Scientific Programme Abstracts

Monday 18 May

9.00 – 10.15

The Central Nervous System

Hall 9

Diffusional MRI of the brain

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By using strong gradient pulse sequences on either side of the 180° pulse of a spin-echo sequence it is possible to make Brownian motion of water the dominant form of contrast in magnetic resonance (MR) images of the brain and spinal cord. This can be done in any direction. Motion of water in the brain is restricted by the presence of membranes, macromolecules and myelin sheaths. By using gradients orientated in different directions it is possible to demonstrate that diffusion of water across myelinated fibres is much less than that along them. This enables white matter tracts to be demonstrated as a function of their direction. In disease, breakdown of membrane barriers and myelin sheaths usually increases the diffusion of water but in a surprisingly large proportion of cases the reverse happens. It is believed that in this situation water molecules may be trapped in myelin sheath layers. The technical developments necessary to implement diffusion imaging will be illustrated and applications in paediatric and adult diseases will be presented.

CT and MR in the diagnosis of intraventricular cerebral masses

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The computed tomography (CT) and magnetic resonance (MR) images were reviewed in all patients presenting with intraventricular cerebral masses at the University Hospital, Nottingham between 1985 and 1991. In an attempt to develop a logical approach to diagnosis, each site within the ventricular system was analysed for the relative frequency of each histological type. The radiological features were noted, in particular the number, extent and morphology of the masses, the presence or absence of calcification or cystic change, the presence and nature of any hydrocephalus, the CT attenuation before and after intravenous contrast enhancement and the MR signal characteristics. The appearances of the commonest masses are described for each site and the main differential diagnoses are discussed. Particular attention is drawn to intraventricular neurocytoma; a recently described tumour that may be mistaken histologically for intraventricular oligodendroglioma. A comparison is made of the value of CT and MR in the diagnosis of intraventricular masses.

Fast spin echo (FSE) techniques in cranial MR imaging

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Considerable savings in examination time are possible using newly available fast spin echo (FSE) sequences. These techniques are based on the principle that multiple phase encoding steps can be acquired in one excitation of the spin system. They provide images with tissue contrast similar, but not identical, to conventional spin echo (CSE) sequences. A prospective study of 50 patients referred for primary cranial magnetic resonance imaging (MRI) examination was undertaken on a 1.5 T imager. Spin density and T_2-weighted images were obtained using CSE and FSE sequences with identical parameters. The diagnostic yield, defined by the supervising radiologist and by two independent reviewers, was compared. A quantitative evaluation of all positive studies based on lesion counts was performed. The two techniques provided images of similar quality. There was complete concordance in the resulting diagnoses. In patients with clinically definite multiple sclerosis, quanti-

tative assessment of scans showed lesions to be more conspicuous on the spin density weighted FSE sequence. The FSE sequence is therefore recommended for routine cranial MRI.

MRI of meningeal enhancement in malignant disease

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Gadolinium (Gd)-DTPA is essential for the diagnosis of metastatic meningeal disease on magnetic resonance imaging (MRI). Pathological enhancement of the cranial and spinal meninges may be difficult to differentiate from the normal and can have a range of appearances in patients with malignant disease. We have reviewed the MR appearances of 30 patients with abnormal meningeal enhancement. Scans were performed on a Siemens Magnetom operating at 1.5 T with a minimum of a T_1-weighted sequence before and after Gd-DTPA enhancement. If cerebrospinal fluid cytology was not obtained or was negative, the diagnosis of meningeal tumour was made by excluding other causes of abnormal meningeal enhancement and by longitudinal follow-up. The most common pattern of involvement of the cranial meninges was generalized dural enhancement. Diffuse leptomeningeal and focal linear and nodular enhancement were also seen, in one case simulating a parafalcine meningioma. Spinal meningeal involvement was either nodular or diffuse. In three cases meningeal involvement could only be identified on the enhanced scans and Gd-DTPA improved visualization in all cases. Meningeal involvement is well recognized in carcinoma of the breast and lung, melanoma, primitive neuroectodermal tumour and lymphoma, and in our series was also seen in metastatic cerebral glioma, teratoma and embryonal rhabdomyosarcoma.

Assessment of meningeal pathology by MRI and CT

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Diffuse meningeal disease may be difficult to identify on contrast-enhanced computed tomography (CT) due to partial volume effects and beam hardening, particularly at the skull base and vertex. Meningeal pathology may be obscured on unenhanced T_1- and T_2-weighted magnetic resonance imaging (MRI) sequences, by adjacent cerebrospinal fluid with similar relaxation times. We have reviewed nine patients with meningeal abnormalities where changes on enhanced CT and unenhanced MRI were difficult to detect. MRI with gadolinium-DTPA (Gd-DTPA) was diagnostic in all cases. Images were obtained on a 0.26 T Picker or 0.5 T GE Vectra MRI system using a head coil. T_1- and T_2-weighted spin echo sequences (time to repeat (TR)/time to echo (TE) 500–2000/20–90) were obtained pre-contrast. T_1-weighted sequences following 0.1 mmol/kg Gd-DTPA intravenously were repeated in three orthogonal planes. In four patients with diffuse meningeal pathology, CT and unenhanced MRI were normal or underestimated the full extent of disease, which was clearly demonstrated after Gd-DTPA. In five patients with focal meningeal lesions at the skull base or vault, CT either failed to demonstrate the lesion or provide conclusive diagnostic information. Meningiomas which were isointense with brain on both T_1- and T_2-weighted MRI sequences only became conspicuous after Gd-DTPA. Despite the high-contrast resolution, multiplanar facility and lack of bone artefact with MRI, meningeal lesions can still be difficult to detect. In patients with a suggestive clinical history and neurological signs, but inconclusive findings on CT and unenhanced MRI, administration of Gd-DTPA is mandatory to exclude meningeal disease.

The role of CT scanning in the investigation of low tension glaucoma

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Low tension glaucoma (LTG) is the combination of glaucomatous optic nerve cupping and visual field defects with normal intraocular pressure. At this centre it is current practice to investigate such patients with computed tomography (CT) of the optic pathway. In this study 30 successive patients imaged for LTG were retrospectively reviewed. All patients underwent thin section contiguous contrast-enhanced coronal CT through the orbits and pituitary region. CT was normal in 18 cases, demonstrated an empty sella in 10 cases, a pituitary macroadenoma in one case and thyroid ophthalmopathy in another. In the latter two cases clinical re-examination was found to be consistent with the radiological diagnosis, rather than LTG. The results of this study suggest that careful clinical assessment should exclude the possibility of a pituitary or optic nerve lesion in LTG and CT should be reserved for patients with atypical features.

Ophthalmology referrals for brain CT — a retrospective audit

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A retrospective study of patients referred for brain computer tomography (CT) by ophthalmologists was carried out to assess its effect on clinical management. 53

patients were included in the study. The most common presenting complaints were visual field defects, headaches, and glaucoma. 21 patients had plain skull X-rays before CT, seven (33%) were reported abnormal, five of which were false positives. In 38 patients the CT was normal and usually resulted in the patient's discharge. In the majority of the 15 patients who had an abnormal CT, this prompted discharge or neurosurgical referral. In the six patients who presented with a homonymous hemianopia, the CT was positive. Therefore we would recommend the following practice: (1) brain CT should be the first imaging examination in patients with a homonymous hemianopia; (2) brain CT should be considered early in the test sequence as this would reduce the number of additional investigations, and follow-up clinic appointments, with considerable cost savings; (3) plain skull X-rays have very little value in non-traumatic ophthalmic conditions and should not be performed; (4) in patients presenting with headaches, brain CT is not indicated in the absence of localizing signs and (5) brain CT is rarely helpful in glaucoma, except in some cases of low-tension glaucoma.

Computed tomography of the brain in psychiatric patients: an audit

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Computed tomography of the brain (CT brain) is often requested in patients suspected of having dementia to exclude an underlying treatable cause. The indication for such scans in patients with psychiatric illness, particularly young patients and those not responding to standard treatment, is less clear. We reviewed the indications for and the results of CT brain scans performed at the request of the psychiatric department over a 4 year period. A total of 270 scans was performed on 256 patients (mean age 57.8 years). There were 118 normal examinations. 139 scans showed either cerebral atrophy, ischaemia or infarction (findings which do not require specific therapy). Significant abnormalities were found in nine patients (13 scans); when follow-up scans and those patients in whom the diagnosis was already known are excluded, the number of unexpected abnormal scans was six in six patients (2.2% of all scans). Indications for these scans included epilepsy, incontinence, neurofibromatosis, previous head injury and surgery. These findings are presented and discussed with suggested guidelines on the rational use of CT in these patients.

The outcome of fetal ventriculomegaly

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Over a 4 year period 34 cases of fetal ventriculomegaly were diagnosed at Queen's Medical Centre, Nottingham. All antenatal and post-natal scans were assessed, liveborn babies followed up from 1 month to 3 years and post-mortem examinations reviewed. There were 12 cases of spina bifida and all patients opted for a termination of pregnancy. There were 13 cases of isolated ventriculomegaly comprising five cases of aqueduct stenosis, four abnormalities of the corpus callosum, one cavum septum pellucidum cyst, one case of porencephaly and two cases of mild lateral ventricular dilatation. The fetuses in this group had a relatively good outcome with six normal babies, two with mild developmental delay, one stillbirth, two patients opted for a termination of pregnancy and two pregnancies are continuing. Associated abnormalities were seen in four cases and these carried a poor prognosis with one fetus stillborn, one neonatal death and two patients opted for a termination of pregnancy. The five remaining cases included three Dandy Walker syndrome, one brain tumour and one case of subdural haemorrhage. There were three terminations of pregnancy, one stillbirth and one baby with severe developmental delay. To conclude, isolated ventriculomegaly carries a relatively good prognosis, the presence of associated anomalies has a poor outcome.

9.00 – 10.15

Radiotherapy Treatment I

Hall 10a

Dose specification: is there a consensus?

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The outcome of radiotherapy, as measured by local tumour control, can only be interpreted meaningfully if the distribution of radiation dose in space and time can be correlated accurately with the clinical and pathological extent of the disease. In order to compare and improve treatment results it is essential that there is a common language used for the definitions of basic criteria such as tumour volume, target volume and treatment volume. Studies are needed to provide anatomical and tumour data for improved definitions of "margins" around tumours for treatment planning. It is recommended by the International Commission on Radiation Units and Measurements (ICRU) that a common method of reporting radiation dose is used internationally in order to facilitate communication between institutions and allow meaningful comparison of treatment results. The ICRU reference point is selected at the centre of the target volume on or near the central axis of the beam as the most clinically relevant, unambiguous and representative point. The dose variation across the target volume is now a compulsory requirement for dose reporting according to new ICRU guidelines. These new ICRU recommendations for reporting external beam therapy will be discussed — do we at last have a consensus?

Radiobiological implications of physical dose inhomogeneity in radiotherapy treatment planning

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Successful radiotherapy requires the delivery of a tumoricidal treatment while sparing as much normal tissue as possible in the irradiated volume. The aim of optimizing radiation treatment planning is to satisfy this requirement. However, expressing the treatment plan solely as a physical dose distribution might be misleading. In most centres, dose variation of 10% (±5%), or even more, is considered to be an acceptable range of inhomogeneity. Converting the physical dose distribution in the irradiated volume into a biological effect distribution (isoeffect lines), using the linear quadratic model, increases the inhomogeneity factor. The biological dose inhomogeneity factor depends on the fraction size as well as radiobiology of the irradiated tissue (*e.g.* α/β ratio). In this analysis the biological dose inhomogeneity factor resulting from a 10% physical dose inhomogeneity was calculated for isoeffective schedules with different fraction size (1–5). For late responding tissue with α/β 1–5, the biological inhomogeneity ranged from 12% (±6%) to 19% (±9.5%) depending on α/β and the fraction size. For tumours and for acute responding tissues with α/β in the range of 5–20, the biological dose inhomogeneity was between 11% (±5.5%) and 15% (±7.5%). For late-responding tissues an increase of 9.5% in the biological effective dose may give a significant increase in the complication probability. Also a reduction of the effective dose by 7.5% may give a substantial drop in the tumour curability. Therefore, it may be preferable to express the outcome of treatment planning in radiotherapy in terms of calculated biological effect distribution as well as distribution of physical dose.

Non-coplanar radiotherapy treatment planning

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Owing largely to limitations in methods of dose computation and target definition, external beam radiotherapy has traditionally operated under the constraint that the central axes of the beams be coplanar. The advent of a newer generation of planning computers, together with the use of computed tomography (CT) and magnetic resonance imaging (MRI), has removed this constraint. A number of examples, planned on the Helax TMS planning system, are presented to illustrate where non-coplanar treatments are valuable or even essential. These arise where it is necessary to ensure that beams do not exit through critical structures

(such as eyes when treating tumours of the brain, ear or parotid) or enter through shoulders (when treating tumours in the neck/chest region) whilst maintaining good conformation of the beams to the target. Emphasis is given to the need to delineate the target as a three-dimensional (3D) object and the importance of its shape at the extremities and to facilities for 3D representation of the target, critical structures and the radiation beams.

Dose distributions for chest wall conformation therapy using 6 MV X-rays and cobalt beams

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Crescent-shaped isodose patterns have been generated in the patients transverse plane to irradiate the chest wall whilst sparing the adjacent lung. A technique using multiple glancing wedged fields combined with two arched fields has been devised for this purpose. The procedure has been applied clinically using the computer-controlled tracking cobalt unit and experimentally on a Philips SL18 linac using 6 MV X-rays. For comparative purposes, a tissue equivalent phantom with lung inserts was "treated" on both machines. Dose distributions were measured using thermoluminescence microrods and Ilford line film. The plan was devised on a Philips OSS treatment planning system. This single plane study demonstrates good control of the isodose pattern with effective sparing of the underlying lung tissue. As expected, the 6 MV X rays provide a more rapid fall-off of dose inside the chest than the cobalt beams. It is anticipated that this study will provide insights into the requirements for software for automatic therapy machine control, collimator design and treatment planning requirements.

Staging of head and neck cancer using magnetic resonance imaging

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The magnetic resonance imaging (MRI) findings in 40 patients with head and neck cancer seen at Mount Vernon Hospital between March 1990 and October 1991 were reviewed. The patients were all clinically staged before the MRI scan. The MRI findings were compared with the clinical staging; at the time of review, the radiologists were not aware of the clinical findings. There were 14 cases of laryngeal carcinoma, two of post-cricoid tumour, five involved the pyriform fossa, six the tongue, five the mouth or oropharynx and two the epiglottis. In several cases, staging was altered as a result of the MRI scan, and radiotherapy planning fields were adjusted. Even when clinical staging agreed with MRI findings, the multiplanar images obtained gave a greater degree of accuracy in radiotherapy planning. We conclude that MRI is a useful imaging technique in head and neck cancer.

The clinician's expectations from treatment

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In radiotherapy, different decisions have to be made successively such as prescriptions of the aim of therapy, the tissue volumes to be treated to specified dose levels according to specified fractionation regimes, and the organs at risk to be spared. The results of treatment can be no better than the input data. A treatment technique that is acceptable and optimal for the particular patient has to be decided upon, and the treatment has to be given within the uncertainty limits that have been accepted for the particular situation. Recording of a sufficient number of data has to be done in order to allow for later analysis of the treatment and for communication with other centres. Increasing sophistication in radiotherapy technology should allow for a better definition of target volumes and better dose distributions, and should thus lead to higher cure rates and less complications. This requires, however, that all the different steps in the whole radiotherapy procedure are optimized.

9.00 – 10.15

Nuclear Medicine I

Hall 10b

Progress in the radionuclide therapy of cancer

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The treatment of thyroid cancer with iodine-131 radioiodine is dependent on the selective uptake of radioiodine due to a function of the differentiated thyroid cancer cells. This functional approach is applied in the use of ^{89}Sr and ^{153}Sm for irradiation of bone metastases of prostate and breast cancer. The new approaches to cancer therapy depend on tissue characterization, *i.e.* through the subtle differences between the surface of the cancer cell as compared with its normal counterpart and on the architectural disruption that is inherent in malignancy. ^{131}I metaiodobenzylguanidine (MIBG) has given benefit to patients with malignant paraganglioma and to children with neuroblastoma even when, as in the latter case, it is the last in the line of treatment after surgery and chemotherapy. For neuroblastoma there should be earlier application of ^{131}I MIBG therapy when the cellular active uptake mechanisms are better preserved. The surface glycoproteins of the cancer cell are antigenic and against these antigens murine antibodies, made monoclonal by the hybridoma technique, are developed. ^{111}In and $^{99}Tc^{m}$ radiolabelled monoclonal antibodies have now a routine place in the early detection of recurrent and metastatic cancer, but the treatment of cancer using monoclonal antibodies labelled with beta-emitting radionuclides to target the radiotherapy is much more complex. Since a typical tumour uptake is about 1% of the injected activity, strategies are essential to reduce the irradiation of critically sensitive normal tissues. These include intratumour, intracavity, intra-arterial administration and the use of a two or three stage approach to circumvent irradiation of normal tissues. A bifunctional, bispecific antibody is required, one part of which binds to the tumour cell surface and the other to the radiotherapy bearing ligand. This antibody is injected first and time is allowed for metabolism of the unbound antibody (which may be helped by a "chase", as in the antibody-biotin streptavidin chase, biotin-radionuclide system). Then the radiotherapy bearing ligand is given. This approach enables a long-lived beta emitter, such as ^{32}P, to be used. This also has a pro-drug effect, for when the ^{32}P-antibody is metabolized at the tumour surface, ^{32}P phosphate may diffuse into the cells and be incorporated in their DNA and RNA. These new approaches depend on the lessons learned from conventional radionuclide therapy and, with genetic engineering techniques providing the "designer" molecules, open the way for selective, cancer-specific targeted radiotherapy.

Dobutamine thallium tomography in the investigation of Syndrome X

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Syndrome X describes patients who have positive exercise tests, anginal symptoms but normal coronary angiograms. We studied a group of 13 Syndrome X patients using tomographic stress thallium scanning. Dobutamine, a β-1 stimulator which increases myocardial oxygen demand, was used as the stressing agent and infused in increasing stages of 5 μg/kg/min starting at 5 μg/kg/min, for 5 min. Blood pressure, ECG and symptoms were carefully noted at each stage. Dobutamine infusion was halted when significant ST depression or chest pain was noted, thallium being injected 2 min before the end of the infusion whenever possible. The stress was tolerated well in all patients with only minor side-effects such as tingling and shaking. Nine patients showed reversible perfusion defects on thallium scanning while four had essentially normal studies. All but two patients (one normal thallium) developed chest pain at 10–120 μg/kg/min Dobutamine infusion. The results show that a high proportion of Syndrome X patients have reversible thallium defects when using Dobutamine; which is a well tolerated and not patient limited method of stress. This suggests that a significant percentage of Syndrome X may

be caused by some form of organic coronary artery disease, such as microvascular disease.

Study of left ventricular function in two families with Romano-Ward syndrome

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Congenital long QT syndrome is thought to arise from an imbalance of the sympathetic innervation of the heart. There is a tendency to life-threatening ventricular arrhythmias. Post-mortem studies have found regions of myocarditis. Is it possible to detect areas of abnormal myocardium during life? We have studied regional wall motion of the left ventricle in eight subjects with one of these conditions. After labelling the blood pool with $^{99}Tc^{m}$, tomographic radionuclide angiography was performed in young members of two families with Romano-Ward syndrome. Two sisters and their mother had significant infero-lateral wall motion abnormalities. The ejection fraction was substantially reduced in the two subjects who had arrhythmias (27% and 30%, normal > 40%). The other family had completely normal left ventricular contraction and ejection fractions (five subjects, two of whom have had symptoms). These results suggest that Romano-Ward syndrome is a heterogeneous abnormality which, in some instances, is associated with abnormal left ventricular contraction. In the family with abnormal left ventricles, the degree of left ventricular impairment may affect the susceptibility to ventricular arrhythmias.

Detection of viable myocardium with gated F18 fluorodeoxyglucose (FDG) positron emission tomography (PET)

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Critical coronary artery stenosis may provide only sufficient perfusion for basal myocardial metabolism without achieving normal contractile function. We describe a novel approach to detect such regions of myocardium which are potentially viable after re-vascularization. This approach has the advantage of directly measuring cardiac motion simultaneously with regional fluorodeoxyglucose (FDG) uptake with only a single low dose of radiation. Gated positron emission tomography (PET) was performed for six transaxial slices 18 mm apart. Wall motion along 36 radii 10° apart was objectively measured for eight short axis slices. Bull's eye images were formed with segmental FDG uptake superimposed on the wall motion. We defined viable myocardium as a continuous region (⩾ 25% of left ventricle) of good FDG uptake (⩾ normal myocardium uptake) and poor contraction (2 standard deviations below normal controls). We studied 32 glucose loaded patients consisting of eight normals and 24 patients (mean age = 61 years, 20 male patients) with angiographically proven coronary artery disease. Viable myocardium was detected in 15 patients: two in the anterior, four inferior, five septal, three apical and one in the lateral region. Study of a patient with dilated cardiomyopathy further validated the technique showing global good FDG uptake but reduced contraction. *Conclusion:* Gated FDG PET can simultaneously detect regions of metabolically active myocardium with poor contraction using a single low dose of radiation.

