in dose across the target volume also affect TCP, leading to requirements on the accuracy of dose distribution, often quoted as around 5%. TCP can be calculated as a function of dose to the tumour cells, starting from the Poisson statistics model, but this simple approach produces very steep TCP versus dose curves. The Nahum and Webb model assumes that radiosensitivity is distributed in a Gaussian fashion amongst the patient population and the model parameters are then adjusted to fit clinical data. Assuming constant clonogenic cell density across the tumour, the change in TCP can be predicted for increasing variations in dose distribution, providing support for the figure quoted above. Allowing clonogenic cell density to vary in simple ways leads to initial conclusions on what variations in dose distribution may be acceptable in these situations. The consequences of these relationships are considered; *e.g.* for dosimetry, treatment planning, patient immobilization, conformal therapy and quality assurance. The possible impact of improvements in procedures and of quality assurance programmes on the dose-effect curves and on the models are considered.

Optimization of conformation radiotherapy dose distribution using maximum entropy and Bayesian methods

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Conformation radiotherapy has significant advantages over conventional radiotherapy treatment methods. A novel optimization approach to the conformation radiotherapy problem is presented, based on the maximum entropy method (MEM) and Bayesian statistics. The MEM approach enables a set of radiation beam profiles to be optimally determined, such that the entropy of the beam profiles is maximized, subject to the constraint that the actual and prescribed dose distributions match. Optimization using Bayesian statistics involves a least-squares error criterion between the optimized and prescribed dose distributions. Primary and scatter dose distributions, and non-homogeneity of the surrounding organs, may be included in the analyses. The algorithms are iterative and are easily implemented. Both methods were evaluated using a number of clinically prescribed target dose volumes based on CT and MRI scans. These included sections of the brain and torso, and target areas in both cases were irregular and complex. Both the MEM and Bayesian statistics method converged easily, and closely matched the prescribed target volume, with very low dosage to the surrounding tissue. These new techniques have advantages of fast convergence and high accuracy over conventional methods.

Clinical implementation of inverse treatment planning

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Current trends in treating deep seated tumours by radiotherapy include the use of non-coplanar, beam's-eye-view-shaped fields, and the method of inverse computed tomography or inverse planning. ("Inverse planning" means calculating the field weights automatically by computer, starting with the 3D dose or biological prescription, thus abandoning "trial and error" planning methods.) Although these techniques can now be realized with the use of multi-leaf collimators, the available planning software to utilize them is in its early development stage. We have developed a computer program with which we can plan non-coplanar, beam's-eye-view-shaped fields. The power of the algorithm has been illustrated in previous papers, where the optimal dose distributions for difficult model problems have been presented. For a problem where an organ at risk was completely enclosed by tumour tissue, the ratio of maximum doses in the organ at risk and the tumour was down to 0.7. As part of the EEC-funded COVIRA project (Computer Vision In Radiology), we have now applied our techniques to real clinical data, and initial results will be presented. Optimized plans will be compared with the results of conventional planning.

ment with the dosimetry of the treatment plan produced, before the patient is treated.

Pulse-by-pulse measurement of the output of a linear accelerator with application to megavoltage computed tomography

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We have studied the random and systematic components of the beam profile fluctuation of a Philips SL 25 linear accelerator operated at 25 pulses per second. This is in connection with the megavoltage CT imaging programme at the RMH/ICR. The output is measured for the arc therapy mode and five gantry positions in stationary treatment mode (-180° , -90° , 0° , 90° , 180°). Considerable variation of the machine output during the build-up is observed, after which the variation of the output is in the range of a few percent. There are some significant and somewhat unexpected systematic structures in the observed data. These may be used to improve the overall signal-to-noise ratio in the reconstructed megavoltage CT images. Phantom image reconstructions will be shown, to illustrate the effects of these variations on the image quality.