Regional left ventricular function following CABG: evidence for hibernating myocardium

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Tomographic radionuclide ventriculography, unlike conventional two-dimensional (2D) imaging techniques, is able to quantify changes in regional left ventricular function. It is, therefore, a useful method for studying the effects of coronary artery bypass surgery and the concept of hibernating myocardium. 20 patients (90% male, mean age 60) were investigated using this technique before and after coronary artery bypass surgery. All patients were imaged using the Aberdeen Section Scanner, which has acquisition and processing times of 25 and 30 min, respectively. Comparisons were made using polar map subtraction of regional ejection fraction and ventricular phase values. 13 patients had triple vessel and three double vessel coronary disease. Seven patients were known to have had at least one prior myocardial infarction pre-operatively and one patient was identified as sustaining a peri-operative infarction. The mean global ejection fraction, for all patients, was 42% pre-operatively and 45% post-operatively (ns). For regional ejection fraction, 26 out of the 80 total segments improved, 24 were unchanged and 30 showed signs of deterioration, post-operatively. With respect to regional phase values, 26 segments improved, 45 remained unchanged and nine showed evidence of deterioration. Thus, although the global ejection fraction changes little following surgery, there are nevertheless important physiological changes in regional function.

Autologous platelet survival in volunteer blood donors

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Healthy age-retired blood donors were invited to take part in research into the preparation and storage of platelets. 31% of donors approached gave their written consent to participate. Volunteers donated either 40 ml or 1 unit of whole blood from which platelets were prepared by standard BTS techniques. Platelets were either returned within 2 h to the donor ($n = 8$) or, in the case of a unit donation, stored agitated at 22°C for 4 ($n = 11$) or 5 ($n = 5$) days. Platelets were radiolabelled with indium-111 before returning an autologous aliquot to the donor. Samples were taken from each donor 1 h post-injection and daily for up to 8 days for determination of platelet recovery and survival. One in three volunteers underwent gamma camera imaging to determine platelet distribution. Four of the 24 volunteers involved in this particular project took part twice to estimate individual variation. The remaining stored platelets were assayed *in vitro* for platelet function and biochemistry. Whilst platelets radiolabelled and immediately returned demonstrated the best recovery (45.1%) ± 13.2) and survival (238.9 h ± 21.7), those stored for up to 5 days remain high (41.9% ± 8.8 and 185.2 h ± 11.8, respectively). Individuals taking part twice showed similar results on each occasion.

Technetium-HMPAO labelled leukocyte scanning in the initial diagnosis of inflammatory bowel disease

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The use of technetium-HMPAO labelled leukocyte scanning (WCS) in assessing activity in inflammatory bowel disease (IBD) is well known. We have retrospectively evaluated its role in the diagnosis of possible IBD in 43 new patients attending gastroenterology out-patient clinics. In 31 patients (Group 1) the WCS was the initial imaging investigation. In 12 patients (Group 2), in whom IBD was more strongly suspected by the clinician, it was used in conjunction with other radiological and/or endoscopic techniques. The prevalence of confirmed IBD was significantly lower in Group 1 (two of 31, 6%) compared with Group 2 (five of 12, 42%) (Fisher's exact text $p < 0.05$). The WCS showed high sensitivity, specificity and accuracy in both groups (sensitivity, specificity and accuracy in Group 1 were 100%, 93% and 94%, respectively, and in Group 2 were 100%, 86% and 92%, respectively). There were two false positive scans in Group 1 and one in Group 2, but no false negative results. The data suggests that the WCS, when negative, is useful as an initial screening test by excluding IBD. The anatomical information it provides, when positive, helps direct further endoscopic or radiological investigations.

The use of HMPAO-labelled white cell scintigraphy in the assessment of recurrent Crohn's disease

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In Crohn's disease (CD), radiological assessment of disease activity is frequently complicated by the radiographic stigmata of previous disease or surgical intervention. This study evaluates the use of Tc-HMPAO white cell scintigraphy (WCS) in recurrent CD, and correlates the findings on scintigraphy with those obtained by barium follow through examinations (BaFT), in 18 patients presenting with symptoms suggestive of CD. The patient group included 11 subjects with previously documented CD, and the final evaluation of disease activity was established by independent clinical methods. The WCS, if positive, was graded for uptake intensity, number of positive sites and anatomical extent. Each BaFT was carefully inspected for ulceration as the indicator of active disease and other stigmata of previous CD, including strictures and mucosal distortion, were recorded. The findings demonstrated a good correlation between clinical and scintigraphic results in recurrent CD. The presence of ulcers in particular correlated with positive WCS, but a significant number of patients without radiographic evidence of ulceration were scintigraphically positive, and subsequently established by clinical asessment as having recurrent CD. The results demonstrated that WCS is a sensitive and specific tool for the assessment of recurrent disease activity, particularly when BaFT is hampered by established stigmata of earlier disease.

9.00 – 10.15

The Application of BS5750 to Radiology

Hall 11a

Management and audit — BS5750 in radiology

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The BS5750 Series, otherwise known as ISO9000-9004, is a set of international standards which provides fundamental guidance on quality management systems, and includes specifications for the use of purchasers. The specifications cover the means by which a supplier of goods and services can establish its management systems to ensure that the purchaser's needs are continuously met. The purchaser may not be the customer in terms that are currently understood in National Health Service parlance. A set of purchaser and customer requirements will be described in the context of a quality management system based upon BS5750. Reference will be made to assessment work already undertaken by Bureau Veritas Quality International in two NHS departments, namely diagnostics and radiology.

Total quality management in a clinical radiology department

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Total quality management is a concept playing an important part in the managerial culture of the best commercial firms at the present time. It is based upon the notion that the end product of a commercial organization is made up of the work of individuals at many levels in that organization, and that if the work of each individual is performed in a way that is the best work of that kind, then the whole will be enhanced in such a way as to serve the customer and gain new markets. This is a leadership challenge to senior managers and results in a well motivated and satisfied workforce. These principles are so relevant to the work of health service organizations, that their implementation is worthwhile. The West Essex Directorate of Radiology is implementing a programme of quality management. They are monitoring all aspects of the quality chain and developing computer programs with Kodak for recording and for planning corrective action when variation exceeds agreed parameters. One department, the Breast Screening Service, is applying for registration under BS5750 so that the quality system is accredited by outside auditors.

The value of BS5750 to any work or business activity — a company view

A. D. O'Neill
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The registration of a work or business activity to one of the BS5750/ISO 9000 series of standards provides a number of important benefits. (1) It gives customers assurance of reliable quality of products and services. (2) It gives greater understanding and control of the business to the staff and managers. (3) It provides a robust framework for continuous improvement of business activities. (4) It pulls together different disciplines in a structured customer-focused way. (5) It is a standard of excellence that recognizes good business practice. This paper covers how registration to BS5750 can help many different work and business activities improve both business performance and customer satisfaction.

9.00 – 12.00

Workshop: How Does Radiology Prosper in the Trust Hospital?

Hall 11b

Chairman: H. Loose
Presentations by: H. Loose, *Freeman Hospital, Newcastle upon Tyne;* D. Perry, *District General Manager, Oxford;* P. Wright, *Deputy Medical Director, Freeman Hospital Trust, Newcastle upon Tyne;* A. Carty, *Medical Director, Royal Liverpool Hospital Trust;* P. Davies, *Clinical Director, City Hospital, Nottingham and* A. Saunders, *Clinical Director, Guy's Hospital Trust.*

This workshop is designed to provide a consensus decision on a subject that is taxing all those concerned. The introduction of the trust hospital has required many overburdened radiologists to adopt managerial and financial skills in addition to their diagnostic and therapeutic expertise. The department of radiology will prosper if it generates income, however, because a greater proportion of the work done is for the other clinical departments of the trust, the department of radiology may be seen as an internal provider? This forum will address the common problems encountered and a number of clinical directors who have wrestled with new philosophy will be prepared to present their solutions. It is hoped that the workshop will be led by discussion. The experts will give presentations on aspects of "trust status" that have caused particular concern. Departmental clinical directors and managers must maintain the profile of the X-ray department and ensure provision of good safe equipment and an efficient 24 h service to patients. It is a challenge which is familiar, but now the funding must also be generated, and the system must be correct to enable the X-ray departments to flourish under "trust status".

10.45 – 12.00

The Chest: Biopsy Techniques and High Technology Imaging

Hall 9

The use of a powered cutting needle (Biopty) for obtaining histopathological material in intrapulmonary lesions

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The sensitivity, specificity and safety of percutaneous transthoracic needle biopsy of pulmonary lesions is well established. Aspiration samples allow an estimation of whether a lesion is benign or malignant but often do not provide an adequate specimen for a specific histological diagnosis. Manual and powered cutting needles provide a larger core in which the lung architecture is preserved, but experience has been limited to chest wall lesions because it has been suggested that there is a higher incidence of pneumothorax and haemorrhage with this type of needle. We present a series of 53 patients in whom intrapulmonary lesions have been biopsied using a powered cutting needle, (Biopty TM, Radioplast, Sweden). 28 lesions were entirely surrounded by lung and 25 had pulmonary lesions abutting a pleural surface. A definitive histological diagnosis was achieved in 44 cases; in nine patients a diagnosis was not established. A wide spectrum of benign and malignant diagnoses was made, including some which could not have been made with non-cutting needles, for example, bronchioalveolar carcinoma, lymphoma, cryptogenic organizing pneumonia and Wegeners' granulomatosis. In this small series only one patient suffered an acute pneumothorax, which required a chest drain. Percutaneous biopsy using the Biopty Gun is a simple and effective method of obtaining high quality samples which allow accurate histopathological diagnoses.

Radiologically guided mediastinal biopsy: a 10 year review

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Between 1981 and 1991, 73 biopsies of presumed mediastinal masses were performed in 71 patients. In 34 patients the mass arose mainly from the anterior mediastinum, in 24 from the middle mediastinum and in 13 from the posterior mediastinum. Final diagnosis was based on surgical resection (25 patients), definitive Trucut specimen histology (21), clinicopathological correlation (20), demonstration of the cystic nature of the mass (three), and supportive scintigraphic features in two cases of mediastinal goitre. Fine needle techniques were used in 57 cases, cutting needles (Trucut) in 32 patients and 16 patients underwent both procedures. Since its introduction to our department 3 years ago, computed tomography has completely replaced fluoroscopy as the imaging modality for needle guidance. Sensitivity and specificity in relation to differentiating malignant from benign disease was 89% and 83%, respectively, for fine needle aspiration, and 96% and 86% for Trucut biopsy. Accuracy in terms of classification of the precise nature of the mass was 75% for fine needle aspiration and 94% for Trucut biopsy. There were no major complications. Radiologically guided mediastinal biopsy is a safe procedure which provides accurate diagnostic information in most cases.

Ultrasound guided biopsy of peripheral lung and pleural lesions

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Guided biopsy of lung and pleural lesions can prove difficult. Small lesions may be impossible to see at fluoroscopy, lesions can be obscured by pleural fluid: the use of computed tomography (CT) is limited and has its own problems of access and single plane imaging. Many small lung lesions lie against the pleura and so are visible on ultrasound. We have performed a study to see if ultrasound guided biopsy is an alternative method for the management of such lesions. 14 patients, (11 males, three females) (age range 48–77 years) have undergone ultrasound guided biopsy of peripheral lung or pleural lesions (from 1 cm to 4 cm in size) in the last 12 months. Solitary lesions were

seen in 10 patients (associated with an effusion in four); one patient showed isolated pleural thickening and three had multiple bilateral lesions. A 20 G Temno needle was used in 13 cases and an 18 G Biopty Gun was used in one case. All patients underwent several passes. Tissue samples were obtained in 12 patients; in one patient failure occurred as the lesion disappeared on introduction of local anaesthetic, in the other the procedure was abandoned when a pneumothorax and surgical emphysema occurred. The only other complication was minor haemoptysis (two patients). The biopsy histologies include malignancy (eight cases) granuloma (one patient) and normal lung (two patients). One sample was inadequate for diagnosis. We believe that ultrasound guided biopsy of such lesions is a simple and safe procedure with a good diagnostic yield. The technique will be discussed.

Avoidance of pneumothorax during percutaneous biopsy of the chest: creating an extrapleural "window"

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This paper reports a method of reducing the incidence of complications of percutaneous chest biopsy by improving extrapleural access. Pneumothorax is the most common complication of percutaneous chest biopsy when the needle crosses the pleural space. Although pneumothorax is not usually serious, the discomfort can be distressing to the patient and is preferably avoided. The parietal pleura is attached to the chest wall by loose areolar tissue, the endothoracic fascia, and can be easily displaced by injecting normal saline to create a track between the chest wall and the pleura, through which a needle can be passed. This technique can be used to approach lesions deep in the mediastinum by either an anterior or posterior approach. Injection alongside vertebral bodies produces some aching but this resolves quickly; local anaesthetic is not used to create the needle-track in view of the risk of entering an anomalous nerve root sheath and injecting into the theca. The injected saline clears rapidly, usually in a few minutes, and no serious sequelae have been observed.

CT assessment of the size of pulmonary nodules: an *in vitro* study

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Categorization of the severity of coal worker's pneumoconiosis (CWP) is traditionally based on the plain radiographic features. The size and profusion of opacities is important, with the presence of nodules measuring 1 cm or more in diameter constituting complicated pneumoconiosis. There is currently considerable interest in the use of computed tomography (CT) for the assessment of CWP and we have undertaken an *in vitro* study to assess the accuracy of CT measurement of the size of pulmonary nodules. 45 rounded nodules of synthetic material of approximate soft tissue density (70 Hounsfield units) were supported in gauze (−950 H) to simulate pulmonary nodules. The true size was accurately measured using a micrometer screw gauge and ranged from 0.58 cm to 2.14 cm. Using 10 mm collimation CT sections, standard lung settings (window level −750 H, window width 850 H) and broad lung settings (WL −550 H, WW 1350 H) permitted highly accurate measurement. On mediastinal settings (WL 20 H, WW 400 H), CT failed to detect nodules under 0.85 cm diameter. Above this size, the degree of accuracy increased as nodule size increased due to decreasing partial volume effect. The use of narrower collimation sections was of no real advantage. Under these optimized conditions, the use of both standard and broad CT window settings permits accurate measurement of nodule size.

Computed tomography (CT) in the assessment of the opaque hemithorax in children

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We examined 22 patients with a completely, or partially, opaque hemithorax to assess the value of computed tomography (CT) in the diagnosis. All features helping to distinguish between differing aetiologies were noted. Diagnoses were subsequently confirmed by histology, microbiology and angiography. All 10 patients with pleural fluid exhibited distinguishing features. All four with empyema showed marked pleural enhancement, two with lymphoma had mediastinal masses, one of which had enhancing pleural nodules. Of two patients with a soft tissue mass and pleural fluid, one mass, a haemangioma, was markedly enhancing, the other, a rhabdomyosarcoma, enhanced less. Rib abnormalities were seen in a patient with lymphangiomatosis and intrapulmonary nodules in an asthmatic patient with veno-occlusive disease. Infected cysts or abscesses were demonstrated in four patients and absence or hypoplasia of the lung in three patients. In one of these, a small trachea with possible obstruction of the normal bronchus by the pulmonary artery was shown. Of five solid masses there were no specific features in two, a fibrosarcoma and an embryonal rhabdomyosarcoma. Calcification and posterior rib splaying, characteristic of a neuroblastoma, were seen in one, and rib abnormalities in two

patients with an Askin's tumour. We conclude that CT, with intravenous contrast, demonstrates many different diagnostic features in children with an opaque hemithorax.

A quantitative HRCT technique for the serial assessment of bronchiectasis

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The clinical management of bronchiectasis is hampered by the lack of a reproducible system for monitoring the disease. High resolution computed tomography (HRCT) has an established role in the diagnosis of bronchiectasis but its utility in identifying disease progression has not been studied. Measurements of bronchial wall thickness on computed tomography (CT) vary greatly with window setting and are thus unsuitable for serial assessment. We have evaluated interobserver and intra-observer variation in objective measurements of bronchial wall circumference, made by three observers. In addition, to assess how accurately a previously scored section could be re-imaged at follow-up, patients were scanned on two separate occasions. 12 patients were scanned on an Imatron Ultrafast CT scanner; circumferences of 61 bronchi were measured using the tracing facility on the scanner console. There was minimal intra-observer variation (standard deviations (SD) for the readings of three observers = 0.40 mm, 0.60 mm, 0.67 mm) and interobserver variation (SD = 0.71 mm); variance was increased in the presence of contiguous vessels. The SD for differences in bronchial circumference on re-scanning patients was 1.57 mm. The reproducibility of measurements of bronchial circumference in this study indicates that this quantitative system promises to be valuable in assessing disease progression.

High resolution CT appearances in pulmonary complications of rheumatoid disease

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The lung may show a wide variety of manifestations in association with rheumatoid disease. The more common complications include pleural effusions, fibrosing alveolitis and necrobiotic nodules. Less commonly recognized associations are obliterative bronchiolitis, lymphoid follicular bronchiolitis, chronic organizing pneumonia and bronchiectasis. The plain radiograph findings of these latter conditions are often non-specific. In addition, interstitial fibrosis secondary to immunosuppressive therapy such as methotrexate or gold salts may be difficult to distinguish from fibrosing alveolitis on chest radiography. This presentation illustrates the wide spectrum of pulmonary manifestations seen on high resolution computed tomography (HRCT) and its use in refining the differential diagnosis of pulmonary complications in patients with rheumatoid disease.

High resolution CT appearances of pulmonary haemosiderosis with pathological correlation

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Pulmonary haemosiderosis is an uncommon condition with non-specific plain radiographic features: disparate and sarcoidosis. The utility of high resolution computed tomography (HRCT) in patients with chronic interstitial lung disease is now well established, but there is no literature on the HRCT appearances of pulmonary haemosiderosis; recent research has been directed towards the immunological basis of pulmonary haemorrhage. We present the HRCT findings in six patients with pulmonary haemosiderosis with pathological correlation in two cases and suggest a pathological basis for these CT appearances. The HRCT findings were similar in all six patients and not reminiscent of other chronic interstitial lung disease. The dominant abnormality was a diffuse nodular pattern with no zonal predominance. The nodularity was uniform in any one patient but varied between patients (ranging from 1 3 mm). Patchy areas of increased attenuation of the lung parenchyma were present in five patients due to more recent haemorrhage. This finding was associated with masking of the background nodularity. In view of these findings it is suggested that the HRCT appearances in the appropriate clinical context are sufficiently diagnostic for the initiation of therapy.

The ATS nodal map — a CT demonstration

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The American Thoracic Society (ATS) has proposed the use of a mapping scheme when describing mediastinal lymph node metastases in bronchogenic carcinoma. The map references major anatomical landmarks which are identifiable at mediastinoscopy. Numerical coding is used to denote specific nodal groups. Importantly for radiologists, this scheme is ideally suited to modern cross-sectional

imaging methods and in particular computerized tomography (CT) and magnetic resonance imaging. Benefits from the generalized acceptance include the avoidance of vague terminology, thus: (a) accurate correlation of normal/abnormal nodal size with site; (b) a more planned and uniform approach to decision making regarding biopsy route; (c) accurate comparison of multi-institutional data. This study utilizes calcified mediastinal lymph nodes seen on axial CT scans to demonstrate this classification and thereby act as a teaching aid to its wider acceptance.

Anterior mediastinal lymphoma

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21 patients with lymphoma, 11 male and 10 female with a mean age at diagnosis of 33 years were studied. Ages ranged from 18–70 years but only three were aged over 40. All patients had a histologically proven lymphoma with a predominantly anterior mediastinal disease distribution. Computed tomography (CT) demonstrated a soft tissue mass rather than individual lymphadenopathy in all but three patients. Associated findings included middle mediastinal involvement in 70% and chest wall invasion in 42%. Low density areas within the anterior mediastinal mass consistent with necrosis or cystic change were found in 25%. Hodgkin's disease accounted for 13 (62%) patients, and non-Hodgkin's lymphoma for eight (38%) patients, all high grade T or B cell. Despite the disease primarily involving the anterior mediastinum, less than 40% had symptoms related to the chest. Involvement of the lung parenchyma, great vessels and pleura were less commonly demonstrated. Despite often extensive thoracic involvement, disease beneath the diaphragm was infrequently found.

MRI of residual lymphoma masses

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Following chemotherapy or radiotherapy, lymphoma masses frequently resolve to leave smaller residual soft tissue abnormalities. Evaluation of adequacy of treatment when these abnormalities remain is a frequent clinical problem. Some authors have claimed that magnetic resonance imaging (MRI) may discriminate between "active" and "sterilized" lymphoma, a low signal on T_2-weighted imaging indicating fibrosis and inactivity within the residual mass. In a prospective study of 34 patients, MR images were obtained of stable residual lymphoma masses identified by computed tomography (CT) scan after chemotherapy and/or radiotherapy. The ability of MRI to assess activity within the residual mass and thus to predict early relapse, was compared with high dose gallium scanning (HDGS) and erythrocyte sedimentation rate (ESR). 11 patients subsequently relapsed. MRI yielded a sensitivity of 44%, specificity of 91%, positive predictive value of 71% and negative predictive value of 78% for detection of residual active disease. These figures compared favourably with HDGS and ESR in our series and suggest a role for MRI in follow-up of lymphoma patients.

10.45 – 12.00

Radiotherapy Treatment II

Hall 10a

Shaping the treatment volume

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Successful radiotherapy for localized tumours depends on the irradiation of a target volume including the tumour and an appropriate margin, to a high dose whilst shielding adjacent normal tissues. In many circumstances this can be achieved by projecting megavoltage beams of rectangular cross-section towards the tumour bearing tissues. However, in order to exploit the strong inverse relationship between dose and volume, and to be able to treat tumours near to particular radiosensitive normal tissues, it is necessary to use beams of irregular cross-section and to consider the resulting dose distribution in three dimensions. Simple methods of producing irregular beams have become well established and are widely available. More recently, the availability of detailed anatomical data for individual patients, computers with power to manipulate images and graphics in seconds rather than minutes and linear accelerators which can be operated under computer control have allowed the developments of some elegant solutions to the volume shaping problem. The simple methods will be reviewed and discussed in comparison with present developments in this important technical aspect of radiotherapy.