Simple methods of verifying dose distribution for tissue compensators

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Uniformity of dose distribution throughout the tumour volume is a pre-requisite for the achievement of cure and tumour control. This may be achieved on a given slice by careful planning using wedge filters and weighting of beams; nevertheless, during the treatment of cricoid or bronchial tumours, external and internal structural inhomogeneities give rise to unacceptable dose variations between different slices of the treated volume, rendering the use of tissue compensators necessary to achieve dose uniformity. There are various literature reports describing the procedure of making compensators, but this paper describes simple methods of verifying the dose reduction achieved from the compensator and checking the agree-

An illustrated technique for total body irradiation: new room for improvement

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The individual techniques for total body irradiation, prior to bone marrow transplantation, are as diverse as the machines and rooms used for the procedure. The recent commissioning of a new Philips SL18 linear accelerator, fitted with a multi-leaf collimator, at the Royal Free Hampstead NHS Trust has enabled the clinical team to re-examine their tried and tested technique. This single-fraction, high dose rate technique is demonstrated to illustrate how the physical designs of the treatment room, and the machine characteristics, have shaped the technique, and to show the other factors which need to be taken into consideration. Patient results are examined to explain why elements of its more technologically primitive roots must be maintained to help the new technique keep pace with improving success rates.

Use of Heustis contouring system with radiotherapy immobilization shells

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The Heustis Compu-Plotter is a device for creating body outlines of patients for use in radiotherapy dose planning. It utilizes a source which transmits a high frequency, low power, AC magnetic field. The position of a sensor, as it is traced around the patient surface, can then be recorded. We have used this device to obtain outlines from immobilization shells which are made by vacuum-moulding sheets of Uvex onto plaster casts of the patients. We have achieved accuracy of ± 2 mm or better for the outlines. The positional accuracy of reference points (used for isocentre alignment for treatment) is ± 1 mm. Various procedures must be observed to obtain satisfactory results, in particular: 1. the device must not be used in close proximity to large metal objects; 2. the transmitter must be clamped in position; 3. the shell must be securely clamped to prevent movement whilst tracing. A special table, with a tilting mechanism, has been developed for use with this device, and is described. It is concluded that the Heustis Compu-plotter,

subject to careful use, provides a quick, accurate method of obtaining outlines from radiotherapy shells.

A multileaf collimator (MLC) menagerie with beam films and isodoses

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To demonstrate the versatility of the multileaf collimator (MLC) on the Philips SL18 linear accelerator to users, potential customers, and fund raisers, a series of easily recognized animal and other shapes have been programmed into the MLC computer. The associated collimator blade movements and positions have been recorded on videotape. The corresponding beam films and a selection of isodose curves measured in a multidata water phantom are included in the video. An elephant waves its trunk, and flaps its ears, in a simulated display of dynamic field shaping and dose control. The isodose curves measured perpendicular to the collimator rotation axis demonstrate the complexity of isodose patterns and offer a challenge to treatment planning system manufacturers. (Video running time: 8 min.)

4.15 – 5.30

General Ultrasound

Argyll I

Opportunist screening for abdominal aortic aneurysms

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The debate as to whether there should be a national screening programme for abdominal aortic aneurysms continues. Two factors that may undermine such a programme are cost and the low uptake by patients. In the light of these problems we are assessing the value of screening a high-risk population of patients already referred to our ultrasound department for a non-vascular ultrasound examination. Male patients, aged between 65 and 74 years inclusive, have had their abdominal aorta assessed and the maximum diameter measured, as an adjunct to their general examination. An abdominal aorta was defined as aneurysmal if its maximum diameter exceeded 33 mm. The results from the first 200 patients screened show a prevalence of abdominal aortic aneurysms of 4%; a figure similar to previous screening studies. We commend "opportunist screening" of patients already attending for ultrasound examination as a low-cost method of identifying patients at the highest risk from abdominal aortic aneurysm rupture.