Optimizing dose with a multileaf collimator for conformal radiotherapy

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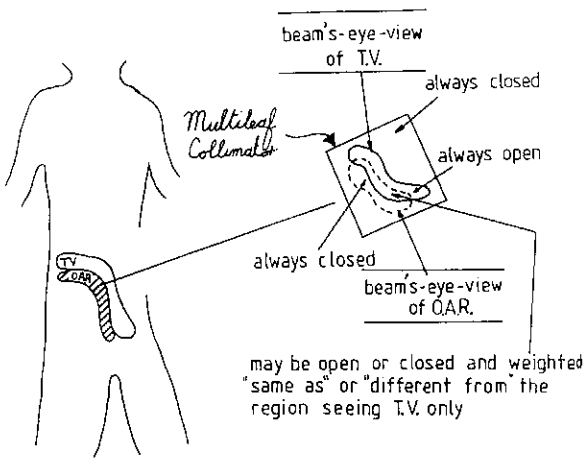
The use of several, preferably non-coplanar, photon beams, geometrically shaped to the beam's-eye-view of the target volume using a multileaf collimator (MLC), can achieve the goal of conformal therapy. A high dose volume may be fitted around the target volume. This paper addresses the extra difficulties which arise when the target volume has one or more concavities in its outline with organs at risk in such depressions. In these circumstances it is not so easy to select beams "seeing" the target volume, which do not also "see" part or all of the organs at risk. The problem then arises of the optimum distribution of beamweights to apply to each MLC location. This problem has been studied extensively and several solutions have been identified. The simplest solution shown in the figure is to use two beamweights per field, one for the part seeing only target volume and one for the part seeing both target volume (TV) and organs at risk (OAR). The optimum distribution of such pairs of weights (for a group of fields) has been determined by simulated annealing for a number of model problems and results will be shown. A second potential solution is to vary the intensity of the radiation continously across the open shaped ports and it will be shown that this leads to even better solutions. In a typical model problem where the organs at risk were entirely surrounded by target volume, the maximum in the dose-volume-histogram of the organs at risk was reduced to some 50% of the maximum in the dose-volume-histogram of the target volume. All solutions are enormous improvements on using the same beamweight for each field.



Potential advantages of 3D conformal planning in extremity soft tissue sarcoma

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The late complications and subsequent limb function, following treatment of sarcomas are related to radiation dose used and tissue volumes irradiated. The impact of conformal blocking on the radiotherapy planning of lower limb soft tissue sarcomas has been studied in 11 patients. Tumour, target and normal tissue volumes were reconstructed in 3D following a computed tomography (CT) planning scan. Dose calculations were performed for conventional and conformal plans using a block margin of 6 mm around the target volume. The volumes of tissue receiving 50%, 80% and 90% of the prescribed dose were compared using CVDDs. There was no compromise of target dosimetry with the use of conformal blocks. The treatment volume was reduced in all patients, and by $> 20\%$ in four of the five patients with thigh tumours. The mean volume of muscle outside the target volume which was irradiated to the 50% isodose was 4.2 l. The volume irradiated to $> 90\%$ was reduced by $> 30\%$ in five of the eight patients with thigh and lower leg tumours. The volumes of femur, tibia/fibula and ilium irradiated to $> 90\%$ were reduced by 38%, 18% and 14%, respectively, by conformal blocking. Considerable sparing was achieved in the volumes of pelvic contents irradiated, including gonads and rectum. This simple but time consuming technique can achieve major reductions in normal tissue irradiation and subsequent improvement in limb function. To realize this potential fully similar advances in patient immobilization and treatment verification are required.

Technical aspects of fractionated stereotactic radiotherapy

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We have developed fractionated, stereotactic external beam radiotherapy for the treatment of malignant brain tumours. The technique utilizes the relocatable Gill–Thomas frame, which is reproducible to an accuracy of 1 mm. This precision depends on skill and expertise in the fitting process, and is monitored regularly. Computed tomographic (CT) scanning is carried out in the frame using a fiducial marker system. Tumour localization on the CT slices accounts for the largest uncertainty in the planning process. An additional error of 1 mm arises from image resolution on the treatment planning computer. The isocentre obtained from the treatment plan is often displaced from the geometrical centre of the target volume by up to 2 mm for larger, more eccentric lesions. The combined error in setting up this target isocentre to coincide with the mean radiation isocentre is 1 mm, and depends upon careful monitoring of the alignment lasers and machine parameters. The dose delivered by multiple arcs is potentially less accurate than with fixed fields. Regular comparison of phantom measurements with computer planning calculations are therefore required. Fractionated stereotactic radiotherapy can be carried out on a standard linear accelerator used for the routine workload of a department. However, it requires additional quality assurance with attention to detail. Even in ideal conditions, a 2–3 mm margin around the tumour is required for technical margins of error.

Fractionated stereotactic external beam radiotherapy for the treatment of recurrent gliomas and solitary brain metastases: a dose escalation study

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Fractionated stereotactic external beam radiotherapy (SRT) has been used to treat patients with recurrent gliomas and as a boost for patients with solitary metastases after whole brain radiotherapy. We report the acute toxicity and early survival results of the first 41 patients. A 5 MV linac and a relocatable stereotactic frame were used. Dose was prescribed to the 90% isodose which encompassed the ring enhancement on computed tomography. Accuracy of dose delivery was within 2 mm. 22 patients with recurrent gliomas have been treated. Two patients received 20 Gy in 4 fractions, two received 30 Gy in 6 fractions, four received 35 Gy in 7 fractions, eight received 40 Gy in 8 fractions, four received 45 Gy in 9 fractions and two received 50 Gy in 10 fractions. Previous radiotherapy varied between 45 Gy in 20 fractions and 60 Gy in 33 fractions. The median survival of this group from SRT was over 50 weeks. Follow-up ranged from 10 to 90 weeks. 19 patients with solitary metastases received SRT boost following whole brain radiotherapy. Doses ranged from 10 Gy in 2 fractions to 20 Gy in 2 fractions. The median survival of this group was 33 weeks and follow-up ranged from 10 to 80 weeks. Fractionated SRT is well tolerated and the initial survival results are encouraging. In recurrent gliomas the results are similar to interstitial radiotherapy.

A computer program for scheduling radiotherapy courses

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The program was developed to enable radiotherapy courses to be booked in advance for a number of consultants in a department with a waiting list for treatment. The allocations for individual consultants were subject to agreement but could easily be changed. A commercial 4GL database retains all of the administrative data for each patient and a linked suite of programs written in "C" keeps track of available start dates and schedules each course according to a specified pattern of treatment days each week. The suite allows for changing and deletion of courses and the use of the "spare slots" created by such activities. It is possible to weight allocations for the more time-consuming set ups. Calendar-related functions automatically provide current dates and allow for Bank Holidays and maintenance days. Mould room and simulator appointments are also dealt with and day lists are provided for all activities. Printed appointed letters are also generated. Over a period of 2 or 3 years data have been archived to provide information on waiting times, patient attendances and working practices, *e.g.* fractionation routines. With the addition of a post code/health district index data are produced for the quarterly returns to the purchasers.

Use of CT planning to improve mantle radiotherapy dosimetry

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Conventional dosimetry for mantle radiotherapy provides only a series of midplane doses at specified points within the target volume and accurate dose determination for specific lymph node groups and critical normal tissues is not possible. We have developed a method of integrating computed tomography (CT) planning and computerized dosimetry with conventional techniques in the planning of mantle radiotherapy in order to provide a more accurate and detailed dose distribution. Patients are first planned using conventional supine and prone simulation and lead blocks for shielding lung and spinal cord are cut as specified. Patients then undergo supine and prone CT planning and the individual target lymph node groups plus critical normal structures are indicated on the CT slices. A Theraplan dosimetry system is used to create accurate dose distributions throughout the target volume, taking account of the specified lead shielding, changing body contours, etc. In the first three patients planned in this way (for an 8 MV linear accelerator at 150 cm focus–skin distance) the doses received by specified lymph node groups were found to vary by a mean of −8% to +10% as compared with the midplane dose at the centre of the field. This gave a dose range of 32.2 Gy to 38.5 Gy for a prescribed dose of 35 Gy. The subcarinal/para-aortic nodes consistently received the lowest doses and the anterior cervical nodes the highest. The dose to the spinal cord with posterior shielding was, on average, 55% of the unshielded dose. The improvement in dosimetry achieved with this technique has important implications for mantle dose specification.

10.45 – 12.00

Nuclear Medicine II

Hall 10b

The influence of nuclear medicine in paediatric imaging

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Advances in imaging techniques have affected paediatric radiology. The use of ultrasound, computed tomography (CT) and magnetic resonance imaging (MRI) has caused a reappraisal of the first line imaging. All these techniques are based on anatomy. Nuclear medicine is characterized by providing physiological data and functional images. Nuclear medicine examinations must be taken in conjunction with the anatomical information. *Renal tract:* In the renal tract vascular abnormalities may be better understood and clearly defined with the use of nuclear medicine, this includes renovascular disease as well as following renal transplantation. In urinary tract infection a dimercaptosuccinate (DMSA) is required to exclude a scar. Vesicoureteric reflux may be detected using indirect radionuclide cystography and thus avoiding the need for bladder catheterization and a marked reduction in radiation dose. In children with a pre-natal diagnosis of a urological abnormality, the ultrasound and dynamic renal scan go hand in hand in grouping these children for further management. *Skeleton:* In the skeleton radioisotopes have a role in suspected infection as well as in children with a limp. Disseminated malignancy is best excluded with bone scanning. *Brain:* $^{99}Tc^{m}$ HMPAO, a lipophilic agent, gives a map of regional cerebral perfusion and provides unique information on seriously ill children in intensive care. In epilepsy pre- and post-ictal HMPAO studies combined with MRI may yet provide new understanding of children with intractable epilepsy. *Respiratory:* In the respiratory tract the small or hypoplastic lung can be readily diagnosed with a chest radiograph and a ventilation/perfusion lung scan. The role to look at the long-term sequelae of children with a foreign body has also been well explored. *Conclusion:* Imaging in paediatrics should be based on the principle of using the least invasive technique and also the lowest radiation burden. Heavy sedation including general anaesthesia may be required for both magnetic resonance and also CT scanning. In general nuclear medicine procedures have a low radiation burden and rarely require sedation of the child. An integrated approach where the pathophysiology as demonstrated by nuclear medicine can be firmly attached to the anatomical diagnosis leads to appropriate use of resources and inflicts the least burden on the children investigated.

Multipurpose scintigraphy with $^{99}Tc^{m}$ pyrphotech in paediatric oncology

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Children with tumours and tumour-like lesions of bones and retroperitoneal space were studied both in the dynamic and static modes of multipurpose scintigraphy using $^{99}Tc^{m}$ pyrphotech. In children with retroperitoneal tumours information obtained using multipurpose scintigraphy after single injection of $^{99}Tc^{m}$ pyrphotech is compared with that using four traditional radionuclide investigations, *i.e.* osteoscintigraphy, renography, nephroscintigraphy and positive tumour scintigraphy. Such related information enables isolation scintigraphic patterns of Wilms' tumour, neuroblastoma and abnormalities in kidney development (including combination with tumours) to be produced, which improve differential diagnosis of these retroperitoneal lesions. Multipurpose scintigraphy also reveals primary tumour, tumour metastasis into bones, renal dysfunction, urodynamics and deformation of urinary bladder in children with tumours of pelvic bones. Scintigraphy with $^{99}Tc^{m}$ pyrphotech in combination with roentgenography contributes to the differential diagnosis of osteogenic sarcoma and Ewing's sarcoma and affords exclusion of some benign bone lesions. Multipurpose scintigraphy is of particular value, when the findings from other modalities are difficult to interpret or require additional evaluation, *i.e.* a "dumb" kidney, bilateral Wilms' tumour, tumours with abnormalities in kidney development, difficult cases of differential diagnosis of osteogenic sarcoma and Ewing's sarcoma, and others.

The external radiation hazard from parents and infants undergoing nuclear medicine procedures

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Regular close contact between a radioactive parent and a young infant, or a parent and a radioactive infant, represents the worst possible radiation hazard to a member of the public from either type of radioactive patient. The doses in these circumstances following diagnostic nuclear medicine procedures have been estimated from published external dose rate measurements and from effective exposure times which allow for the intermittency of close contact and for dose rate decay. These effective exposure times have been based on published observations of the greatest total time per day spent by an infant in close contact with a parent. It is concluded that for $^{99}Tc^{m}$ procedures, the dose equivalent to an infant from a radioactive adult, and to an adult from a radioactive infant, will be less than 1 mSv as long as in the former case, the activity administered to the adult patient does not exceed the ARSAC maximum value. For ^{111}In leukocytes, the activity administered to an adult should not exceed 8 MBq. It is also concluded that a nurse caring for one radioactive child or paediatric patient is unlikely to receive a dose equivalent of 60 μSv in a working day, unless the patient is classified as totally helpless.

An evaluation of the clinical usefulness of captopril renal scintigraphy

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The primary objective of this study is to evaluate the clinical usefulness of captopril renal scintigraphy in the diagnosis of renal artery stenosis. 48 patients who underwent pre- and post-captopril $^{99}Tc^{m}$ DTPA renal scintigraphy in our hospital over the last 3 years were reviewed. A fall of > 5% in split renal uptake between pre- and post-captopril scans was considered positive. 35% were positive scans, almost all of whom had either follow-up renal arteriography or Doppler ultrasound. This confirmed renal artery stenosis in 60%, the remainder having normal renal vasculature. Angioplasty was performed in those with stenotic lesions and the outcome will be discussed. Of those with negative scans, three patients underwent arteriography which demonstrated single renal artery stenosis in one and bilateral disease in another. The remaining patients with negative scans have satisfactory hypertensive control on medication. We conclude that while captopril renal scintigraphy is an effective and useful diagnostic tool, it remains a measure of renal physiological response to captopril unlike arteriography which demonstrates anatomical lesions. There remains a high incidence of false positives. A review of diagnostic criteria for a positive scan will be discussed.

Diagnosis of pulmonary embolism: clinical practice and the use of diagnostic imaging

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We retrospectively reviewed 166 episodes of illness diagnosed as pulmonary embolism in 155 patients to assess the accuracy of the diagnosis. In 125 episodes (75%) VQ or Q scans were performed. In 29 episodes (17.4%) the diagnosis was made, without VQ/Q scans, on clinical grounds; in 14 (8.4%) of these episodes this clinical diagnosis was made after death but without a post-mortem examination. In 12 episodes (7.2%) pulmonary embolism (PE) was diagnosed only on post-mortem examination. In those patients having VQ/Q scans, the diagnosis of PE was made with a high probability VQ/Q scan in 84 episodes (50.1%), intermediate probability VQ/Q scan in 17 (10.2%), low probability VQ/Q scan in 18 (11.4%) and a normal VQ/Q scan in six (3.6%). Pulmonary angiography was performed only in one episode (0.6%) and was positive in a patient with a high probability Q scan. PE was diagnosed without confirmatory angiography or positive venography in 22 episodes where the VQ/Q scan showed low probability or a normal study. PE was diagnosed antemortem in 15 episodes without VQ/Q scan. Clinical presentation and risk factors for PE were scored for each episode. There was no significant difference in score between different VQ/Q groups or those diagnosed without scans. The diagnosis of pulmonary embolism continues to be made on unreliable clinical grounds.

A comparison of SPECT and planar imaging in pulmonary embolus

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In an attempt to evaluate single photon emission computed tomography (SPECT) imaging in pulmonary embolus we compared SPECT with conventional planar ventilation perfusion scans performed consecutively on 11 patients referred with suspected pulmonary embolus. V/Q mismatches with a "high probability" of being due to pulmonary embolus were noted in three patients by both SPECT and planar imaging. In one of these patients

SPECT enabled segmental localization of a defect to the posterior segment of left upper lobe. In one other patient SPECT enabled identification of multiple additional subsegmental defects. A matched V/Q defect was seen in one patient by both SPECT and planar imaging. This study suggests that SPECT and planar scanning are equally sensitive in the diagnosis of "high probability defects," however, the ability to localize defects segmentally and to identify further subsegmental defects are sufficient to recommend SPECT scanning as a favourable alternative to planar scanning in the diagnosis of suspected pulmonary embolus.

Closing the feedback loop of audit

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In 1990, the level of satisfaction felt by patients attending our department was assessed by means of a direct interview (100 patients) and postal survey (190 questionnaires posted, 105 returned). The questionnaire used in both cases was identical and designed to cover all aspects of patients attending for a nuclear medicine investigation (*e.g.* directions to hospital, parking, reception, etc). More criticisms were received from the postal survey subgroup. These initial surveys established a baseline level of patient satisfaction and identified areas where there was room for improvement. Certain areas were then targeted for action. One year on, the postal survey was repeated (200 posted, 105 returned). The number of "dissatisfied patients" had fallen from 18% to 13%. This improvement occurred primarily in those areas which we had targeted (hospital directions, waiting facilities). In those areas where no action could be taken (*e.g.* car parking), no improvement was seen indicating that the methods of assessment were valid. Whilst the need to repeat such surveys following the implementation of change has been stressed, it is surprising how few times this had been reported. Repeating the survey allows the effect of any action to be assessed, thereby closing the audit "feedback" loop.

Notes

10.45 – 12.00

Musculoskeletal Imaging — Joint Disease

Hall 11a

Advanced imaging of the hindfoot

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The complex structure and function of the hindfoot is often poorly understood and difficulties in localizing symptoms can cause problems in differentiating hindfoot pain from ankle and foot pain. The radiograph remains the initial investigation of choice but errors in interpretation may occur because of overlapping structures, numerous accessory ossicles and normal variants. It is for these reasons that many of the newer imaging techniques have a role in the investigation of the ankle and foot including bone scintigraphy, computed tomography (CT), magnetic resonance imaging (MRI) and to a lesser extent ultrasound. The principal role of scintigraphy is in the detection of occult lesions, such as stress fractures, osteoid osteomata and symptomatic normal variants. Whereas ultrasound is valuable in the assessment of tendon pathology, notably of the achilles, CT can be performed in a number of different planes with the coronal plane the most useful. Trauma is arguably the commonest indication for CT of the ankle and hindfoot and is used primarily to clarify the full extent of injury, rather than to make the initial diagnosis. Amongst other conditions, CT is also useful in the assessment of suspected tarsal coalition. The role of MRI in the foot and ankle is evolving, particularly with the increasing sophistication of software. It will undoubtedly be the investigation of choice for soft tissue disorders, although CT remains superior when bony detail is required.

Magnetic resonance and CT arthrography of the shoulder

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Double contrast computed tomography (CT) arthrography of the shoulder has been used to assess the capsular mechanism and glenoid labrum in patients with pain or instability. Magnetic resonance imaging (MRI) has recently been shown to demonstrate both damage to the rotator cuff and the glenoid labrum. High levels of sensitivity and specificity have been reported for tendinitis and labral tears. Detailed comparative studies of CT arthrography and MR are required to assess the relative role of each investigation and a prospective study has therefore been undertaken. 40 patients (29 male and 11 female) with average age of 32 years were evaluated. All patients underwent CT arthrography within 6 weeks of the MR study which was performed on a 0.5 T GE Max system. All images were reviewed separately by two authors in the absence of any clinical information. 29 patients were referred with recurrent dislocation and 11 were suspected of an impingement syndrome, but some patients with dislocation demonstrated evidence of rotator cuff disease and others with rotator cuff symptoms had labral defects. There was a close correlation of findings between the two techniques with regard to labral lesions with only one case out of 31 seen on MR that was not evident on CT arthrography. However, the anatomy of the labral injury was more confidently and accurately assessed on CT arthrography. Capsular stripping was only diagnosed in one case on MR, but 18 cases were demonstrated on CT arthrography while capsular thickening was only seen on MR. Hill-Sachs lesions were demonstrated on both CT arthrography and MR in 16 cases but an additional four cases demonstrated bone bruising without a cortical defect on MR. Tendinitis and impingement were demonstrated in 10 cases on MR but in only one of these cases was a partial tear diagnosed on CT arthrography. Seven full thickness tears were demonstrated on both MR and CT arthrography while one was demonstrated only on CT arthrography. These results show that MR is the first investigation of choice for extra-articular pathology while intra-articular changes, in particular the labral tears, were more confidently assessed by CT arthrography.

Superior image quality of high field MR system in comparison with low field MR system in joint disease

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The optimal field strength in magnetic resonance imaging (MRI) is still discussed controversially. The objective of

this study was to assess the effect of field strength on diagnostic quality in traumatic and inflammatory diseases of the knee and ankle. MRI studies at 2 T (79 examinations) or 0.23 T (104 examinations) were performed in 56 patients with traumatic and 127 patients with inflammatory lesions of the knee and ankle. The quality of all images was assessed by the consensus of three radiologists on a scale of diagnostic (3+, 2+) and non-diagnostic (1+) image quality. More than 90% of images in both systems were diagnostic. However, the proportion of 3+ quality images was significantly higher ($p < 0.001$) at 2 T (2 T:64/79 = 81% *vs.* 0.23 T:51/104 = 49%). Motion artefacts were the main cause of reduced image quality. We conclude that high field imaging at 2 T provides better image quality than low field imaging at 0.23 T in patients with traumatic and inflammatory diseases of knee and ankle.

Magnetic resonance tomography of the shoulder: a comparative study with arthroscopy

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In order to evaluate the diagnostic efficacy of shoulder magnetic resonance tomography (MRT), a prospective study was conducted in which MRT results were compared with arthroscopic data. *Method:* 61 patients were examined with a 1.5 T superconductive magnet (Magnetom, Siemens); mean age 44.1 years; 36 males; 25 females; 31 right; 29 left and one bilateral. The examination protocol consisted of a paracoronal T_2-weighted spin-echo (SE) sequence (time to repeat (TR) 2400/time to echo (TE) 19–90/2 acquisitions), a parasagittal T_1-weighted SE sequence (600/19/1) and a transversal gradient-echo sequence (FLASH 450/10/1 a = 50°) with a slice thickness of 4 mm each. 22 patients had an arthroscopy and the data could be compared. *Results:* The diagnostic efficacy of shoulder MRT was assessed as follows: impingement of the rotator cuff: sensitivity 100%, specificity 75%, accuracy 90%. Rupture of the rotator cuff: 100%/82%/90%. Rupture of the biceps tendon: 66%/100%/95%. Labral lesion: 60%/83%/72%. Lesion of the joint capsule 50%/85%/81%. Hill–Sachs defect 100%/100%/100%. *Discussion:* MRT of the shoulder, conducted as a non-invasive tool without intra-articular application of contrast media, is a valuable method to assess the rotator cuff. The differentiation between degenerative changes and ruptures might be difficult in some cases. The results concerning the diagnosis of shoulder instability are far less reliable. Despite good soft tissue contrast an intra-articular injection of contrast media is necessary to judge the glenoid labrum and the joint capsule.

The contribution of variations of acromial morphology in rotator cuff disorder — MR imaging

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We evaluated the relationship between the supraspinatus outlet and the severity of rotator cuff disorders by magnetic resonance (MR) imaging in 55 shoulders of patients with clinical impingement syndrome. All cases had spin-echo T_1-weighted and gradient-echo sequences performed on a 1.5 T system. The acromial shape was categorized into three types (flat, curved, and hooked). The anterior slope was measured in degrees on oblique sagittal planes at the level of the coracoid process. The lateral slope was assessed on oblique coronal images at the level of the acromioclavicular joint. Rotator cuff disorders were categorized into four groups (normal, tendinitis, partial- and full-thickness tears). Surgical confirmation was available in 16 shoulders. Results of statistical analysis showed that severity of rotator cuff disorders was closely related to the acromial shape, anterior slope, and patient's age. Osteophytes protruding from the undersurface of the clavicle appeared frequently in the acromioclavicular joint. However, the lateral acromial slope did not reach statistical significance among groups. We conclude that MR imaging is of significant value in evaluating supraspinatus outlet; and thus the extent of the subacromial decompression can be accurately assessed for surgical planning.

Comparison of contrast media in CT arthrography of the shoulder

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*Department of Radiology, Royal Orthopaedic Hospital, Birmingham and *Robert Jones and Agnes Hunt Hospital, Oswestry, Shropshire SY10 7AG, UK*

Evaluation of the shoulder by computed tomography (CT) arthrography is well recognized. Logistical problems in transferring the patient from the screening room to the CT suite may occur, thereby prejudicing the quality of the scan. The purpose of this prospective study is to quantify the relative absorption/dilution of two contrast media in 78 patients undergoing CT arthrography of the shoulder. All

patients received 3.5 ml 300 mg I_2/ml contrast medium and 10 ml air. Group A received iohexol, Group B iohexol and 0.1 ml of 1 in 1000 adrenaline and Group C iotrolan. A CT slice through the midglenoid was selected and the attenuation value of the contrast medium measured as was the time from the initial injection (approx. 20 min). A single CT slice through the same anatomical level was repeated 1 h after the injection and the attenuation value was measured again. The mean attenuation in Group A was considerably lower than in Groups B and C both at 20 min and 1 h. The mean attenuation in Group B was slightly lower than Group C at 20 min but higher at 1 h. Marked dilution of all the contrast media occurred in the presence of a complete rotator cuff tear. This study shows that the absorption/dilution rate of the dimeric contrast medium iotrolan is significantly less than that of iohexol alone. The synovial vasoconstriction from the addition of adrenaline to the iohexol results in superior contrast quality on the delayed scans. Further analysis and discussion of the data is presented.

Ultrasound evaluation of displacement in the ossified hip

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Clinical evaluation of children with abnormal muscle tone is unreliable. These children, at increased risk of late hip dislocation, undergo frequent pelvic radiographs for assessment and reassurance. Sonographic assessment of unossified neonatal hips is an established technique, but it has not been adopted in ossified hips because of an inability to demonstrate the acetabular floor. The authors compared sonography with pelvic radiography in 24 children aged 9 months to 12 years, most of whom had cerebral palsy. Sonograms were reported without knowledge of plain radiographic findings. 22 normal hips in 11 subjects were correctly identified sonographically. Displacement of 18 hips in 10 subjects correlated with plain films. In two cases radiographic displacement of the femoral heads was not detected sonographically. This discrepancy is due to the scans being obtained in hip flexion but the plain radiographs in extension. This has been observed to cause transient changes in displacement. In one case posterior displacement was identified on a sonogram but was impossible to detect on radiography. Transient femoral head migration during muscle spasms was clearly demonstrated sonographically. This would require prolonged fluoroscopy for radiographic evaluation. In the authors' institution sonography is considered to provide additional information and has replaced the plain radiograph for most assessments.

Demonstration of osteochondritis dissecans of the elbow by computed tomographic arthrography

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Osteochondritis dissecans (OD) of the elbow is an uncommon condition usually affecting the capitellum in young males. Like OD elsewhere, its aetiology is unknown, though repeated trauma, vascular insufficiency, or both, have been implicated. Appropriate treatment depends on accurate delineation of the lesion, the integrity of the overlying cartilage, and the identification of loose bodies. 11 patients with OD of the elbow were assessed. From the plain radiographs, only 5 out of 10 visible lesions were confidently diagnosed as OD. Conventional arthrography contributed little to the diagnoses. In eight of the 11 patients plain computed tomography (CT) identified the site and extent accurately in all, and the presence of intra-articular loose bodies in four. Computed tomographic arthrography (CTA) was performed in all cases using a standard technique and confirmed the plain CT findings in all, with the exception that one osseous loose body was obliterated by contrast media. CTA was able to delineate precisely the state of the overlying cartilage in every case. In five of the 11 patients, the whole cartilage was intact, whilst in two cases fissuring and thinning of the cartilage was seen. Cartilage defects overlying the area of OD were identified in four of the 11 patients, three of which had associated loose bodies. OD affected the capitellum in nine patients, the capitellum and olecranon in one, and the trochlear in one. Examples of OD demonstrated by CTA will be shown.

Automated measurement of interbone distance on macroradiographs of osteoarthritic knees using the symmetric axis transformation

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Radiographic changes in osteoarthritis include joint space narrowing, subchondral cortical thickening or changes in underlying cancellous bone and osteophytosis. Automated methods of quantifying the changes are being developed to aid understanding of the inter-relationship between disease features. A method of analysing digitized radiographs of knees has been developed to delineate bony margins of the joint space automatically and convert them, using the symmetric axis transform, into profiles of interbone

distance across joints. Problems addressed include those arising from taking measurements from a two-dimensional projection of a three-dimensional object. Using ×5 macroradiographs of post-mortem knee joints, the accuracy and reproducibility of the technique has been analysed. It was found that interbone distance could be measured with a reproducibility of between ±0.20 mm and ±0.06 mm depending on the position in the joint. A rigid protocol for radiography of patients allowed accurate assessment of joint space narrowing in the knees of 39 osteoarthritic patients with medial tibiofemoral compartment involvement. Weight-bearing ×5 macroradiographs taken in both standing and tunnel views, allowed assessment of cartilage loss on the tibial plateau and both inferior and popliteal surfaces of the femoral condyle and showed that different patterns of cartilage loss could be found.

The patello-femoral joint — a comparison of geometry measured on the "skyline" view and axial computed tomography

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In the quest for a treatable cause of anterior knee pain, 30°, 60° and 90° "skyline" views of the patella are obtained, primarily to assess the functional relationships of the patello-femoral joint. Patello-femoral malalignment predisposes to recurrent subluxation and dislocation, articular cartilage damage and premature degenerative change. The aim of this study is to evaluate critically, by comparative assessment, the information provided by skyline views and computed tomography (CT). *Methods:* We studied patello-femoral geometry on 50 symptomatic knees imaged by a "skyline" view (Marchant's view), and axial CT. Respective measurements of the patello-femoral angle (assesses patellar tilt), the congruence angle (assesses lateralization) and trochlear depth were obtained. The data from each technique were assessed independently to avoid the possibility of observer bias. *Results:* Significant numbers of false positives and false negatives are observed on the "skyline" views in all three measurements (*e.g.* 12% false positive and 24% false negative for lateralization). The results are presented in graphic form and visual examples will be shown to correlate with the statistical results. *Conclusion:* "Skyline" views are inaccurate and unsuitable primarily because they cannot be obtained in less than 30° of flexion. CT shows that all but the worst cases of misalignment have corrected at this degree of knee flexion. We suggest that "skyline" views have no role in screening for maltracking as florid examples will be missed, and would strongly urge that no surgery be performed on their basis alone as this would result in inappropriate operations. Although CT is the preferred mode of assessing patello-femoral geometry, difficulties are still encountered and the ways of circumventing them will be discussed.

Notes

12.15 – 1.15

Mackenzie Davidson Memorial Lecture

Hall 9

Molecular biology in common disease

D. J. Weatherall
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The "new" sciences of molecular and cellular biology have important implications for every aspect of clinical practice. The ability to isolate, sequence and express human genes is making it possible to define the molecular basis for monogenic disease and in the future should lead to a much better understanding of the pathogenesis of common polygenic diseases, conditions such as heart disease, stroke, autoimmune disease, the major psychoses and cancer. This field is already making a major impact on the pharmaceutical industry and biotechnology is starting to play a major role in diagnosis and therapy. To illustrate some aspects of the applications of molecular biology to clinical practice, current work on human gene action and how this appears to break down in common disorders such as cancer will be described. The likely practical applications of this new knowledge, particularly for diagnostic medicine, will be reviewed and an attempt will be made to anticipate the changes in clinical practice which may follow on from these new advances.

2.15 – 3.45

Ultrasound

Hall 9

Ultrasound exposure measurement for safety

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Diagnostic ultrasound has an enviable and well-deserved reputation as a powerful investigative tool without apparent hazard. The question of safety has been kept under periodic review, and recent developments have caused further re-evaluation. By reviewing published surveys of measurements of ultrasonic output, steady increases have been demonstrated over two decades in both pressures and intensities. Exposure in some pulsed Doppler applications now differs little from that used in ultrasonic physiotherapy. It is now possible to make measurements of the pressure pulse with considerable accuracy using a PVDF hydrophone. The peak negative pressure, which may exceed 4 MPa, is relevant to the assessment of cavitation, and the degree of shock relates to the heating and streaming potential of the beam. Derived measurements of time-averaged intensity (I_{spta}) reach 5 W/cm² in some Doppler beams, and tissue absorption at these intensities causes temperature increases of a few degrees. However, total acoustic power, from a force balance measurement, may be a more useful indicator of heating potential; diagnostic powers reach 300 mW for some Doppler applications. Changes in US FDA regulations may throw a greater responsibility onto the user to make informed judgements regarding safety, using on-screen indices. The value and limitations of the models used in deriving these indices need to be understood.

Three-dimensional ultrasound of the fetus

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Objective: To investigate if three-dimensional (3D) ultrasound data sets of the fetus can be acquired in routine practice. Is transabdominal (TA) or transvaginal (TV) ultrasound the best means of acquiring 3D data sets in early pregnancy? To create 3D fetal reconstructions and to examine with high speed multiplanar reconstructions. To measure fetal volumes. *Methods and materials:* A 3.5 MHz sector probe and 5 MHz vaginal probe for the Acuson 128 were used in conjunction with an electromagnetic 3D position sensor (Polhemus) to acquire 3D data sets on more than 20 fetuses ranging in gestational age from 11 to 20 weeks. The $256 \times 256 \times 128 \times 8$ bit data set is processed and stored on a multiprocessor transputer workstation. 3D fetal image reconstructions were made and high speed multiplanar reprocessing (MPR) was performed. TA and TV data sets were compared. Fetal volumes were calculated after data set segmentation. *Results:* 3D reconstructions and high speed MPR reveal morphological information not possible with conventional scanning. Data set archiving and interactive multiplanar reformatting allows complete elective ultrasound re-examination of the fetus. TV ultrasound gives best results in early pregnancy. *Conclusion:* 3D fetal ultrasound is a completely new way of imaging the fetus which has great potential for diagnosis of fetal abnormalities.

Measurement of ultrasound exposure *in utero*

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The quantification of ultrasound exposure *in utero* is important for the assessment of ultrasound safety. Estimates from *in vitro* measurements involve substantial approximations. In this work we measured ultrasound exposure directly *in utero* using a miniature PVDF hydrophone introduced trans-cervically. All measurements were carried out immediately prior to termination of pregnancy typically at about 10 weeks gestation. The hydrophones were rectangular in area, mounted on the obliquely-cut tip of a steel rod. Absolute calibration was carried out against the NPL Ultrasound Beam Calibrator, and both frequency dependence and directional dependence were measured. Intra-uterine measurements were carried out in both

imaging and pulsed Doppler fields. The pulse waveform was captured on a digital oscilloscope, at a digitization rate of 200 MHz, and downloaded to a microcomputer for subsequent analysis. Initial measurements using a 3 MHz phased array demonstrated peak negative pressures up to 0.9 MPa at a depth of about 6 cm, and clear evidence of non-linear harmonic generation in amniotic fluid. The method allows a direct evaluation of the "estimated *in situ* exposure" values required by the US FDA, and quoted by many manufacturers.

Comparison of antenatal ultrasonography and postmortem findings in abortuses for lethal renal disease

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Comparison was made between antenatal ultrasonography and postmortem findings on fetuses terminated for lethal renal disease. 29 postmortems were performed over 4 years (1987–1990). The distribution was as follows: outflow obstruction = 9 (31%); cystic disease = 7 (24%); developmental abnormalities = 11 (38%); miscellaneous group = 2 (6.8%). The ultrasonography sensitivity varied between 60% and 88%, and specificity was between 58% and 77%. We review reasons for the difference and discuss ways in which to improve the quality of antenatal renal scanning.

Correlation of antenatal ultrasound and pathological examination in 153 malformed fetuses

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153 cases of fetal abnormality which came to pathological examination and had also undergone antenatal ultrasound were reviewed. The autopsy diagnosis was taken as correct and any ultrasound errors revealed were classified according to whether or not the missed abnormality would have affected management. This included any effect on genetic counselling for future pregnancies. The primary diagnoses in the 153 cases were: 67 nervous system anomalies, 19 gastrointestinal, 18 genitourinary, 13 chromosomal, 10 skeletal and 26 other abnormalities. 46% of the total number had multiple abnormalities. There were 67 cases (44%) where autopsy showed further anomalies (whether detectable ultrasonically or not) or altered the ultrasonic diagnosis. Of these 67 cases, 10 were due to false positive ultrasound diagnoses. However, only 36 (24% of the total) were findings which altered management. Errors in ultrasound diagnosis were associated with the presence of multiple anomalies and oligohydramnios. One third of those with spinal neural tube defects were shown to have renal anomalies. Pathological examination remains a valuable tool in the management of fetal anomaly. The presence of one abnormality on ultrasound examination must prompt the search for others.

Antenatal detection of congenital diaphragmatic hernias: the Northern Region experience

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Notifications of congenital diaphragmatic herniation to the Northern Regional Fetal Abnormality Survey were studied for the 7 year period 1985–1991. The NRFAS is a central register for this large but fairly well defined geographical area of 3 million people. Antenatal ultrasound made a specific diagnosis of diaphragmatic herniation in only 19 of 99 fetuses although this has improved to 40% in the last 2 years. In the majority the diagnosis was made by identifying cardiac displacement, usually with stomach alongside the heart in the thorax when the hernia was left sided. We have evidence that some congenital diaphragmatic hernias (CDH) are undiagnosed because of their dynamic nature. A further 12 structurally abnormal fetuses found to have CDH were identified by antenatal scans; the commoner associated defects were of the body wall (six), heart (six), neural tube defects (nine), renal agenesis (four) and ascites and/or pleural effusion (three). Differentiation from cystic adenomatoid malformation (CAM) of the lung was a problem in two fetuses; four CAMs and 1 thoracic enterogenous cyst occurred in these 7 years. The overall survival rate (36%) is poor. Termination may be offered if diagnosis is made early in pregnancy but in this study four fetuses diagnosed before 24 weeks gestation are alive.

Evaluation of "echo-shadow" complex in sonographic diagnosis of cholelithiasis in non-visualized gallbladders

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A prospective study was performed on 1470 patients referred for gallbladder ultrasound to determine the reliability of the "echo-shadow" complex for diagnosis of gall stones in non-visualized gallbladders. In 1294 patients, the

gallbladders were clearly visible and they were either normal or contained unequivocal stones and were excluded from the study. In 176 patients, gallbladder lumen were not demonstrated but an "echo-shadow" complex was noted in the region of gallbladder fossa. Among them in 142 patients, (Group 1), although the gallbladder lumen were not visible, the anterior wall of the gallbladders were outlined with ultrasound, demonstrating the "double-arc-shadow" or "WES" sign. In the remaining 34 patients, (Group 2), the walls of the gallbladders could not be imaged with ultrasound. Following sonography, oral cholecystograms were carried out in all 176 patients belonging to the two groups. Cholecystograms of all Group 1 patients revealed either non-functioning gallbladders or contracted gallbladders with stones. However, in four patients belonging to Group 2, normal gallbladders were demonstrated with cholecystograms, although sonography failed to outline the gallbladders. Reasons for the failures will be analysed and the importance of demonstrating the gallbladder wall in such cases prior to diagnosis of gall stones will be highlighted.

Ultrasound monitoring of diabetic injection technique

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Do thin diabetics accidentally inject insulin into muscle? This is a theoretical risk if subcutaneous tissue (SCT) thickness is less than needle length (13 mm), given the current recommendation of full-depth needle insertion perpendicular to the skin. A novel technique was devised to determine depth of injection. The smallest saline bolus consistently identified in SCT by ultrasound was 0.8 ml. Addition of air (optimum volume 0.1 ml) allowed 0.2 ml saline (equivalent to 20 U insulin) to be detected. Ultrasound was used to measure SCT thickness in 50 insulin-treated diabetic patients. Men had significantly less SCT thickness compared with women. 30 patients had less than 10 mm of SCT at upper anterior thigh. These patients injected a simulated insulin bolus (0.2 ml saline + 0.1 ml air) into this site by the recommended technique. The depth of the bolus was determined by ultrasound. In 63%, the bolus was clearly in SCT; in 37%, the bolus was either in deeper SCT or within the fascial plane between SCT and muscle. No patients injected into muscle. Contrary to widespread belief, accidental injection into muscle does not appear to be common in thin diabetics who avoid this complication by modifying the recommended injection technique.

Endo-anal ultrasound is reliable in mapping anorectal sphincter defects

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Defects in the anorectal sphincter complex have been identified in the past by electromyography. This technique is painful and time consuming. We have compared endo-anal ultrasound (EUS) with operative findings to assess its value in identifying defects in the anorectal sphincter complex in a prospective analysis. A total of 37 patients was studied (F = 33; M = 4). Their ages ranged from 26 years to 80 years (median = 56). The reason for anorectal assessment was faecal incontinence ($n = 33$) and rectal prolapse ($n = 4$). The examination was performed with a Bruel and Kjaer ultrasound scanner type 1846 and endoprobe type 1850 using a 7 MHz rotary transducer. All patients were in the left lateral position. EUS identified all external anal sphincter defects ($n = 19$) and all but one internal anal sphincter defects accurately ($n = 20/21$), $p = < 0.001$. A deficient puborectalis was identified in two patients and combined defects were identified in 11 cases. 18/19 external sphincter defects were anterior. Of the internal sphincter defects, 12/20 were anterior, 5/20 posterior, 2/20 were seen on the right and 1/20 on the left. We conclude EUS is a quick and reliable method of mapping defects in the anorectal sphincter complex.

2.15 – 3.45

Radiotherapy Treatment III

Hall 10a

Quality assurance — what is possible?

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The adequacy of technical methods used in treatment set-up may affect the value of the whole radiotherapy process. A quality assurance programme using portal films may be used to investigate the accuracy of the techniques used, and to establish the pattern of errors which arise, together with their causes. This provides information for improving or modifying methods, and establishes an achievable baseline or quality standard. Many studies have reported the achievable accuracy for various sites and methods, and stress the need to check portals on the treatment machine to detect and correct systematic errors early in the course. The availability of digital portal imaging devices is an important development which will allow dynamic intervention to correct a treatment set-up. To make effective corrections, it is necessary first to analyse the error trends with each technique and gain knowledge of the factors involved. Systematic errors are potentially correctable, random errors are not. Technique modifications can reduce random error and prevent most systematic errors. At this centre, sequential studies, analysis and practice modifications have increased accuracy so that a standard deviation of 1.5 mm can be achieved when treating the pelvis.

Imaging and portal verification

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Megavoltage portal imaging is becoming a well established method for assisting in the accurate positioning of patients who are being set up for external beam radiotherapy. The major improvements over film-based methods are (1) instantaneous imaging, which facilitates pre-treatment changes to the patient set-up, (2) digital image processing and display, which improves image quality and utility, and (3) digital image handling, which permits, for example, rapid image retrieval and comparison. A variety of different hardware implementations is available although the method which is currently favoured by the manufacturers is based on a metal-phosphor fluorescent-screen detector which is viewed by a television camera. These methods will be reviewed and typical images will be shown. A system has been developed at the Royal Marsden Hospital/Institute of Cancer Research in which simulator images, CT images and treatment-time images are all available to verify and if necessary correct the patient position. It is VAX based with several different means for entering and comparing CT, simulator and megavoltage (portal) images. Patient images are held in a data base. An 18-month study of reproducibility of patient position for several common treatment sites has been concluded (as of December 1991). This has involved more than 140 patients and 2000 individual patient images.