The reliability of ultrasound in the prediction of the level of obstruction in patients with obstructive jaundice: a comparison with PTC

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This small study was instituted in response to the authors' impression that there was frequently poor correlation between the presumptive level of obstruction identified on

ultrasound and that identified at percutaneous transhepatic cholangiography (PTC). A subset of patients undergoing PTC and combined drainage at this hospital were studied to confirm or refute this impression. In all, 25 patients were studied, all of whom had had ultrasound and PTC at the same institution and on the same admission. There was poor agreement between the detected level of obstruction as detected at ultrasound and that seen at PTC. The ability of ultrasound to detect high ductal obstruction is worse than its reliability in identifying low common bile duct obstruction. There was no observable difference between the reliability of ultrasound performed by consultants and by senior registrars.

Colour Doppler sonography of thyroid diseases

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We set out to evaluate the diagnostic value of pulsed and colour Doppler sonography in thyroid diseases. First, we examined 15 healthy volunteers to define the normal vascularity of the thyroid gland. Then, the information given in 68 cases by pulsed colour Doppler (degree and type of vascularity) was correlated with the data of biology, sonography and scintigraphy ($n = 68$), cytology ($n = 9$) and pathology ($n = 31$). We found 29 goitres, 14 Graves' disease, six thyroiditis, 21 adenomas and four carcinomas. In Graves' disease, the augmented blood flow was diffuse and involved the whole gland. In focal lesions due to functional adenomas or carcinomas, we noted internal flow signals. However, non-functional adenomas showed hyper-vascularity at the margins of the lesion. These different correlations allow us to state the advantages and limits of

pulsed colour Doppler for the different lesions. Colour Doppler sonography appears particularly interesting in the evaluation of cold or iso-fixing nodules.

Ultrasound-guided biopsy of small (less than 3 cm) neck masses: accuracy and sensitivity in clinical practice

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Improvements in sonographic equipment have made small non-palpable neck masses amenable to US guided fine needle biopsy (FNB). We reviewed our experience with FNB of small thyroid, parathyroid, lymph node, and other neck masses to determine the diagnostic accuracy of FNB in these small masses. FNB was performed in 116 (mean 1.7 cm, range 0.6–3 cm, median 1.6 cm) neck masses (lymph node 46/116, thyroid 66/116, parathyroid 4/116, parotid 2/116) in 102 patients. Masses greater than 3 cm were excluded. FNB was carried out under US guidance with 22–25 gauge needles, using freehand technique. Adequate specimens were obtained in 107/116 (92%) masses to enable a diagnosis of benign or malignant disease to be made. 9/116 specimens were non-diagnostic. FNB histology was confirmed by surgery or follow-up in all patients. 44/46 (96%) lymph node biopsy specimens were diagnostic with 24/26 malignant biopsies and 20 benign biopsies. 59/66 (89%) of thyroid biopsy specimens were diagnostic, with 50/66 benign biopsies and 9/66 malignant biopsies. Of the four parathyroid adenomas biopsied, one biopsy was non-diagnostic. Two parotid abscesses were aspirated successfully. There were no complications. We conclude that US-guided FNB of small neck masses is a complication-free procedure with a high diagnostic accuracy (92%).

Thyroid diseases and colour Doppler sonography: from ultrasound macroscopic analysis to microscopic imaging

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The aim of this retrospective study was to compare the data given by colour Doppler sonography and pathology in thyroid disorders in order to evaluate the utility of colour Doppler US in the differential diagnosis of thyroid diseases. The study included 28 patients (24 females, 9 males) and 32 different lesions: goitres ($n = 8$), Graves' disease ($n = 11$), adenomas ($n = 10$) and carcinomas ($n = 3$). In Graves' disease, the augmented blood flow was diffuse and involved the whole gland. In focal lesions, both colour Doppler US

and pathology showed different vascularity according to the disease. Intranodular vascularity was present in functional nodules and carcinomas. Perinodular flow was observed in nonfunctioning adenomas. The correlation between colour Doppler ultrasound and pathology does allow better understanding of the advantages and limitations of colour Doppler US, particularly in nodular lesions of the thyroid gland.

Fetal Doppler studies and their effect on management and outcome

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Poor fetal outcome is associated with an abnormal waveform on Doppler velocimetry, but its clinical usefulness in screening the at-risk fetus is uncertain. This study reviews the outcome and management of 110 patients who underwent fetal aortic and umbilical artery Doppler analysis. Indications were small-for-dates babies or maternal hypertension in 63 cases, multiple gestation in 18, postmature in seven and others in 22. There were 15 pregnancies in which abnormal Doppler, velocimetry provoked delivery; all these fetuses survived. There were six in which an abnormal Doppler study did not provoke the clinicians to induce delivery, and of these there was one stillbirth (in a twin pregnancy) and all the other fetuses survived. There were 17 pregnancies in whom Doppler studies were normal but who were induced for other parameters of distress. There were two neonatal deaths in this group. There was no significant difference in Apgar scores between the groups in the surviving fetuses. This gives Doppler velocimetry an accuracy of 80%, sensitivity of 48.5% and specificity of 93.5%. A normal fetal Doppler velocimetry result may be falsely reassuring and should be viewed in conjunction with other well established indicators of fetal wellbeing.

Normal ranges of pulsatility and resistive indices throughout pregnancy and their role

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Ultrasound is often used as the initial procedure in pregnant women with suspected renal tract obstruction. Its use however is limited. Renal tract dilatation is common in pregnancy, making it an unreliable sign. Duplex Doppler ultrasound has shown promise in the diagnosis of renal obstruction, with a change in renal resistance bringing about a rise in the resistive index (RI) and pulsatility index (PI). However, there are significant changes in renal blood

flow in pregnancy and its effect on the RI and PI are unknown. In order to assess this, 100 women were studied at various stages through pregnancy. Patients were studied with an Acuson 128 fitted with a 3.5 MHz sector scanner. Renal pelvic dilatation was assessed and gated Doppler signals were obtained from interlobular arteries to obtain values of RI and PI from both kidneys. Results show that there is a wide variation in PI throughout pregnancy. The RI however was relatively constant, with no value greater than 0.7 and no difference between the two kidneys in any individual patient of more than 0.12. There was no relationship between RI or PI and the degree of pyelocaliectasis. These results indicate that RI is relatively constant throughout pregnancy, and that a value of > 0.7 is abnormal and may be useful in the diagnosis of renal obstruction in pregnancy.

The use of ultrasound in the assessment of the Klippel Trenaunay syndrome

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The Klippel Trenaunay syndrome (KTS) is a rare mesodermal abnormality causing venous anomalies, cutaneous capillary naevi and bone and soft tissue hypertrophy of one or more limbs. We compared colour Doppler ultrasound with the standard techniques of ascending venography and

varicography in the assessment of 14 patients with KTS. We found ultrasound more effective than ascending venography, with or without varicography, in the demonstration of the abnormal superficial vein, the connections with the deep veins and the deep veins themselves. From our work we conclude that ultrasound should be performed before surgery in all patients with KTS. In addition we suspect that the incidence of deep venous hypoplasia and aplasia in KTS has been overestimated in the past because of the difficulty of opacifying these vessels at venography.

Indirect scanning of the scrotum using an acoustic window

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The authors reveal the disadvantages of the familiar methods of ultrasound examination of the testes. They offer their own modification of the methods and a device for indirect scanning of the scrotum using an acoustic window. The results from 136 patients examined by the new method are presented and discussed. The diagnostic accuracy of the method is reported to be 97.79%, sensitivity 98.98% and specificity 94.74%. The authors assume that the indirect scanning of the scrotum using an acoustic window is a reliable diagnostic method. They recommend it for the routine ultrasound practice.

4.15 – 5.30

Interventional Angiography

Argyll III

Imaging and intervention in the surgical AV fistula

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We set out to compare intravenous digital subtraction angiography (IVDSA) and colour flow Doppler ultrasound (US) in imaging of the surgical arterio-venous (AV) fistula, and to present cases of radiological stenting of stenoses in the AV fistula and the draining veins. 30 patients with AV fistulae for haemodialysis were studied. The fistula was imaged with colour flow Doppler and IVDSA and the findings compared. The major clinical problem with AV fistulae is development of stenoses, which may occur on the arterial side, at the anastomosis, in the fistula or downstream in subclavian vein. The technique for IVDSA and colour Doppler ultrasound is described. Both techniques readily identified stenoses. Doppler US was easy to perform and non-invasive but anatomical description and demonstration of central stenoses were problematic. IVDSA was a more complex technique and required a central catheter but was easier to interpret. A number of cases are presented of fistula angioplasty and subclavian venous stents. The results from central stenting are excellent, from fistula angioplasty less so, particularly in longer stenoses. Case selection is discussed.