Precision radiation therapy using on-line portal imaging

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An in-depth evaluation of on-line portal imaging has been carried out over the period 1989–1991, using a fluoroscopic imaging system with the capability of acquiring, processing and displaying static and dynamic ("movie") portal images. After alignment of anatomical features in matching portal and simulator images, field positioning errors are calculated by a rigid-body regression analysis. Parameters used to quantify treatment errors are target coverage, target under-dose area (TU), normal tissue over-dose area (NTO), field edge displacements, and field shifts. Action levels are defined for various treatment sites and field sizes, which indicate the need for correction of the beam location relative to the patient. Field positioning errors observed during a course of treatment are displayed either as a plot of cumulative dose coverage or as a parametric image of regret. Plots of TU *versus* NTO are used to define minimum

margin widths for planning treatments of the head and neck, thorax and pelvis. On-going studies are evaluating the effect of patient immobilization on treatment accuracy.

The implementation of patient position correction using on-line radiography imaging

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Several groups have been involved in the development of digital image systems for the purpose of obtaining images during, or immediately prior to, the delivery of external beam radiotherapy. Such a facility enables direct, on-line verification of patient set-up if a suitable "gold standard" image is available with which to compare the images obtained. An integrated imaging system has been developed for verification of patient position. Digital treatment-time images are compared with digitized simulation images, obtained from film or from an X-ray image intensifier. All simulation images have any distortion removed and are scaled to the magnification of the treatment-time images before the comparison procedure. Various methods may be used to obtain the translation and rotation necessary to make the treatment-time image register with the simulation image. Should the treatment set-up be significantly in error, the treatment may be paused while the patient's position is corrected. The facility exists to carry out such a procedure for any combination of couch and gantry angles, within 2 min and to an accuracy of 3 mm or better. The implementation of the facilities discussed above will be described. Specifically, the various methods of comparing planar radiological images and the algorithms for registering simulation and treatment-time images and for evaluating the necessary adjustment to the patient position as a function of couch and gantry angle will be presented.

The use of an integrated megavoltage imaging system for studies of patient positioning reproducibility

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A megavoltage imaging system designed and built at the Royal Marsden Hospital has been in clinical use for over 18 months. This comprises a scanning detector for portal imaging, facilities for incorporation of simulator images, and computerized image storage and display. Image comparison software is available to permit use of the system for studies of patient position reproducibility during routine radiotherapy. Results are presented of both random errors (those resulting from day-to-day variability in set-up) and systematic errors (those repeated on each occasion that the treatment is given), for radical treatments of the brain, head and neck, and pelvic regions. For in-cast treatment, both for brain and head and neck regions, random errors are small. 522 set-ups analysed from 26 patients show 95% of treatments to lie within ± 3 mm from the mean daily position. Mean systematic errors for this patient group are small, although for individual fields, systematic errors of over 5 mm have been found. For radical pelvic irradiation, 269 set-ups from 24 patients have been analysed. Random errors are rather larger, with 95% of set-ups being within ± 4.5 mm of the mean daily position. Mean systematic errors are again small, although for individual fields, errors of over 5 mm have been found.

Ovarian tumours: a prospective study to audit the role of CT scanning

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A prospective study was performed to audit the role of CT scanning in the current management of ovarian tumours in the Yorkshire Regional Oncology Centre. A total of 60 abdominal-pelvic scans was obtained on 44 patients over a 1 year period. Pre-scan questionnaires were completed by the referring clinicians in respect of their clinical impression of disease status, and their intended management. The data were subsequently correlated with information on patient follow-up over a 21 month period from initial CT scan. There was agreement between clinical and CT staging in 41 cases (68%); non-agreement occurred in 19 cases (32%) and in nine (47%) of those immediate management was changed. CT scanning was most likely to alter management in patients with stage III or more disease and in patients with epithelial tumours. Post-operative, pre-treatment scanning did not have a major effect on immediate management and the role of such base-line scanning is questioned.

An investigation into radiotherapy treatment couch sag

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Radiotherapy treatment techniques which involve posteriorly directed fields require certain sections of the couch to be radiotransparent whilst maintaining rigidity. Many designs are available, *e.g.* tennis racket-type, Perspex and Melinex sections. They may sag in the region of

contact with the patient as increased radiotransparency is often at the cost of mechanical rigidity. In this investigation, four different couch panels were tested for sag, when patients were lying on them, by using a mechanical pointer. 125 measurements were taken for each panel. The results demonstrated that three out of four of the panels regularly sagged more than 0.5 cm during routine use. This amount of sag may constitute a systematic error for isocentric treatments and if not accounted for could potentially give a geographic miss to some of the target volume, *e.g.* from lateral fields. This issue of couch sag may need addressing further by manufacturers and radiotherapy staff.

A simple method of verifying dose distribution around a Selectron applicator

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This paper describes a simple method of verifying the dose rates at point of interest by measurement with TL dosimeters. These measurements have been compared with the calculated dose rates using a RT planning system at these points. The measurements agree closely with the calculated values. This makes the post-installation quality control of a new Selectron remote afterloading machine easy and fast.

Notes

2.15 – 5.15

Committed for Life: Purchasing Equipment Seminar (A seminar arranged by the National COR in conjunction with the BIR)

Hall 10b

Purchasing — art or science?

M. R. Eddy
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Purchasing would appear on the surface a relatively simple task. The purpose of this paper is to show what should be taken into consideration when embarking on radiology equipment buying. How often are goods or services purchased that meet the needs of the customer, but do not give value for money! The paper will give an overview of the formalized tender procedure taking into account appraisal of suitable sources of supply, EEC regulations pertaining to equipment purchase and the application of charity monies. The legal framework required to safeguard authorities in this multimillion pound area of NHS expenditure will also be covered. All equipment purchased should be at the lowest possible cost commensurate with acceptable standards of quality and specification which meet the customer's needs. The role of negotiation is vital to establish true value for money, but it can only do this as an integral part of the whole procurement process.

Quality issues

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The following topics will be discussed: the Manufacturers' Registration Scheme (MRS), and the responsibility of manufacturers under the scheme; HEI 98 which refers to a management system for all equipment, and the importance of maintenance of equipment; the work of MDD, and its future role within Europe, the CE marking, and MDD's role to ensure that all medical devices meet the appropriate standards of safety, quality and effectiveness, and comply with the relevant EC Directives; evaluation and assessment of up-to-date equipment and the role of FAXIL and KCARE, in this process; the importance of publishing the findings; the Department's position with regard to the TRS document within the European market, and the importance of maintenance of equipment.

Department profiles

D. J. Manton
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Planning is a problem. As with solving any problem, the first step is to define it — a statement of the obvious, but planning will require many statements of the obvious. The needs of the New Department have to be defined early so that resources are made available. Only when these are known can detailed planning start. There will be discussion of the complexity of determining the radiological needs of a district and of designing a department to meet those needs.

The outward tender

E. M. Pitcher
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This paper discusses the production of a tender specification for diagnostic X-ray equipment. The process starts with the establishment of a clinical statement of need and continues with the translation of these requirements into a technical specification. The tender will be produced by a partnership of engineers, physicists, users and purchasing officers. The format of the specification will depend on whether any building work required will be organized "in-house" or will be a "turnkey" operation. The technical specification may be divided into sections specifying the general type of equipment required, the particular requirements of each site, the accessories and options available and the provision of training and maintenance. The specifi-

cation should be designed with the knowledge of equipment available on the market but should clearly specify the users' requirements. The tender should ensure that all relevant safety standards and minimum performance requirements are met and allow information in a common format to be collected to allow a true comparison to be made during the option appraisal process. The criteria for the selection of equipment should be established at an early stage and may include such considerations as the reduction of patient dose. If an accurate tender specification is produced the equipment selected should satisfy the users' requirements whilst also being value for money.

Reply to the outward tender

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Association of X-Ray Equipment Manufacturers, London WC2H 7BN, UK

Receiving the outward tender is not always straightforward, as when published in the *European Journal* the entry can easily be missed owing to the vast number of items and headings that have to be read. As every tender is so different once the tender has been received you then have to endeavour to interpret what the user really requires. Modern X-ray, imaging and radiotherapy equipment is very complex, and adapting to meet the users' exact requirements is not always easy or indeed possible. Over-detailed tender specifications, which are usually compiled to suit individual requirements, increase the cost to the manufacturer and customer alike, as the manufacturer has to respond to each question separately, rather than return the tender together with his standard equipment specification. Turnkey projects can often involve the manufacturer in a great deal of expense, often amounting to many thousands of pounds for the production of drawings and costings to submit with the tender for a contract which in the end he may not get.

Maintenance

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However complex, radiological equipment is no exception to the rule that it is purchased for its capability to satisfy the user requirements in a reliable fashion. Capability and reliability, however, are specific design features available when the equipment is installed and operated under certain specified conditions. These conditions will include installation requirements and recommended maintenance specifications. Maintainability is a specific design feature; it determines how easily the maintenance specifications can be applied. Capability, reliability and maintainability with their associated maintenance specifications, are all outcomes of the quality of design, manufacture, installation and maintenance of the equipment. Systems for control of quality are essential in each facet. They merit detailed consideration when purchasing the product. When ownership transfers to the user, maintenance is a cost of use and as such a service to be purchased and managed with the same care and attention given to the selection and specification applied to the performance and quality of the equipment itself. In the same way that the equipment purchaser at the outset was able to consider alternative manufacturers who could satisfy his purchase specification, likewise it is possible to consider alternative service suppliers judged capable of meeting the equipment supplier's recommended maintenance specification. Capability and reliability of the maintenance function are quality features and therefore equally accessible to assessment by the purchaser as they too are a design feature of that service, whether implicit or explicit. While the purchase of the equipment and its subsequent service may be considered as two entirely separate purchase transactions not necessarily obtainable from a common source, clearly they must be considered together since they have a mutual influence on each other in the areas of documentation and training. These issues will be explored in the light of the principles embodied in reports published by the NCOR and Medical Devices Directorate of the Department of Health.

Alternative finance and leasing

E. H. W. Luxton
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Health authorities normally obtain their capital for major equipment and building purchases from allocations from public funds. The cost of such funds is significantly less than the cost of financing from alternative private and commercial sources. However, in certain circumstances use of private sector finance as an alternative to outright purchase from public funds may represent best value for money and facilitate cost-effective and quicker development of new and existing services. Guidance on the scope for use of private sector capital in the NHS was issued in October 1989 (EL(89)MB142) and updated in April 1991 (EL(91)53). The Treasury has also issued its own guidance on use of private sector finance. Despite the availability of such guidance many health authorities continue to make decisions relating to leasing or financing of equipment which represent poor value for money and which are based on inadequate option appraisal.

2.15 – 3.45

Nuclear Medicine III

Hall 11a

The metastatic survey revisited

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Although scintigraphy, of the whole skeleton or limited to the trunk, is still widely practised in patients with cancers which are known commonly to metastasize to bone, there is little evidence that this does or should affect current management. A Consensus Panel at Radiology 90 agreed that there is no tumour in which *routine* skeletal imaging can still be justified, although there remain many specific indications. Evidence which has continued to accumulate since then has largely reinforced this view. In carcinoma of the breast additional centres have confirmed that few of the patients presenting with stage 1 disease but who develop metastases within 3–4 years are detected at the initial screen, which itself carries a not insignificant false-positive rate. Some papers suggest that the detection rate is increased if SPECT is employed, but the effect of this on the false-positive rate has not yet been determined. Although the detection rate is higher in more advanced disease it affects management in only certain subgroups. In carcinoma of prostate evidence now suggests that bone scintigraphy is necessary only in patients with prostate-specific antigen levels over 20 ng/ml, to determine the extent of skeletal involvement. In other tumours indications have become more specific and complex.

The role of bone scan in trauma

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The isotope bone scan provides a convenient means of evaluating the whole skeleton and is exquisitely sensitive for lesion detection. It is particularly helpful in clarifying cases of bone trauma where a fracture is suspected *e.g.* a scaphoid injury with typical clinical features, yet negative X rays. The bone scan has been extensively used to assess sports injuries, *e.g.* to evaluate lower limb pain, and differentiate stress fractures from other causes of pain such as shin splints. An accurate diagnosis can greatly affect the management of these cases. The bone scan also has a role to play in the evaluation of non-accidental injury of childhood.

Clinical high resolution skeletal SPET in 8 min utilizing a multidetector gamma camera

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The purpose of this study was to assess the ability of a new whole body multidetector gamma camera system (Toshiba GCA 9300A) to produce clinical high resolution skeletal single photon emission tomography (SPET) with an 8 min acquisition. 23 patients in whom there were clinical indications for skeletal SPET were imaged with the Toshiba GCA 9300A system using high resolution parallel hole collimators and continuous rotation acquisition mode; projections were binned at 60 steps, matrix size was 128 × 128 corresponding to a 3.2 mm pixel size. In five patients three acquisitions were performed for 8, 16 and 32 min. Reconstruction was performed with Butterworth prefiltering and a Shepp and Logan backprojection filter. Images were displayed in transaxial, sagittal and coronal views. 8 min skeletal scintigraphy demonstrated good localization of both benign and malignant pathology. There was no clinical advantage in performing 16 or 32 min acquisitions though there was an improvement in image quality. A multidetector gamma camera produces high resolution skeletal SPET images within 8 min. This will enable precise information on the localization of pathology in the skeleton to be obtained with practical imaging times and no additional radiation burden to the patient.

The role of isotope bone scanning in patients with foot/ankle pathology

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We present the findings of a retrospective study comparing radiography and bone scintigraphy in 96 consecutive

patients undergoing isotope bone scanning for clinically suspected localized foot or ankle pathology. An experienced radiologist reviewed the relevant radiographs and made a prediction as to the expected bone scan findings "blind" as to clinical information and bone scan results. A second investigator correlated these predictions with reports produced by one of two radiologists experienced in bone scintigraphy and also with the clinical outcome. In the 58% of patients with an abnormality demonstrable on initial radiographs, bone scan predictions corresponded well with actual scan reports. In these circumstances the bone scan failed to provide additional clinical information. In the 42% of patients with normal initial radiographs 10% of bone scans revealed abnormalities of varying clinical significance. We discuss these radiographically occult abnormalities and the clinical relevance of our overall results.

Radiology in the clinical management of osteoid osteoma

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19 patients with clinical symptoms and radiographic abnormalities suggestive of an osteoid osteoma were referred for CT and/or MRI. The diagnosis of osteoid osteoma was made in 11, and involved the lower limb (five), the spine (four) and the hand (one) and foot (one). In several patients there was considerable delay (3 months to 6 years) between presentation and confirmation of the diagnosis. All patients had plain radiographs; in six there was characteristic sclerosis but in three the lesion was not seen. Radionuclide bone scan ($n = 9$) showed increased uptake in eight. CT ($n = 11$) demonstrated the nidus in nine of 10 active lesions, with surrounding sclerosis in seven; there were linear cortical lucencies within the sclerosis in six. To demonstrate diagnostic features it was essential to perform thin section CT with appropriate targeting and bone algorithms. MRI ($n = 4$) did not demonstrate the cortical lucencies seen on CT, but marrow oedema and parosteal soft tissue changes were better seen on MR. The extent and distribution of soft tissue changes and bone sclerosis differentiated osteoid osteoma from other pathologies (stress fracture ($n = 4$) and osteomyelitis ($n = 4$)) confirmed in the remainder of the patients. *Conclusion:* In patients in whom a clinical diagnosis of osteoid osteoma is considered, a radionuclide bone scan is imperative, even if radiographs are normal, since this will localize the area of increased uptake. This can then be scanned using an appropriate high resolution CT technique which will confirm the diagnosis and localize the nidus pre-operatively. MRI should be reserved for patients in whom the differential diagnosis between osteoid osteoma, trauma and infection remains uncertain, and in whom the increased sensitivity of MRI to soft tissue changes may be helpful.

Metastatic disease and the equivocal bone scan: the value of magnetic resonance imaging

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We studied 45 consecutive patients referred to our department in a 6 month period with known primary malignancy and back pain in whom the isotope bone scan was reported as equivocal. All patients had abnormal isotope uptake localized to the spine. 12 patients (12/45) were shown to have bony metastases on plain X ray. In the remainder, X rays showed normal or benign appearance and magnetic resonance imaging of the spine was offered. 24 patients underwent MRI examination which showed vertebral metastases in 11 (11/24). MRI is a useful, non-invasive, complementary investigation for evaluation of patients known to have malignant disease and suspected of having vertebral metastases on bone scan.

A study of two anti-CEA monoclonal antibodies for immunoscintigraphy of small cell lung cancer

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21 patients with histologically diagnosed small cell lung cancer underwent immunoscintigraphy with one of two radiolabelled anti-CEA monoclonal antibodies (Mab). 10 patients received Mab F6 labelled with indium 111 (Oris Industrie, France) while 11 patients received BW341/26 labelled with technetium 99m (Behringwerke, Germany). 38 sites of disease were identified by clinical examination, chest radiography or other relevant investigations. Serum CEA concentration was measured in 19 patients and was raised in three. Tumour was imaged in 13 patients corresponding to 18/38 known sites of disease. Seven out of the 10 patients imaged with ^{111}In antibody were positive (9/18 sites) and 6 of the 11 patients imaged with ^{99}Tc^{m} antibody were positive (9/20 sites). The ^{99}Tc^{m} antibody did not offer any clear advantage over the ^{111}In antibody. All three patients with raised serum CEA levels showed positive images as did eight of the 15 patients with normal CEA levels. Although routine use of anti-CEA antibody in patients with small cell lung cancer is not advocated, immunoscintigraphy warrants further study using more specific antibodies.

2.15 – 3.45

Cardiovascular Advances

Hall 11b

The current role of diagnostic and interventional bronchial angiography

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Selective angiography of the bronchial arteries in Man was first performed in 1964 by Viamonte, only 10 years before bronchial artery embolization for the treatment of massive haemoptysis was first described by Remy. Further experience since then has greatly increased our understanding of the pathophysiology of the pulmonary circulation. Diagnostic angiography of the systemic supply to the lungs is helpful: (a) in sequestration and scimitar syndrome; (b) in chronic pulmonary artery obstruction, congenital or acquired; (c) in arteriovenous malformations; (d) in the investigation and treatment of severe haemoptysis. Thus a thorough exploration may require seeking (where appropriate) a patent ductus arteriosus, anomalous aortopulmonary feeders, the bronchial arteries themselves, and transpleural feeders from interior phrenic, internal mammary, thyrocervical and axillary arteries. Massive haemoptysis usually arises from the enlarged systemic circulation in damaged lung as in tuberculosis or bronchiectasis. Where surgery is contraindicated because of bilateral disease or poor respiratory reserve, and where medical management has failed, embolization offers an 80% chance of stopping the bleeding. The complication rate is low but extreme care must be taken to avoid any spinal artery feeders. Embolization may also have a role in the management of recurrent non-life-threatening haemoptyses.

Preliminary experience with the Palmaz coronary artery stent

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14 patients were treated by the placement of Palmaz coronary stents in 15 vessels. Stent placement was carried out either because of acute re-occlusion following angioplasty or severe dissection, with the exception of two cases in which stents were placed electively because of recurrent re-stenosis following angioplasty. A total of 16 stents were placed (LAD 10, circumflex 1, RCA 5). Complications were experienced in one patient in which the stent and balloon could not be passed through the stenosis and the stent could not be withdrawn into the guiding catheter. In this case the stent was expanded proximally in the artery. Following stent placement all the patients were followed up by frequent clinic visits and re-angiography and thallium scanning at 3 months. All patients were placed on Warfarin for 3 months. One patient had acute re-occlusion of the stent despite being placed on Warfarin and this was successfully re-opened. Two patients had to undergo further angioplasty (for re-stenosis, 1, distal disease, 1). In the case of the patient with distal disease, a second stent had to be placed. Patient follow-up data and results of re-angiography are presented.

Observer variability of contrast echocardiography for the detection of patent foramen ovale

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There is increased interest in the use of contrast echocardiography for the detection of patent foramen ovale, both in patients with unexplained stroke and divers with decompression sickness. The interpretation of individual scans is very subjective. We have assessed the inter- and intra-observer agreement on a consecutive series of contrast echocardiograms. 100 subjects were studied. Agitated saline contrast was injected rapidly into an antecubital vein during imaging of an apical four chamber view of the heart. All injections were recorded on video tape. Four observers subsequently reviewed the recordings independently, on two occasions each in a darkened room. Only the last injection for each subject was displayed. Repeated observation of an injection was allowed. The kappa statistic for intra-observer variability for each of the four observers was

0.95, 0.91, 0.90 and 0.88 (a value of 1 implies complete agreement betweeen an observer's two interpretations). The inter-observer variability (95% CI), using the proportion of agreement method, was 0.78 (0.72–0.84) and 0.91 (0.87–0.93) for the presence and absence of patent foramen ovale, respectively. We conclude that contrast echocardiography when used for the detection of patent foramen ovale is subject to clinically acceptable inter- and intra-observer variability.

Functional parameters for the right ventricle evaluated by magnetic resonance imaging in patients with single lung transplantation

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Purpose: Qualitative and quantitative assessment of flow in the main pulmonary artery (MPA) and superior vena cava (SVC) in patients with chronic lung disease, before and after single lung transplantation. *Materials and methods:* Cine magnetic resonance imaging with velocity mapping was used to study 13 patients before and 16 patients after lung transplantation. Eight normal subjects with dobutamine induced tachycardia were studied for comparison. *Results:* Despite the slower heart rate in the post-transplant patients 91 ± 12/min compared with the pre-transplant group 101 ± 12/min ($p < 0.001$), MPA flow (mean $\pm$ SD) in the first group 3.09 ± 0.64 l/min/m^2 was significantly higher than in the second group 2.91 ± 0.41 l/min/m^2 ($p < 0.05$). SVC flow in the post-transplant patients 1.21 ± 0.32 l/min/m^2 was higher than in pre-transplant patients 1.02 ± 0.26 l/min/m^2 ($p < 0.001$). The SVC flow in all but three pre-transplant patients showed a forward systolic peak with absent or reverse flow during diastole. The three patients showed a biphasic curve with a dominated diastolic peak. In all post-transplant patients the flow curve showed a systolic and a diastolic forward peak and a ratio (1.41 ± 0.62) similar to that of controls (1.39 ± 0.33) matched for heart rate (96 ± 13/min). *Conclusion:* A significant improvement of MPA and SVC flow after lung transplantation was demonstrated with magnetic resonance imaging owing to a decreased vascular resistance which could be useful to monitor right ventricular performance after lung transplantation.