Management of splenic artery aneurysms and pseudoaneurysms

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Splenic artery aneurysms and pseudoaneurysms are clinically occult, usually presenting only when they rupture. The

standard surgical teaching is that aneurysms over 2 cm in diameter and all pseudoaneurysms should be resected to avoid rupture. Endovascular techniques offer an alternative form of therapy. We reviewed our experience to determine the advantages of each approach. 15 cases of splenic artery aneurysm and three of pseudoaneurysm were diagnosed at one hospital over a seven year period. Clinical information was obtained by chart review and all radiological investigations were reviewed. Predisposing factors for aneurysm development included systemic hypertension (five) and portal hypertension (two). The three cases of pseudoaneurysm were due to pancreatitis. Two of the pseudoaneurysms were treated by embolization. This was unsuccessful in one case where the pseudoaneurysm measured over 8 cm in diameter. Three of the aneurysms were treated surgically with an average hospital stay of 14 days and post-operative complications including pneumonia and sub-phrenic abscess. Two of the aneurysms were successfully treated by embolization with no complications. Interventional techniques offer a lower complication rate than surgery but post-procedure imaging to ensure obliteration of the aneurysm or pseudo-aneurysm is mandatory.

Endovascular stenting in the treatment of renal artery stenosis

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Percutaneous transluminal angioplasty (PTA) of ostial renal artery stenosis (RAS) is often technically unsuccessful and is associated with a high incidence of re-stenosis due to elastic recoil. Endovascular stenting has been reported to produce improved technical results and perhaps a lower re-stenosis rate than PTA alone, but its role in the treatment of RAS is not clearly established. We have performed

combined PTA and endovascular stenting in eight patients with RAS, using the Palmaz balloon-expandable stent. The lesions treated have included atheromatous ostial RAS and fibromuscular hyperplasia, and the clinical indications for PTA/stenting have been uncontrolled hypertension and/or chronic renal failure. Short-term patency of the stents has been assessed non-invasively by colour Doppler ultrasound, and six-month arteriographic follow-up is presented in three cases.

Aneurysm stenting — a Utopian dream or an approaching reality?

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Aortic aneurysm stenting has already been performed on animal models and recently in humans. The ideal system remains elusive. A series of six dogs with surgically created aortic aneurysms were bypassed with a novel system involving a bilateral femoral approach using silicone coated Palmaz stents. All aneurysms were successfully bypassed, but the coated stents thrombosed over the next few weeks. The feasibility of the technique is demonstrated, but further work on a suitable stent coating material is required.

TIPSS: lessons learnt from follow-up

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We report our experience of transjugular intrahepatic stent shunt (TIPSS) with emphasis on the problems that have arisen during the course of follow-up. TIPSS has been attempted in 24 patients with technical success in 19. There was one procedure-related death. Four patients have had further bleeding following TIPSS. One of these patients died despite a patent TIPSS. In another the TIPSS was occluded and could not be recanalized. The other two who re-bled had stenosis of the TIPSS or hepatic vein. Whereas we initially followed the TIPSS patients with Doppler ultrasound, we now feel that this is inadequate because problems such as hepatic vein or TIPSS stenosis may not be detected. Therefore we perform transjugular portography for follow-up. This permits diagnosis and correction of any problem, as well as measurement of the portal pressure gradient and shunt dilatation if required. Stenting of the hepatic vein during the TIPSS procedure may be necessary to prevent subsequent hepatic vein stenosis.