The value of coronary angioscopy in coronary angioplasty

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Coronary angioscopy was carried out in three patients using a new disposable angioscope, designed to be delivered to the coronary arteries via standard coronary angioplasty guiding catheters. The device is 4.5 french in diameter and can be passed over an 0.14 diameter coronary guide wire. A clear field is obtained by dilating a small latex balloon attached to the angioscope and flushing clear fluid through the scope at a rate of 30–600 ml/min. The fibre is moveable and can be passed down the artery even when the balloon is inflated. Angioscopy with this instrument appears to give cleaner and more reliable imaging than two other devices tested. Angioscopy was carried out in conjunction with coronary angioplasty in the three patients, documenting the disease before and after angioplasty. In all three cases a coronary stent was deployed and the angioscopic findings were used to determine the site of stent placement as well as confirming that satisfactory stent deployment had occurred. The angioscopic findings also contributed to the decision making process in deciding to place the stent.

Various manifestations of hypertrophic cardiomyopathy on ultrafast computed tomography

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Ultrafast computed tomography (UFCT), which is a new type of computed tomography based upon electron beam technology, was performed in 28 patients with hypertrophic cardiomyopathy, using an Imatron C-100. Images were assessed on variability of left ventricular hypertrophy, the pattern of left ventricular contraction, right ventricular hypertrophy, dilatation of the left atrium and thickening of the mitral valve. The long-axis and short-axis views of the left ventricle were obtained by sluing the patient's table. 40 ml of non-ionic contrast material was administered intravenously, using a mechanical injector for each study, and typically three studies were required for one patient. 14 of 28 patients (50.0%) had asymmetric septal hypertrophy (ASH), five (17.9%) had diffuse hypertrophy, and nine (32.1%) had apical hypertrophy. In 10 patients with ASH and two with apical hypertrophy, non-hypertrophied segments in end-diastole showed vigorous contraction, 15 patients showed homogeneous left ventricular contraction, and one showed partial apical contraction. Right ventricular hypertrophy was noted in 12 patients (42.9%), dilatation of the left atrium in 13 patients (46.4%), and mitral valve thickening in three (10.7%). UFCT was useful in the evaluation of apical hypertrophy, right ventricular hypertrophy and left atrial dilatation, which could be difficult to obtain with echocardiography.

MR imaging of heart after correction of tetralogy of Fallot

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The purpose of this study was to assess the function and anatomy of right ventricle, outflow tract, and pulmonary arteries using MR imaging in patients who had correction of tetralogy of Fallot 10 years previously, in conjunction with echocardiography. 14 patients were studied (eight males and six females), with an age ranging from 13 to 19 years. There were two groups: the first group (eight patients) consisted of patients who had extensive right ventricular outflow tract/resection with Gortex patch, and the second group (six patients) consisted of resection with or without pulmonary valvotomy. Right ventricular dimensions were assessed using spin echo images and then systolic and diastolic volumes were assessed using contiguous gradient echo images. In all patients the right ventricle was enlarged and the average election fraction was 50%. The regurgitation fraction and gradient across the pulmonary valves were assessed using phase encoded flow mapping, and the results corresponded with echocardiography. There were four peripheral pulmonary artery stenoses which were not detected by echocardiography. There were two residual septal defects. There were three other associated cardiac anomalies. We found that MR imaging allowed quantitative and anatomic insight of the heart in patients who had correction of tetralogy of Fallot, thus supplementing the clinical and echocardiographic evaluation of the patient.

Feasibility of left ventricular aneurysm resection assessed using tomographic radionuclide ventriculography

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It is now established that patients with dyskinetic aneurysms are much more likely to benefit from aneurysm resection than patients with akinetic aneurysms. We have, therefore, developed a new method of acquiring multigated, tomographic, radionuclide ventriculograms which are able to assess both the anatomy and the extent of the "backward" stroke volume into the aneurysm. From this latter measurement, a prediction of the improvement in overall stroke volume following resection can be made. Imaging using the Aberdeen Sector Scanner and processing using a dedicated small computer takes 20 min and 30 min respectively, allowing the technique to be used routinely. 20 consecutive patients with ventricular aneurysm and 10 controls were compared. The mean age of the patients was 57 (90% being male) and the mean age of the controls was 55 (70% being male). In eight patients, simulated resection improved the stroke volume by less than 10%, in eight patients by 10–20% and in four patients by > 20%. No control subject demonstrated any significant aneurysmal stroke volume. This technique shows great promise in assessing aneurysm formation and suitability for resection.

Radiology of the Churg–Strauss syndrome

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The Churg–Strauss syndrome is a rare disorder characterized by hypereosinophilia and systematic vasculitis occurring in patients with asthma and allergic rhinitis. We reviewed the radiological features in nine patients (three men and six women), with this syndrome. All nine patients had chest radiographs, six had CT scans of their paranasal sinuses, three had routine paranasal sinus views, three had hand radiographs, two had radiographs of the feet, whilst one patient had an MR of the brain. A total of 27 chest radiographs, eight paranasal sinus radiographs, six CT scans of the paranasal sinuses, four pairs of hand radiographs, two pairs of feet radiographs and one MR scan of the brain were analysed. Radiological features present included thickened mucosa and soft tissue masses within the paranasal sinuses which in one case was associated with bony destruction, isolated antral polyps, cardiomegaly related to congestive cardiomyopathy owing to cardiac granulomas, pulmonary infiltrates and multiple small areas of white matter abnormalities in the brain on MRI.

Artefacts in the ascending aorta on computed tomography: yet another measure of aortic distensibility?

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On modern CT systems capable of 1 s data acquisition times, the ascending aorta often appears to have a blurred outline. It has been suggested that this new artefact arises because of aortic wall motion during systole/diastole. Thus the artefact might provide an indication of aortic distensibility (as on ultrasound and magnetic resonance). The artefact was evident in 48 of 53 patients undergoing routine chest CT; its extent was subjectively and objectively assessed. The maximum and minimum cross-sectional aortic areas were assessed from the margins of the blur. The area of the blur, expressed as a fraction of the minimum

aortic cross-sectional area, decreased with age ($p < 0.001$) and was significantly smaller in the 13 patients with known cardiovascular problems ($p < 0.05$). These findings were substantiated by the subjective gradings which showed less marked artefacts amongst elderly patients (although this observation did not reach statistical significance). Artefacts were less prominent in 16 patients with evidence of aortic wall calcification, both on subjective grading ($p < 0.05$) and formal area measurements ($p < 0.05$). These observations lead us to believe that this artefact is an indicator of aortic distensibility and thus, indirectly, of cardiovascular status.

Magnetic resonance flow mapping in the thoracic aorta of patients with aortic coarctation

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Magnetic resonance imaging with velocity mapping was used to characterize and to measure flow and its regional distribution in the thoracic aorta of 10 patients with coarctation of the aorta. 10 healthy volunteers were studied for comparison. Flow waveforms were studied in an oblique plane perpendicular to the ascending aorta (AA) at the level of pulmonary bifurcation and to the descending thoracic aorta (DA) 1 cm distal to the coarctation segment. Instantaneous flow was calculated from mean velocity and the cross-sectional area of the vessel. Peak forward flow (Q_f,l/min), time-averaged flow (Q_m,l/min) and DA/AA flow ratio were measured. In the controls, Q_f in the AA and DA (mean $\pm$ SD) was 28.3 ± 4.4 and 17.8 ± 2.7, respectively. Q_m in the AA was 5.6 ± 0.8 and in the DA was 3.5 ± 0.7, and the ratio of DA/AA flow (Q_m) was 0.62 ± 0.07. In patients with coarctation, AA Q_f 25.5 ± 4.8 and AA Q_m 5.8 ± 1.2 were similar to those of controls, while DA showed a lower Q_f 10.4 ± 3.4 ($p > 0.001$), a lower Q_m 2.6 ± 0.9 ($p < 0.05$) and a lower DA/AA ratio 0.47 ± 0.18 ($p < 0.05$) than controls. These differences are most likely related to the resistance imposed on flow by the coarctation and could be an additional index for monitoring patients with coarctation of the aorta.

Notes

4.15 – 5.30

Gastrointestinal imaging

Hall 11b

Videofluoroscopy in the assessment of dysphagia following neurological disease

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A significant number of patients with stroke or other neurological disease present with difficulty in swallowing. We have examined over 55 such patients over a wide age range in the last 3 years, using videofluoroscopy. Patients are examined in presence of a speech therapist initially in the lateral and then, if necessary, in the AP projection, starting with 1, 3 and 5 ml aliquots of barium suspension, followed by barium paste and solid food mixed with barium paste. The average screening time is approximately 5 min. The diagnosis is often made on screening and subsequent management techniques can also be assessed. Videotape allows detailed analysis of the findings to be made later. Once identified, many of the problems are amenable to treatment by re-educating the patient using techniques employed by speech therapists. Our findings suggest that about half the patients are at risk of silent aspiration. 20 patients are now able to continue with oral feeding; two have had to go on to non-oral means; 11 patients are receiving on-going treatment; one has had surgery and eight have died. We suggest that videofluoroscopy has a valuable role in the assessing and planning of treatment of patients with dysphagia.

A swallow assessment clinic: why and how

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This 15 min VHS video programme highlights the number of patients with a wide range of conditions in whom a dynamic videofluoroscopic assessment of the oral, pharyngeal and cervical oesophageal phases of swallowing is indicated. The need is probably greater than has been realized to date. It has been shown that at least 40% of stroke patients, in hospital or at home, will have a swallowing problem and almost half of these will be silently aspirating, having lost their cough reflex. This number could be 500 each year in Northern Ireland (population 1.5 million). There are also many patients with other neurological conditions, congenital and acquired or who have had major throat or neck surgery who will have similar swallowing difficulties. All these need assessing and some require training or therapy in order to reduce the risk of aspiration pneumonia and to help manage their nutrition and hydration. We illustrate how a swallow assessment clinic, operated by a radiologist, a speech therapist and a dietitian, can satisfy this need. Our videofluoroscopic technique, using a modified barium swallow, is demonstrated with a variety of cases from the 400+ patients we have examined since 1986. References are available with the video.

A new chair of radiology — a purpose-designed seat to assist fluoroscopy

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Fluoroscopic examination of the seated patient is occasionally necessary, particularly when evaluation of swallowing is required in the patient with neuromuscular or cerebrovascular disease, as well as for proctography in all patients. We have used a variety of methods, including sitting a patient on the table foot rest or on a narrow wheelchair, but no method has proved satisfactory. We have designed and built a simple chair of tubular steel, which has a padded seat and back support and a detachable foot rest. The arm rests of the seat can be swung behind the seat to allow access and proctography. The total cost of materials for the seat was under £100. The seat attaches to the foot rest of the fluoroscopy table by a single central lug, which fits a hole in the foot rest provided by manufacturers for the fixation of other devices. Single central fixation allows the seat to pivot about a vertical axis allowing lateral, frontal and oblique views during assessment of swallowing

and lateral views during proctography. The patient can be secured within the seat by a seat belt attachment. One particular advantage of the seat is that the foot rest can be removed and the base and upright back of the seat positioned on a trolley, so that even the most immobile patient can be seated securely and examined. The use of this device allows safe and controllable examination of all patients with swallowing disorders and allows greater comfort for those undergoing proctography.

Patterns of colonic transit in severe intractable constipation using oral ^{111}In-DTPA scintigraphy

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A simple, clinically applicable method for assessing colonic transit in constipated patients has been developed. 3.7 MBq of ^{111}In-DTPA is taken in water on day 1. The following day at 18 h posterior and anterior abdominal scans are acquired and repeated twice daily until the 5th day. No bowel preparation is used and normal diet is maintained throughout. Six regions of interest (ROIs), from caecum and ascending colon (1), to rectosigmoid colon (6), are drawn on each colonic image. Counts from anterior and posterior ROIs are combined, and decay and background corrected. Percentage of ingested activity in each ROI, and faecal loss (ROI 7) is calculated, and used to calculate the geometric centre of gravity of the isotope (COG). A normal range of COG was obtained from 16 control subjects. 33 patients with constipation were investigated and showed three patterns of transit: (1) transit within normal range ($n = 5$); (2) proximal delay ($n = 26$), who showed early delay of progression of COG (< 3.6 at 48 h), with delayed right colonic emptying and accumulation of isotope in the transverse colon and splenic flexure; (3) left colonic delay ($n = 7$) where progression of COG was normal at 48 h but later showed accumulation of isotope occurring in the descending and rectosigmoid colons. The oral scintigraphic method enables differentiation of patterns of colonic transit in constipated patients which may influence treatment.

Validation of region of interest drawing in oral colonic transit scintigraphy

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The changing morphology of the colon during prolonged studies of transit hinders the application of fixed regions of interest (ROIs) for analysis. Drawing ROIs individually on each image was adopted to overcome this problem but in turn may increase the subjective error in analysis. The validity of individual ROI drawing was therefore investigated. Inter- and intra-individual variation in analysis of seven colonic transit studies was assessed. Each scan was assessed on at least one occasion by three assessors at intervals of 6 weeks. Each anterior and posterior scan was divided individually into six ROIs. Corrected counts were used to calculate the percentage of ingested activity in each ROI and the centre of gravity of the isotope (COG). Results from each analysis were compared using repeated measures ANOVA. The major source of variation in analysis was the between patients component (variation estimate VE = 1.9), and the patient/time component (VE = 0.46). Although the assessor/patient component (*i.e.* variation between assessors' analysis of scans) was a significant source of variation (VE = 0.003), it was small compared with the other components and could be regarded as negligible. Individual ROI drawing in the analysis of oral colonic transit scintigraphy is a reliable and reproducible technique.

Oesophageal scintigraphy in the assessment of balloon dilatation of the oesophagus for achalasia

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Balloon dilatation of the distal oesophageal sphincter is widely employed for the treatment of achalasia of the cardia. We have used oesophageal transit scintigraphy to assess the effectiveness of dilatation and for the long term follow-up of patients with achalasia. Taking the whole oesophagus as the region of interest, time-activity curves were generated following ingestion of a 10 ml bolus of a solution of ^{99}Tc^{m} sulphur colloid in the erect position. After 30 s, the isotope was followed by a bolus of 100 ml of water to produce "oesophageal washout". Parameters measured included the time taken for activity to fall below 50% of maximum (T50), and the percentages of retained activity at 30 s (B30) and at 100 s (B100). The normal transit curve was established by study of 22 healthy volunteers. Oesophageal transit studies were performed in 17 patients both before and after balloon dilatation. Mean T50 fell from 66 s pre-dilatation to 25 s post-dilatation, mean B30 fell from 76% pre-dilatation to 55% post-dilatation, and mean B100 fell from 43% pre-dilatation to 17% post-dilatation. Serial post-dilatation transit studies were also performed in a group of patients to assess the long term response to balloon dilatation. The results are fully presented and the usefulness and limitations of oesophageal transit scintigraphy in the assessment of achalasia are discussed.

Radiology of Crohn's disease in Asian immigrants of East Birmingham

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Crohn's disease (CD) is thought to be uncommon amongst the Asian population. The aim of this study is to assess whether there is any difference in the pattern of disease in Asian immigrants. We report 20 cases of intestinal CD from Asian immigrants who presented to our Unit since 1970. We note no difference in the diagnostic radiological features. However, small bowel studies show that 30% of patients with active mid small bowel disease have a disease free terminal ileum. Barium enema studies show that 38% of patients with colonic CD have the disease confined to the distal colon and the mean age of such patients is 23.5 years (range 14–37). In white populations, disease free terminal ileum is reported to occur in 3% of patients with CD and localized proctocolitis is noted to be a common feature of CD of the elderly. We feel that the above features are atypical. Although distal colitis in Asians is commonly due to an infective cause or ulcerative colitis, the possibility of CD needs to be considered and investigated in unresolving cases.

Long linear ulceration in Crohn's Disease

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There are many patterns of ulceration seen in Crohn's colitis, and some of these are felt to be specific when differentiating Crohn's from ulcerative colitis. We undertook a retrospective assessment of 106 patients (40 male, 66 female) who all had proven Crohn's colitis, and who had all had at least one double contrast barium enema (DCBE) in a period between 1977 and 1990. In particular, the sites and extent of ulceration were noted, as well as features such as strictures, fistulae, pseudopolyps and nodularity. These results will be demonstrated. A particular form or pattern of ulceration in the large bowel was noticed in seven patients. We have called this long linear ulceration, and it seems to be a separate, but probably related, form of ulceration from the usual fine, shorter linear ulcers occasionally identified in the small bowel of patients with Crohn's disease. We define them as being deep, long, linear ulcers 5 cm or more in length. All seven patients affected were young (20–30 years old) except for a woman of 45 years. Six were female and one was male. The transverse colon was the commonest site (five patients), and in every case there was associated extensive ulceration in the colon, with aphthous ulcers and deep ulceration between 1–3 mm. Three patients had repeat DCBE at a later date and in none was long linear ulceration seen again. Two of the three developed a stricture, but not at the site of the linear ulcers. The features of these ulcers will be demonstrated. Long linear ulceration may be another pattern which when seen will help differentiate Crohn's from ulcerative colitis.

Peritoneal slide: an observation to identify peritoneal adhesions

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Adhesion of bowel loops to the anterior abdominal wall is not an uncommon finding in patients who have had previous laparotomy. These adhesions are usually not confined to the region of the abdominal wall scar. Owing to the increased trend in laparoscopic procedures such as laparoscopic cholecystectomy, there is a need to identify the presence and location of such adhesions. This is because puncturing a fixed bowel loop by introducing a laparoscopic trochar into the abdomen may have grave consequences. Ultrasound is a well established investigation to look for peritoneal masses and free intraperitoneal fluid. Using a high frequency probe (7.5 MHz) one can clearly identify the movement between parietal and visceral peritoneum in a normal subject during all phases of respiration. Adhesion of a bowel loop to the anterior abdominal wall will certainly restrict such a slide. Therefore, by observing the peritoneal slide with real time ultrasound at the potential sites for the introduction of the laparoscopic trochar on the anterior abdominal wall, we believe that the presence and location of fixed bowel loops can be easily defined. A video tape of about 2–3 min demonstrating normal and abnormal peritoneal slide and how to locate the position of the fixed bowel loops will be presented.

Radiological evaluation of the ileoanal (Parke's) pouch: should we continue to do pouchograms?

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The radiological investigations of 68 patients who had a Parke's pouch (W type) were reviewed. Underlying diag-

noses were ulcerative colitis (52 patients), familial polyposis coli (11 patients) and Crohn's disease (five patients). 50% of the patients had a loop ileostomy as part of a two stage procedure. 20 patients had documented post-operative complications. 45 pouchograms were performed, 35 of which were routine prior to closure of the ileostomy in a two stage procedure; one demonstrated an unsuspected leak. 10 were obtained in patients with documented post operative complications; in this group there were six true positive, one true negative and three false negative results. 21 indium labelled leukocyte scintigrams were performed in patients with symptoms of infection. 19 true positives and two true negatives were found. Three CT scans were obtained in patients where an abscess was indicated by scintigraphy and CT guided drainage was performed in two. We conclude that scintigraphy should be the first investigation in patients with a Parke's pouch and infective complications, followed by CT if an abscess is suspected. The role of the pouchogram is unclear from our series and further studies may be helpful.

Small bowel changes following the modified Scopinaro procedure for morbid obesity

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Scopinaro (1986) described partial gastrectomy with pancreatico-biliary by-pass for morbid obesity which combines the advantages of gastric reduction and small bowel by-pass without the detrimental metabolic effects of jejuno-ileal by-pass. Between 1987 and 1991 48 patients underwent a modified operation of truncal vagotomy, stapled transverse gastric partition and gastro-ileal anastomosis, and upper GI tract contrast studies have been performed on 24 patients. Mucosal fold thickness and luminal diameter were correlated with time following the procedure (range 1 50 months). There was a significant increase in mucosal fold thickness with log(time) ($p < 0.0005$), and a similar significant increase in lumen diameter with log(time) ($p < 0.0044$). Mucosal fold thickness and bowel lumen calibre changes reach a plateau at 20–30 months post-procedure. This is mirrored by the patients' weight loss which is rapid initially but also plateaus at around 30 months. Jejunalization of the ileum is a recognized feature following jejuno-ileal by-pass, but has not been described previously following gastric reduction surgery.

Magnetic resonance imaging following surgery for ano-rectal anomalies

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The diagnosis of ano-rectal anomalies in the newborn is made by a combination of clinical and simple radiographic examination. The majority of children are satisfactorily treated on this basis. However, a small proportion of patients will have subsequent problems, in particular troublesome faecal incontinence. The assessment of these children for further management is often difficult. We investigated the potential role of magnetic resonance imaging in this situation. 11 patients (mean age 12 years) were studied using a Picker Vista HP2025 0.5 T scanner. T_1-weighted images were obtained in sagittal, coronal and axial planes. The images were assessed for pelvic musculature, the appearance of the lower bowel and spinal anomalies. These were correlated with the clinical findings and results of conventional radiological imaging. Abnormalities of the distal bowel and pelvic musculature were most common (in seven patients each). These included gross rectal dilatation and deficiency of pelvic floor muscles, particularly puborectalis. Spinal anomalies were found in four cases, including sacral agenesis, hemivertebrae and a sacral lipoma. These findings are illustrated and are discussed with reference to their effect on subsequent management.

Congenital duodenal obstruction: diagnostic features in 53 neonates

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This study reviews the radiographic features of 53 neonates presenting to a national Children's Hospital over a consecutive 4 year period with congenital duodenal obstruction. In each case correlation was made between radiographic features and subsequent findings at surgery. Of 53 children, 27 presented with intrinsic obstruction, owing to duodenal stenosis in nine cases, owing to duodenal duplication in two cases, owing to isolated annular pancreas in two cases and owing to the presence of a web in one case. 26 patients presented with extrinsic obstruction owing to malrotation; of those, 17 patients had a high caecum with associated volvulus and bands and nine patients presented with volvulus secondary to incomplete bowel rotation. These results suggest that intrinsic and extrinsic congenital duodenal obstruction occur with

similar frequency. It highlights the role of prenatal ultrasound in the early diagnosis of duodenal atresia and the specificity of the "double bubble", "beak", "windsock", and "corkscrew" signs in accurate diagnosis.

Ultrasound in the investigation of the gastrointestinal tract

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Barium radiology of the small and large bowel involves a substantial radiation dose to patients, many of whom are young, often with a low index of clinical suspicion, or requiring repeated examinations for inflammatory bowel disease (IBD). We prospectively examined the value of ultrasound (US) in patients undergoing small bowel barium studies and in patients having barium enema examinations for suspected IBD. Using an Acuson 128 5 MHz curved linear array probe US was performed by a radiologist unaware of the clinical history, immediately prior to the barium study. Another radiologist performed the barium examination unaware of the US findings. To date 37 patients have had 46 barium examinations (small bowel enema 18, follow-through 12, barium enema 16). 18 revealed an abnormality (IBD 15, tuberculosis one, diverticular abscess one, subacute obstruction one). US correctly detected 15 of the 18 radiological abnormalities. Of the three false negatives on US two examinations were difficult owing to the presence of multiple abdominal scars. There were two false positives on US both of which occurred at the beginning of the study. The preliminary results suggest that with experience US could be the first line investigation in patients with suspected small bowel pathology and in those with suspected large bowel IBD. This may enable more selective use of barium radiology.

Notes

Tuesday 19 May

9.00 – 10.15

MR Technology

Hall 9

The current status of MR angiography and flow measurement techniques

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Magnetic resonance (MR) flow techniques are available which give a quantitative measurement of velocity or flow. Velocity phase maps can be acquired in which the pixel value is linearly related to the velocity at that point within a vessel. Such techniques can be used to obtain measurements at various points in the cardiac cycle. In addition, flow in small cerebral vessels can be measured. Recently, pulse sequences have been developed to obtain a rapid display of the velocity profiles in vessels. MR angiography gives a qualitative assessment of flow in vessels, producing an image which mimics X-ray angiography. The three main categories of MR angiographic technique will be reviewed. The first is the phase contrast method which can produce images of either a thick section or a three-dimensional (3D) volume where stationary tissue appears black and flowing blood appears as a high signal. The second technique is known as the inflow or time-of flight method, this produces a 3D data set using either 2DFT or 3DFT. The angiogram can then be viewed from any angle after acquisition using computer reconstruction. The third technique utilizes fast imaging following an injection of MR contrast. The various techniques will be described and their relative merits and shortcomings will be discussed.

An evaluation of signal properties for MRI

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The evaluation of the performance of magnetic resonance (MR) systems can be divided into the following categories: signal properties, geometric properties, artefacts and MR specifics such as T_1, T_2 relaxation rates. MAGNET, the Magnetic Resonance National Evaluation Team, quantifies an extensive set of parameters which cover the wide range of the four groupings. The aim of the team is to assess these properties for a selection of coils and imaging sequences. The results of assessments are supplied to the National Health Service to assist purchasing decisions. This paper will address the first and most fundamental grouping, signal properties. These are characterized by the parameters; the signal-to-noise ratio (SNR), and uniformity, the distribution of signal throughout the image field. The range of techniques to evaluate SNR will be presented and reviewed for their efficacy, including spatial and Fourier domain analysis. An indication will be given of the appropriate method to use in the presence of non-uniformity and artefacts. The use of contour plots to characterize uniformity will be discussed in depth. Volumetric assessments for head coils and surface coils will be demonstrated. The results presented will compare a number of commercially available systems of varying field strength and coil type, identifying those with high SNR and uniformity values.

Radio frequency eddy current losses for an annular conductor in MRI

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The quantitative assessment of the signal-to-noise aspects of magnetic resonance (MR) imaging as a function of static field strength depends upon the provision of a means of simulating the r.f. interaction (loading) between the MR receiver and the patient. A popular practical solution is the use of a saline-filled test object of annular geometry within which standard MR test objects may be positioned. The present study provides a theoretical and experimental framework for this type of loading. A semi-infinite model is used to derive the induced electric field and equivalent

resistance of an annular conductor located within an idealized saddle coil. Predictions made with this model agree well with both test object experiments and data for the human head over the frequency range 1–63 MHz.

Applications for machine design of the use of superconducting coils

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The dominant sources of noise in whole body magnetic resonance imaging are associated with the receiver coils and the body itself. Typically, the former is dominant at low fields (less than 0.3 T) and the latter at high. Therefore, it might be expected that the use of superconducting coils would be of greater value at low field rather than high. The availability of high temperature superconducting materials (HTSC) such as yttrium barium copper oxide, which have a critical temperature greater than that of liquid nitrogen liquidation, offers the possibility of practical systems. Extrapolation from high frequency results indicates that HTSC coils at megahertz operation frequencies should have a surface resistance, at 70 K, several orders of magnitude smaller than that of copper, which implies a substantial increase in the intrinsic Q of the coil. Consequently, receiver coil design must be reconsidered to attain the maximum signal-to-noise ratio and body noise dominance. Coil geometry can be optimized for r.f. performance, without regard for filling factor, in the conventional sense, which is no longer an issue.

3D MR imaging—manipulation and display on an independent console and independent workstation—a comparative study

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The aims of this study were: (1) to compare an independent console (GE DCIII) with a workstation (Sun Sparcstation 2), and (2) to compare three commercially available software packages, "Sun vision" (Sun Microsystems Inc.), "Analyze" (Mayo Foundation) and "MR Console" (General Electric) with respect to their ability to display and manipulate three-dimensional (3D) data. Magnetic resonance (MR) imaging studies were obtained on an IGE Vectra 0.5 T MR system as 3D volume acquisitions from patients being investigated for underlying tumours. Particular attention was directed in these comparative studies to functionality and user friendliness and the capacity for further program development. Data from each tumour study were manipulated separately on each system. The time required to perform each of a series of functions was measured. A scoring system (0–4) was used to assess perceived image quality, tumour conspicuity and quality of viewing facilities for a variety of functions. A further assessment of user friendliness was obtained by counting the number of interactions required to perform each manipulation. The facilities for transferring images from MR scanner to DCIII and workstation were also compared with respect to ease, speed and quality of transfer. The DCIII has some advantages over the "Sun" station because of its integral relationship with the scanner. Post-processing on the DCIII, however, was frequently slower, required more interaction and had restrictions which did not apply on the "Sun" station. For routine image display and diagnosis the DCIII performs well but, for more sophisticated post-processing, an independent workstation is desirable.

Applications of a simple method of 3D MR image reconstruction from regular 2D images

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Three-dimensional (3D) imaging has been shown to be useful in clarifying structures difficult to visualize with two dimensional images. Three-dimensional magnetic resonance (MR) imaging has a lot to offer due to MRI's remarkable ability to distinguish between soft tissues. Software has been developed that will transfer and reformat regular 2D MR images from a General Electric (GE) SIGNA Scanner in such a way as to enable them to be displayed in three dimensions on a Sun workstation. The equipment and software needed for a 3D imaging system is described. This 3D imaging system has been applied to MR angiography using GE's flow-sensitive sequences. This system has also been used to view cartilage of the patello-femoral articulation in the knee. Clinical examples are illustrated. Routine GE pulse sequences were used, although special parameters were used to obtain good contrast between the tissue of interest and other tissues. Limitations of 3D imaging have arisen from non-uniformity of the images and from the great sensitivity of MR to internal signal differences in individual tissues. Possible solutions to these problems and improvements in the techniques are discussed. This technique, when used to complement 2D images, helps the radiologist to visualize and, more importantly, to convey to other doctors, complex relationships of pathology and normal structures.

The phase-inverting harness; a new method of dual surface coil imaging

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Local receive-only surface coils are widely used in magnetic resonance to image the spine and many joints. The increase in the magnitude of signal received improves spatial resolution and reduces examination time. However, the signal intensity from planar coils is not uniform and diminishes rapidly beyond the radius of the coil. We have developed a system using the dual coil adaptor to link two r.f. matched and tuned coils. These can be placed anterior and posterior, or lateral to the area of interest. In order to overcome the 180° phase shift experienced by the opposed coils, which would otherwise lead to signal cancellation at the mid-point of the imaging volume, a length of cable, equal to half the wavelength at the resonant frequency, is added to the circuit. This results in even signal distribution across the imaging volume. We have used this system to image the shoulder, wrist and brachial plexus. Examples of these applications will be demonstrated, including the effect of removing the phase harness. This simple device expands the range and applications of existing surface coils with minimal cost implications.

APT—hard pulse trains for fat suppressed MRI at 0.5 T

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Fat suppression can be achieved by the use of frequency selective r.f. excitation applied at the fat frequency, which is shifted by about 3.5 ppm from the water resonance for proton magnetic resonance imaging (MRI), or about 74 Hz at 0.5 T. The effect can be achieved either by applying a single r.f. pulse, shaped to tailor its spectral content, or by applying a string of hard pulses. A number of groups have used binomial hard pulse trains (*e.g.* 121, 1331, 14 641) to saturate fat selectively, with limited success. Such pulse trains are probably of limited value in MRI, as the lower order trains do not have a flat null response around the water frequency, while the higher order trains have a very sharp response at the fat frequency. Thus the desired effect of the sequence is degraded by relatively small static field errors. Significantly better results can be achieved by hard pulse trains (APT, for Cockneys) specifically designed for a flat response at both the water and fat resonances. APT has some significant technical advantages over tailored single pulses. Good results have been achieved in imaging the orbit at 0.5 T. Unlike short tau inversion recovery, fat-suppressed T_1-weighted images unambiguously enhance signal from tissues which take up paramagnetic contrast agents.

Magnetization transfer imaging of the brain

C. J. Baudouin, J. V. Hajnal, A. Oatridge, J. M. Pennock and I. R. Young
NMR Unit, Department of Diagnostic Radiology, Royal Postgraduate Medical School, Hammersmith Hospital, DuCane Road, London W12 0HS, UK

Magnetization transfer (MT) imaging is a technique involving the application of off-resonance pulses to saturate the macromolecular pool of spins invisible on nuclear magnetic resonance imaging. The aim of this study was to assess the effects of such saturating pulses on the images obtained from volunteers and patients with intracranial lesions. *Methods:* Imaging was performed at 0.15 and 1.0 T. 23 patients with intracranial lesions (13 neoplasms, five infarcts, three haemorrhage, two other) were imaged. Off-resonance saturating pulses were incorporated into short and long time to repeat (TR) spin echo, and short and medium TI inversion recovery sequences. *Results:* The application of off-resonance pulses results in loss of signal from normal grey and white matter with reduction of both available magnetization and measured T_1. Pathological tissues show varying amounts of MT. Saturating pulses cause little signal loss in cystic tumour components and haemorrhage. Solid tumour, oedema and infarction are less affected than normal tissue. This results in increased conspicuity of lesions particularly with sequences such as the MT–single tau inversion recovery sequence which exploit T_1 changes as well as loss of available magnetization. *Conclusion:* Pathological tissues show varying amounts of magnetization transfer. Sequences can be designed to exploit these effects and can result in increased lesion conspicuity.

9.00 – 10.15

Combined Chemotherapy and Radiotherapy — Promises and Problems

Hall 10a

Combined chemotherapy and radiotherapy in non-small cell lung cancer

M. H. Cullen
Birmingham Oncology Centre, Queen Elizabeth Hospital, Birmingham B15 2TH, UK

The standard treatment for localized, inoperable non-small cell lung cancer in the UK, and most of the rest of Europe, is with radiotherapy. Fewer than 5% of cases achieve long-term survival with the vast majority of patients dying with distant metastases and local recurrence. The need for effective systemic treatment is clear. Until recently the activity of chemotherapeutic agents has been insufficient for serious consideration as potential adjuncts to radiotherapy. Furthermore the toxicity, in an elderly population, has been prohibitive. However, there are now a handful of drugs (cisplatin, vinblastine, ifosfamide, mitomycin C) which, having been tested in more than 100 cases, demonstrate objective responses in 20% of cases or more. Combinations of these seem reliably capable of producing partial and complete remissions in around 50% of patients. Improvements in anti-emetic therapy have significantly enhanced the potential use of drugs like cisplatin and ifosfamide in non-curative chemotherapy settings. Hence the current interest in combined modality therapy for non-small cell lung cancer. Two studies reporting survival benefit in randomized trials have recently appeared. In one case (CALGB trial), the trial was discontinued on the basis of a significant difference between the chemotherapy plus radiotherapy arm and the radiotherapy alone arm on group sequential analysis. No estimate of the degree of benefit can be made when trials are analysed in this way. In the other trial (from France) the original report was negative. Later analysis demonstrated a modest survival advantage for the combined arm. In both trials the response rate to chemotherapy was low and no mention is made of symptomatic improvement. There is an urgent need for more secure answers to this question and at least one UK trial (the MIC trial) is attempting to address it, and will be discussed.

Adjuvant and adjunctive chemotherapy in head and neck cancer: a meta-analysis

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Despite 43 prospective randomized studies published in the literature and 30 years of research, the value of adjuvant and adjunctive chemotherapy in head and neck cancer remains controversial. Many overviews of the published literature have been previously published and presented, but none of these have included all the published literature. Here we review the 43 prospective and randomized studies which have been published to date and address the question as to the value of chemotherapy. These studies have been very extensively reviewed to check whether their design complied with the criteria for a prospective randomized study. Before arriving at the final number of 43 prospective randomized studies, many studies were excluded owing to irregularity in the design and failure to comply with the criteria for meta-analysis. Mantel Haenszel summary analyses were used to obtain the relative risks of side-effects

Figure 1

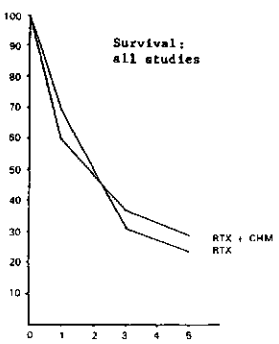
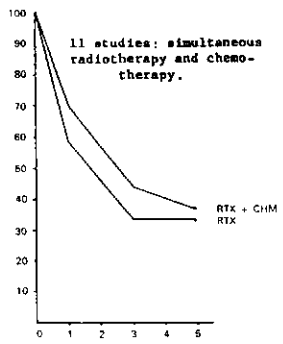


Figure 2



in the radiotherapy plus chemotherapy group from the 43 studies. It was fairly obvious that the addition of chemotherapy has indeed significantly increased the morbidity as well as the chance of tumour response to treatment and the local control of the tumour at 2 years. Surgery and a schedule of radiation did not seem to impact on the overall outcome from the treatment. Overall, the addition of chemotherapy did significantly improve the 5 year survival rate, but that improvement was found to be due to simultaneous chemotherapy alone rather than any other scheduling of chemotherapy (Figs 1 & 2). Further analyses will be presented.

Interrupted hyper-fractionated radiotherapy with concomitant chemotherapy for bulky, inoperable Ewing's sarcoma

D. Spooner, *A. Cassoni and †M. Sokal
*Queen Elizabeth Hospital, Birmingham 15, *Middlesex Hospital, London, WC1 and †Nottingham General Hospital, Nottingham, UK*

In an attempt to avoid a large interval between doses of cytotoxic drugs when conventional radiotherapy is given for Ewing's sarcoma, we have followed a regime piloted by the German CESS 86 protocol. Cytotoxic chemotherapy is given for the first 3 days, together with radiation therapy of 2240 cGy m.p.d. in 14 fractions (× 2 per day, separated by 6 h). This is repeated 3 weeks later and at 6 weeks 1600 cGy m.p.d. is given in 10 fractions over 5 days. 11 patients were treated and followed for a median follow-up period of 27 months; 10 patients had large inoperable pelvic primaries, and one had a large, inoperable skull tumour. The acute toxicity was minimal. *Late results:* one severe cutaneous fibrosis; one iliocaecal stenosis; one local recurrence (at 3 months) and three progressive distant disease. Our pilot study has demonstrated the feasibility of the above regime. Careful monitoring of late toxicity is required.

Acute toxicity study of synchronous chemotherapy and radiotherapy as adjuvant treatment after primary surgery in early breast cancer

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We are presently undertaking a randomized study of neoadjuvant *vs.* adjuvant therapy for early stage breast cancer. In both arms of the study patients received post-operative radiotherapy and synchronous full-dose chemotherapy with no dose modification, except for haematological toxicity. We now present the results of a prospective study comparing the acute toxicity profile of this group of patients (Group (A)) with a similar group treated with radiation alone (Group (B)). Our results have shown no significant difference in the acute skin toxicity with 46 of the 58 (79%) patients in Group (A) developing a mild/moderate skin reaction compared with 37 of the 50 (74%) patients in Group (B). 12 of the 58 patients (21%) in Group (A) developed a moderate/severe reaction compared with 13 of the 50 patients (26%) in Group (B). The main factors relating to the severity of the acute skin reaction have been examined and appear to be due to the radiotherapy technique and are discussed further. Out of 58 patients four (6%) developed symptomatic radiation pneumonitis in Group (A) but responded to a short course of steroids and had no permanent deficit. No patients have developed neutropenic septicaemia. We conclude that synchronous chemotherapy and radiotherapy has an acceptable acute toxicity profile.

Metastatectomy in patients with soft tissue sarcoma

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Between 1970 and 1990, 220 patients with soft tissue sarcoma referred to the Royal Marsden Hospital Sarcoma Unit have developed lung metastases. Of these, 44 patients (median age 32 years) have been treated by metastatectomy. The commonest histologies were malignant fibrous histiocytoma (10) and synovial sarcoma (8) and extremity the commonest site. Mean time to lung metastasis was 934 days. The mean number of metastases found at surgery was two (range 1–15) and 22 patients had one. On nine occasions more lesions were present than were discovered pre-operatively and on three occasions fewer. Surgical complications were minor apart from one pulmonary embolus and one post-operative death following tumour embolus into the middle cerebral artery. 14 patients received adjuvant chemotherapy and one patient received radiotherapy to unresected disease. Lung was the first site of relapse in 22 patients. All nine patients with bilateral resections relapsed in lung. Although the metastasis-free interval following primary treatment of both groups was the same overall, 5 year survival and survival from development of lung metastasis (50% *vs.* 20%) was better in those undergoing thoracotomy and was not related to the number of metastases resected or disease-free interval. On multivariate analysis of all 220 cases, the use of lung resection was the most important factor determining survival of those with lung metastases (RR 0.2) with age < 40 and extremity also important.

Measurements of platinum uptake in head and neck tumours using X-ray fluorescence

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Platinum is the basis of the first inorganic compound to be used widely in cancer chemotherapy. Quantification of the platinum concentration in tumours would be of value in evaluating the pharmaco-kinetic behaviour of the drug and achieving a better therapeutic ratio. Platinum can be measured *in vivo* by X-ray fluorescence using excitation sources of either ^{57}Co or, more recently, ^{99}Tc^{m}. Initially, the ^{57}Co source and a planar hyperpure germanium detector in a 90° scattering geometry were used. Whilst successful in measuring the platinum concentration in the kidneys, this scattering geometry was found in practice to be difficult to use for measurements about the head and neck. A new instrument was consequently developed in which an annular ^{99}Tc^{m} source was used in a 180° scattering geometry with the same planar detector. The results of an initial clinical study of patients with head and neck tumours indicate the benefit obtained in using this new arrangement.

MRI of osteosarcomas and Ewing's sarcomas: the potential of dynamic Gd-DTPA scanning for quantifying the chemotherapy response

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Chemotherapy of osteosarcomas and Ewing's sarcomas has developed tremendously during recent years. After pre-operative chemotherapy the tumour may be resected locally. It remains a diagnostic challenge to answer the question as early as possible during pre-operative chemotherapy whether the tumour is responding or not, so that the treatment modalities can be intensified. During the last 5 years we examined 45 osteosarcomas and 22 Ewing's sarcomas with magnetic resonance imaging at 1.5 T. Of these, 16 osteosarcomas and six Ewing's sarcomas had a follow-up study for a 2–5 month period. They received a dynamic Gd scanning, which consists of one slice which is scanned repetitively in rapid succession using a T_1-weighted spin-echo sequence. Gadolinium-DTPA is given as a bolus immediately after the first scan. Quantification is done by means of an "irregular region of interest" (ROI). A phantom was introduced as a standard. The time-intensity diagram prior to treatment reflects the significant increase and high signal intensity level, indicating a hyperperfusion of a malignant tumour. During chemotherapy perfusion decreases and correspondingly the signal intensity declines. If the intensity decreases by more than 20% relatively to the baseline examination after 4 or 6 weeks, the pathologist will find less than 10% of residual tumour viability after completion of the chemotherapy. This indicates a response. The diagnostic accuracy lies between 85 and 90%. Therefore dynamic gadolinium-DTPA scanning seems to be an excellent tool for a reliable and non-invasive quantification of tumour response during pre-operative chemotherapy.