Radiological insertion of an implantable drug delivery system for long term vascular access

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An increasing number of patients with haematological and oncological conditions frequently need long-term venous access. Hickman lines have traditionally provided this access but need constant high quality care. An alternative method is a totally implantable system with a subcutaneously located injection reservoir entered by right-angled needles, for example the Vasuport (TM Viggio-Spectramed). Traditionally these catheters have been inserted surgically in theatre. The insertion may be performed under local anaesthetic and fluoroscopic control in an angiography suite. Using a technique similar to the insertion of a permanent pacemaker, a subclavian vein is cannulated. The implantable delivery system is placed subcutaneously at a site convenient to the patient by forming a small subcutaneous pocket. The delivery system is tunnelled to the subclavian vein. We describe the technique of insertion of this system under radiological guidance and discuss the extension of this system into use within the arterial system for regional chemotherapy. We suggest that the implantable drug delivery system for long-term access is cost effective and can be conveniently inserted under radiological guidance. The ability to guide insertion of this system into the arterial tree under radiological control will make this a useful technique when regional chemotherapy is desirable.

Assessment of the effect of percutaneous transfemoral procedures on the femoral nerve

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A great variety of vascular procedures are performed via the percutaneous transfemoral route. Local anaesthetic is usually infiltrated on both sides of the artery in both superficial and deep planes. The femoral nerve at the inguinal ligament lies just lateral to the artery running in the femoral sheath. Despite this close proximity, neurological complications following such procedures are rare. With the advent of true outpatient procedures (where the patient may walk away after only a 30 min recovery period) transient neurological problems related to the injection of local anaesthetic assume real significance. We report on the neurological assessment of 50 patients following assorted transfemoral procedures. Motor and sensory function was assessed in the territory of the femoral nerve within an hour of the procedure. The detailed results are described. Short term sensory deficits and, particularly, weakness can result,

which has important implications when patients ambulate early.

Pelvic pain syndrome: treatment by ovarian vein embolization

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A study of the efficacy and safety of ovarian venous embolization in the treatment of pelvic pain syndrome was undertaken. Pelvic pain syndrome (PPS) is characterized clinically by chronic pelvic discomfort, frequently associated with menstrual symptoms and dyspareunia. The diagnosis is made by the exclusion of organic pelvic pathology, usually involving a combination of ultrasound and laparoscopy. An association between PPS and ovarian varices has been recognized for many years but it is only recently that the primary problem is venous reflux in incompetent ovarian veins. Selective ovarian venography is the most useful diagnostic test. Surgical ligation of the ovarian veins has been employed in small series of patients with encouraging results. Six patients with the clinical and radiological features of this condition underwent bilateral ovarian venous embolization. All patients were treated by proximal and distal embolization of the ovarian veins with steel coils. Technical success was achieved in all cases. There were no procedural complications. All patients obtained rapid symptomatic relief and remain asymptomatic at follow-up (2–12 months). No clinical or biochemical disturbance of ovarian function occurred. The primary cause of PPS is ovarian venous reflux, analogous to the male varicocele. Preliminary experience indicates that ovarian venous embolization is a safe and effective treatment for PPS.

Combined radiological and surgical management of venogenic impotence using coil embolization

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Impotence presents a difficult management problem when the cause is a persistent vasogenic leak. The results of surgery on the proximal deep dorsal vein and the crural veins are disappointing. Eight male patients complaining of impotence did not respond to intracavernosal injections of papaverine and phentolamine. These patients underwent colour duplex Doppler studies (using an Acuson 128,

5 MHz probe) of the cavernosal arteries which were found to respond to 60 mg of intracavernosal papaverine. Venous leakage was subsequently confirmed in all eight patients by pharmacocavernosography. Under general anaesthetic all eight patients underwent insertion of a 5F vascular sheath into the proximal deep dorsal vein. The deep and the superficial draining veins of the penis were ligated distally. The patients were then transferred to the angiography suite. The patent draining veins were selectively catheterized using a variety of catheters through the indwelling vascular sheath, and were embolized with a combination of steel and platinum coils, 3% sodium tetradecol and absolute alcohol. Complete occlusion was only possible in four cases. Partial occlusion was possible in the remaining four. One patient had a complete response with a return of normal erections and one has had no benefit. Six of the eight now respond to the intracavernosal therapy of papaverine and phentolmine. A combination of surgery to the distal veins and embolization of the proximal veins may be the treatment of choice for those men with pure venous leaks seen at cavernosography.

Inoue mitral balloon valvotomy technique: a clinical and echocardiographic assessment

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We assessed the clinical and echocardiographic outcome in patients undergoing mitral valvotomy using an Inoue single rubber nylon balloon. The first 45 patients (38 females, mean age 55; seven males, mean age 57) undergoing Inoue mitral valvotomy at Bristol Royal Infirmary were assessed pre and postprocedure by New York Heart Association criteria in terms of function ability. Pre and postprocedure echocardiograms were assessed for mitral valve area and mitral regurgitation. In addition the preprocedure echocardiogram was scored using 2D image criteria of the valve and its apparatus by an observer blind to the clinical and echocardiographic outcome. The mean mitral valve area prior to valvotomy was 0.95 cm² which rose to 1.58 cm² following valvotomy. The mean increase in valve area of 0.645 cm² had 99.5% confidence intervals of 0.35 cm² to 0.89 cm². 38 of 44 patients improved clinically, mean echo score of 6.5. Six patients showed no clinical improvement, mean echo score 8.5. Four patients in this group had an increase in mitral regurgitation which required subsequent valve surgery. There was one death owing to a late retroperitoneal bleed. The clinical success rate of 86% in our group has made this technique our treatment of choice for many cases of mitral stenosis. There is, however, evidence that patients with grossly abnormal valves or mitral regurgitation may benefit less from balloon valvotomy.

Thrombolysis and stroke

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The incidence of cerebrovascular complications in 115 cases of acute vascular occlusion treated with intra-arterial thrombolysis is analysed retrospectively. Risk factors and duration of thrombolytic therapy are assessed. Agents and doses employed are r-TPA ($0.5-1.0 \text{ mg h}^{-1}$, $n = 99$) and streptokinase (5000 U h^{-1} , $n = 16$). Duration of treatment was determined by serial angiography. Five patients

suffered stroke, two fatally. The mean age of the patients was 63 years (range 61-71). Two patients had pre-existing cerebrovascular disease and two had a history of ischaemic heart disease. The mean duration of lytic therapy was 23 h (range 10-55 h). Cerebral CT showed five non-haemorrhagic infarcts. Echocardiography failed to demonstrate mural thrombus or valve vegetations in all cases. Cerebrovascular complications are a significant cause of morbidity and mortality. Our study demonstrates a higher than expected incidence of strokes, all of which were surprisingly non-haemorrhagic. The cause of this may include the possibility of thrombolysis-induced embolism or be related to inherent patient risk factors.

WEDNESDAY

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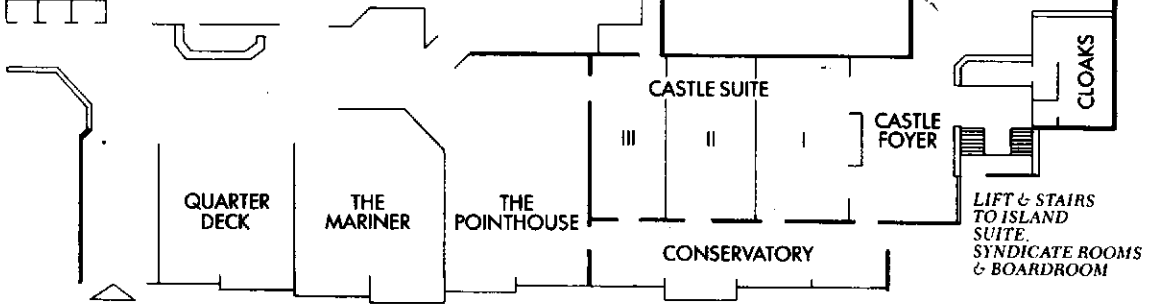
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