9.00 – 10.15

Radiological Audit

Hall 11a

The role of hysterosalpingography in the evaluation of infertility—a clinical audit

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Department of Radiology, and Department of Obstetrics and Gynaecology, Western Infirmary, Glasgow G11 6NT, UK

We have performed a retrospective study of 112 patients who presented for the investigation of infertility, over a 5 year period between 1986 and 1991. All patients had primary or secondary infertility for greater than 2 years. Ovulation and semen analysis had been shown to be satisfactory. In patients who also underwent laparoscopic hydrotubation these results were compared. Hysterosalpingography was performed without pre-medication, with up to 20 ml of non-ionic contrast using Leech–Wilkinson cannula, Foley or Harris catheter, under fluoroscopic control. Laparoscopic hydrotubation involved laparoscopy under general anaesthesia, with pneumoperitoneum and assessment of tubal anatomy. Patency was established by visual inspection of the tubes after trans-cervical injection of dye (methylene blue). The radiological and laparoscopic findings were compared and the cost of each type of investigation was also calculated. Results and implications for the rationalization of the management of the infertile patient will be discussed.

Observation of significant abnormalities on lumbar spine radiography

J. Fowler, P. Tyrell, J. S. Millar, J. F. Leahy, K. Patel, J. A. Hill and A. M. Davies
Department of Radiology, Birmingham General Hospital, Birmingham B4 6NH, UK

In the past some publications have advocated limiting the routine lumbar spine series to a single lateral film to reduce the departmental workload and radiation dose to the patient. Series have been quoted in support of this idea in which the prevalence of significant abnormalities was extremely small. The purpose of this study is to determine what proportion of significant abnormalities are detected on the antero-posterior (AP) and lateral films when viewed separately in a series of cases where the prevalence of abnormalities was artificially increased to an unknown level. Five radiologists of varying experience were required to report separately on the AP and lateral lumbar films of 300 cases in which randomly included were nine cases with a disc infection, 14 with a metastasis and seven cases with an inflammatory spondylitis. At a later date the radiologists repeated the exercise, reviewing all the films together. Analysis of the observations was performed. As might be expected in such a study the false positive rate was relatively high, particularly in the least experienced radiologists' responses. Nevertheless the overall results show that the majority of early inflammatory spondylitis cases will be missed on a solitary lateral film as will many of the metastases. Conversely fractionally more of the infections were observed on the lateral film than on the AP. Further analysis in terms of sensitivity, specificity, positive and negative predictive values are discussed. The authors conclude that it is preferable to reduce the overall number of lumbar spine examinations performed than to prejudice the detection rate of significant, albeit rare, abnormalities by restricting the number of films obtained.

Audit—the admission chest radiograph in a sickle cell crisis

Wai Lup Wong, P. D. Holder, A. B. Ayers and L. M. MacDonald
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A chest radiograph often forms part of the "diagnostic work-up" in a patient with a sickle cell crisis. This retrospective study assesses the diagnostic yield and suggests some guideline indications for chest radiography in this situation. We identified all patients admitted to St Thomas' Hospital with a sickle cell crisis who had a chest radiograph on admission, between 1 August 1989 and 31 July 1991. Of the 220 admissions, 30 (14%) were excluded because of incomplete records. The radiographs were divided into two groups. The first group were those with radiographic abnormalities which would have influenced the immediate clinical management. The other group consisted of normal chest radiographs and those with abnormalities associated

with sickle cell disease which would have had no immediate influence on clinical management. The results of both groups were analysed with respect to the clinical signs, symptoms and age of the patients. Our study indicates a chest radiograph is not essential in all patients admitted with a sickle cell crisis. It is only required in those with specific clinical signs. The possible savings in terms of radiation and finance with more selective chest radiography in these patients is discussed. Sickle cell patients have numerous radiological investigations during their lifetime so it is vital to reduce their unnecessary exposure to radiation.

Chest radiography for general practitioners: effects of request review on referral patterns

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In order to assess the value of chest radiography for general practitioners we prospectively reviewed 2017 chest radiographs over a 10 month period. A total of 1424 patients was referred to the chest clinic (requested unvetted) and 593 to the radiology department (formal consultative process). Referrals to the chest clinic were more likely to be inadequate with regard to history and physical examination (73% *vs.* 33%; $p < 0.005$) including smoking status. Patients referred to the chest clinic were more likely to have normal radiographs (66% *vs.* 53%; $p < 0.005$) and conversely were less likely to have clinically related abnormalities (21% *vs.* 26%; $p < 0.05$). Patients were more likely to be referred to the chest clinic for reassurance and for chronic airways disease and the radiology department was the more likely place of referral for rib fractures and for suspected primary or secondary cancer. Abnormalities were rare in the 10–29 year age group and when reassurance alone was sought. Patients presenting with haemoptysis or with symptoms of lower respiratory infection or of chronic airways disease often had abnormal examinations. Improved communications and the introduction of guidelines should promote the rational use of limited resources.

General practitioner access to radiology services

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Department of Diagnostic Radiology and Nuclear Medicine, Leeds General Infirmary, Leeds LS1 3EX, UK

In 1981 a joint working party of the Royal College of General Practitioners and the Royal College of Radiologists agreed that direct access to radiology services was essential to GPs. A postal survey was performed a decade later to assess this ideal, involving both the local medical committees of the British Medical Association and local faculties of the Royal College of General Practitioners. Plain radiographs were found to be generally available (95%+), but access to contrast examinations, ultrasound and mammography was often limited or poor, 81% and 47%, respectively having access to barium meals and enema, 53% to obstetric ultrasound, 48% to non-obstetric ultrasound and 21% to mammography. More positively, a number of respondents noted that where there was a good relationship between GPs and the radiology department limited access was open, following direct communication, to all investigations available including computed tomography and nuclear medicine. Despite the often limited access, approximately 75% described the service as either good or excellent. This was often unrelated to the number of investigations available and was more likely to be related to the quality of service provided. This was echoed spontaneously by quoting either long waiting lists for investigations or unreasonable delays in obtaining reports.

General practitioners' opinions on the role of barium meals and endoscopy

L. A. Webb, M. E. Finlay, M. J. Keir, P. D. Clarke, L. R. Gordon and J. P. Owen
Department of Radiology, University of Newcastle upon Tyne, Newcastle upon Tyne NE1 4LP, UK

A total of 676 was surveyed and 325 (48%) completed questionnaires were returned. Difficulty in swallowing was the only clinical reason for preferring barium studies. Endoscopy was clearly preferred in patients aged over 20 years, for GP reassurance, prolonged symptoms, previous similar episodes and previous gastric surgery. There were no such preferences for barium studies. GPs had a good understanding of the diagnostic capabilities of the techniques but some areas of poor appreciation were identified. GPs also understood the significance of most phrases in radiological reports but specific areas of poor understanding were discovered. Treatment and specialist referral preferences in response to radiological phrases were identified and phrases poorly understood highlighted. Only 3% of respondents knew the radiation dose of a barium meal.

Diagnostic yield of barium enema in a district general hospital

T. Y. K. Chan, *S. Said, *D. Ellis, I. Mootoosamy, P. E. Thurley, N. G. Reading, J. W. Frank and C. P. Cooper
*Department of Radiology and *Medical Audit Unit, Whipps Cross Hospital, Leytonstone, London E11, UK*

The diagnostic yield of inpatient and outpatient referrals for barium enema over a 5 month period was assessed with

reference to the specialities and presentations. There were 320 surgical (including 11 from urology and 10 gynaecology), 133 medical referrals and 47 from geriatrics. 28 cases had no diagnoses specified and were excluded from calculations. In those aged under 40 years, the overall positive yield was 31% (16/51). Only one cancer was detected. Of the remaining 15 positives, seven had inflammatory bowel disease. This contrasted greatly with the diagnostic pattern of the over 40s age groups in whom inflammatory bowel disease accounted for only five of the 266 positives. A large majority (208) had diverticular disease. There were 28 carcinomas and eight cases of polyps. The overall diagnostic yield for the over 40s was 63% (266/421). The diagnostic yield from surgical referrals was similar to that from medical ones, in both the outpatient and in-patient categories. Geriatric referrals had a higher yield mainly because of a proportionally higher detection of carcinomas. The proportion of diverticular disease was similar in all three referral groups. Change of bowel habits, diarrhoea, rectal bleeding and abdominal pain were the most frequent presenting complaints, although the presence of an abdominal mass gave the highest positive yield (carcinoma or diverticulitis). Clinical suspicion of diverticular disease was confirmed in 90% of cases but this was thought to be related to the high prevalence of the condition. In-patients had higher diagnostic yield in all three referrals groups, reflecting the frequently more serious conditions warranting admission. This study shows that the diagnostic yield for hospital referrals was as high as 60% (282/472) of which a great majority were uncomplicated diverticular disease. Inflammatory bowel disease was diagnosed in 12 patients who tended to be younger and who might benefit from flexible sigmoidoscopy before proceeding to barium enema if warranted. The high overall positive yield was likely to be due to a secondary screening process whereby general practioners' referrals were further assessed by hospital specialists who had easier access to other investigative tools including sigmoidoscopy, radiography and ultrasound (for abdominal mass), as well as cross-specialty consultation.

Audit of outpatient barium services; user friendly or friendly abuse?

J. G. Houston and N. McMillan
Department of Radiology, Western Infirmary, Glasgow G11 6NT, UK

Over 3000 patients attend the X-ray department of two city hospitals annually for outpatient barium examinations, accounting for 15–30% of radiologists' work. With this size of service and the particular demands of these examinations on patients, an audit of the appointment system and patients' attitudes to the service was undertaken. 100 patients, 50 from each centre were asked to fill out questionnaires before and after their outpatient examination, and the delays in the appointment system were quantified. The average age was 51 years (range 18–83 years), 61 females, 49 males, equally referred by GPs and outpatient clinics. 40% of patients arrived late for their appointment; delays in public transport and insufficient parking were possible causes. 60% are taken within 15 min of their appointment. The level of information about examination that patients receive was thought too low. 60% were not told by the referring clinician what the procedure involved, 5% did not know what examination they had come for, 14% thought the preparation inadequately explained, 50% thought the examination better than expected, indicating unnecessary anxiety which might be allayed by further information while waiting for the procedure. 96% thought staff very helpful and 98% were overall satisfied with the service.

Audit on the management of patients for barium enema

T. Y. K. Chan, *S. Said, *D. Ellis, I. Mootoosamy, P. E. Thurley, N. G. Reading, J. W. Frank and C. P. Cooper
*Department of Radiology and *Medical Audit Unit, Whipps Cross Hospital, London E11, UK*

A 5 month prospective study of 500 consecutive hospital in-patients and outpatients referred for barium enema was analysed with respect to the preparation for, and the management at the time of, the investigation. All patients had colonic continuity (*i.e.* excluding colostomy enema). There were 320 surgical (299 general surgery, 11 urology, 10 gynaecology), 133 medical and 47 geriatric referrals. The female to male ratio was about 3 to 2. 60% in-patient requests were undertaken within 1 week. Some 16%, however, did not have the enema until more than 3 weeks after. Concomitant medical conditions that precluded necessary preparation, and early discharge with the enema being done as an outpatient procedure accounted for most of the delays. Only 11% outpatient appointments were performed within 1 week. 36% took 1–3 weeks and 53% longer than 3 weeks. The average delay from appointment time to the enema examination was less than 30 min in 62%. Two-thirds of those who had to wait longer suffered because of "departmental reasons". The screening and total examination times were both appreciably longer with the geriatric patients. This was probably due to their general frailty, which was subjectively but independently assessed by the radiologists and the nurses, the latter often having a lower score for these patients' fitness. Their frailty was also reflected in a high number of unsatisfactory preparation

(29%) and of incontinence (36%), leading to incomplete (35%) and undiagnostic (24%) examinations. Balloon catheters were used in 13% of all patients, but mainly in the elderly. 9% of all patients were distressed. 8% had defaulted previous enema appointments and 12% used ambulance transport, a large majority of these categories being over 70 years old (94% and 73%, respectively). The clinical relevance of the request, and the adequacy of clinical information given were deemed satisfactory in 85% and 79%, respectively. Only in 49% were the performance and/or findings of sigmoidoscopy specified. This study shows that better organization may be required, especially to reduce the delays in both the request–appointment and appointment–examination times, and that geriatric patients would need extra help to make barium enema a worthwhile diagnostic test.

Notes

9.00 – 10.15

Hepatobiliary and Pancreatic Imaging

Hall 11b

Imaging complications of liver transplantation

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Orthotopic liver transplantation involves the creation of venacaval, portal venous, hepatic artery and biliary anastomoses. A wide variety of complications may arise in liver transplant patients. These include vascular, biliary and general complications as well as rejection or infections related to the necessary immunosuppression. Ultrasound with Doppler is the primary imaging method for the liver and associated structures. Angiography and venography may be required for direct visualization of the vasculature. Cholangiography may be performed via the T-tube or by PTC or ERCP. Computed tomography scanning is also helpful in some clinical situations. The role of magnetic resonance imaging has yet to be fully developed. The use of these imaging modalities in relation to the more common complications will be discussed.

Radiological evaluation of pancreatic allografts

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Pancreatic transplantation is an acceptable treatment method for certain groups of diabetic patients, notably those who already require immunosuppression for renal allografts. In some centres, 70% of pancreas transplant patients are now insulin independent long term. As well as the well-recognized complications of immunosuppression, patients with pancreatic transplants have graft-related complications including rejection, exocrine leakage, vascular thrombosis, pancreatitis and sepsis. We have reviewed the role of radiology in the management of the last 12 pancreatic transplants. The value of contrast studies, angiography, ultrasound including Doppler, radioisotope scans, computed tomography and magnetic resonance imaging in the management of these patients is presented.

Scintigraphic differentiation of surgical jaundice from medical jaundice of viral/schistosomal origin

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**Department of Diagnostic Radiology, Ain Shams University Specialized Hospital, El-Khalifa El-Maamoun Street, Abbassia, Cairo, Egypt, †Department of Nuclear Medicine, King's College Hospital, London, UK*

The hepatic index (HI) derived from $^{99m}Tc^{m}$ IDA scanning and defined as the net liver to heart ratio, 2.5–10 min after injection, was evaluated in 33 cases with biopsy-proven hepatocellular disease and jaundice (G1), 14 patients with obstructive jaundice (G2), and 28 controls. The hepatocellular disease of G1 was due to hepatitis B infection and/or *Schistosomiasis mansoni*. The causes of biliary obstruction in G2 were biliary atresia, stone/stricture, carcinoma of pancreatic head or cholangiocarcinoma. They were verified by biopsy, on surgery or by ERCP. The 28 controls were divided into 18 matching the age and sex of 18 patients of G1 and 10 similarly matching 10 cases of G2. The HI was 3.16 ± 1.93 and 1.89 ± 1.45 (mean ± 1 standard deviation (SD) in G1 and G2, respectively, with significant difference ($p < 0.05$)). Each of G1 and G2 also differed significantly from the corresponding controls ($p < 0.01$). None of the patients of G2 had shown a HI more than 5. It is concluded that the hepatic index is a simple and useful test in excluding biliary obstruction. However, owing to the overlap of ranges, it has only a potential value in differentiating obstructive from hepato-cellular jaundice.

Ultrasound assessment of the normal and obstructed Roux Loop following surgical biliary diversion

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Curative and palliative surgical treatment of pancreatic and biliary tumours and other procedures including liver trans-

plantation involve creation of a bile duct to small bowel Roux Loop anastomosis. Ultrasound is a well-established modality for the examination of the biliary tree. It is the first-line method for post-operative imaging of these patients. We describe the appearances in three cases of recurrent obstructive jaundice due to obstruction within the Roux Loop or more distally. The cause of the obstruction was demonstrated by ultrasound in all cases. This provided useful information for further management of the patients. For comparison purposes the ultrasound appearance of the unobstructed Roux Loop will also be demonstrated.

The role of pre-operative intravenous cholangiography in patients undergoing laparoscopic cholecystectomy

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Laparoscopic cholecystectomy for gallstone disease is rapidly gaining in popularity amongst surgeons and patients. Its morbidity in experienced hands is almost as low as that of conventional cholecystectomy, and the small incisions required lead to fast recovery and improved cosmetic results. There has been much contention recently, however, as to which pre-operative investigations are required to exclude the presence of common bile duct calculi. In our hospital, the surgeons require routine intravenous cholangiography (IVC) on every patient considered for laparoscopic cholecystectomy, while in many other centres surgeons are content with a normal biliary tree ultrasound and liver function tests often combined with a peroperative cholangiogram. Our paper reviews 100 patients on whom IVCs were performed prior to laparoscopic cholecystectomy. We analyse liver function tests and ultrasound findings and review the IVCs evaluating the usefulness of this investigation. The IVC had previously become almost obsolete and its resurgence would have obvious implications. We therefore consider the implications of its routine use in terms of radiological practice, cost and patient morbidity and mortality, and discuss alternative pre-operative and peroperative assessment protocols.

Antegrade cholecystography following percutaneous cholecystostomy for acute cholecystitis

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The diagnostic value of antegrade cholecystography in a consecutive series of 44 patients with scintigraphically confirmed acute cholecystitis, treated by percutaneous cholecystostomy, has been evaluated. Six patients did not have antegrade cholecystography due to either catheter migration or gangrenous gallbladder perforation. Antegrade cholecystography was performed in the remaining 38 patients in two separate clinical settings; firstly, in patients suspected on clinical grounds of having persisting cystic duct obstruction, and, secondly, in patients in whom return of bile drainage suggested spontaneous reopening of the cystic duct. In the clinically persisting cystic duct obstruction group, antegrade cholecystography showed the cause of obstruction to be impacted calculi in either the gallbladder neck or in the cystic duct, in all patients. In the clinically patent cystic duct group, antegrade cholecystography confirmed cystic duct patency in all patients, with good demonstration of the biliary tract in most patients. Nine patients from a total of 23 patients with acute calculous cholecystitis in this group had associated common duct calculi; in three patients with non-dilated common ducts. This latter finding suggests that small calculi may pass from the cystic duct into the extrahepatic bile ducts during an episode of acute calculous cholecystitis.

Gallstone recurrence following percutaneous cholecystolithotomy

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Using radiologic interventional techniques the gallbladder can be cleared of stones with a high success rate. As with any treatment option that leaves the gallbladder *in situ*, there is an accompanying risk of stone recurrence, which is currently unknown for the radiological method. A total of 98 patients was studied prospectively to determine the recurrence rate of stones and clinical outcome following successful percutaneous cholecystolithotomy (PCCL). Follow-up included clinical assessment and ultrasound examination at 3, 6 and 12 months followed by annual intervals. The overall recurrence rate was 27% at a mean follow-up of 17 months (range, 3–36 months). By actuarial life-table analysis, the cumulative proportion of gallstone recurrence was 10.3, 21.1, 32.0 and 29.1% at 6, 12, 24 and 36 months, respectively. Of the 27 patients with recurrent stones, 16 remain asymptomatic, four have experienced biliary colic, three abdominal pain, three non-specific upper gastrointestinal (GI) symptoms and one jaundice secondary to a common duct stone. Two patients have subsequently undergone cholecystectomy. 11 of the stone-free patients have remained symptomatic; seven with abdominal pain and four with non-specific upper GI symptoms. This data indicates that stone recurrence following successful PCCL

occurs in the minority, and is usually asymptomatic. Despite the advent of laparoscopic cholecystectomy there remains a role for PCCL in selected patients.

CT assessment of gallstones; correlation with physicochemical properties

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Computed tomography (CT) appears to be the modality with the best potential to classify gallstones. However, attempts to correlate CT with chemical composition have not always been successful. We have determined physical attributes (mass, weight and density) of 29 gallstones, which were then CT scanned. Morphology, mean attenuation and where appropriate, regional attenuation were determined. After fragmentation the stones were biochemically analysed for calcium, cholesterol and bilirubin content. All stones were visualized, at least in part with CT; none was completely isodense with saline. A mean CT density of < 0 Hounsfield units (HU) predicts the stone is morphologically rimmed ($p < 0.01 - \chi^2$). The majority of rimmed stones had a density < 1 g/cm^3. All non-rimmed stones had densities > 1 g/cm^3 and > 0 HU. Cross-correlation data with the biochemical analysis will be presented, along with the ease of fragmentation (performed in a standardized way using a holmium–YAG laser) of the different gallstones. It appears that physical, rather than chemical attributes, may be more important in determining the response to some of the newer non-surgical gallstone therapies.

Intravenous cholangiography — is there life after death?

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The advent of laparoscopic cholecystectomy has seen the re-introduction of the intravenous cholangiogram as a method of imaging the extrahepatic biliary tree prior to surgery. We are in the process of reviewing the intravenous cholangiograms carried out on patients awaiting surgery for gallbladder disease (80 patients to date). The aims of the study are to assess the usefulness of the intravenous cholangiogram in detecting stones in the common bile duct, and hence assessing the radiographic and diagnostic quality of the examination. Comparisons with other imaging modalities of the biliary tree are made where available. Surgical management on the basis of the intravenous cholangiogram is discussed (including endoscopic retrograde cholangiography/sphincterotomy and laparoscopic cholecystectomy), along with outcome and follow-up over a period. Side-effects of the examination are also discussed.

Notes

10.45 – 12.00

Trauma

Hall 9

The advancement of trauma radiology

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Over the past decade, diagnostic imaging has become an increasingly important and integral part of the management of the traumatized and critically ill patients. In particular, the increasing application of cross-sectional imaging methods such as computed tomography and magnetic resonance has produced a revolution in the speed of the diagnostic process. Newer imaging procedures have naturally been compared with more traditional methods of physical diagnosis, which has spawned controversy about the safest, most accurate and most cost-effective diagnostic approaches to be used. This review examines the assessment of the critically injured patient both from the perspective of plain film analysis, as well as the more modern approaches using cross-sectional and even three-dimensional imaging techniques. The implications of the newer high-speed techniques will also be discussed.

Usefulness of three-dimensional computed tomography in cranio-facial traumatology

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Imaging of cranio-facial traumatology has to define accurately the bone structures involved in the trauma and the associated soft tissue lesions, especially in the orbital cavity. Moreover, it has to offer all the details necessary to the surgeon to plan a reconstruction that is very often difficult for the complex anatomy of this region. 50 patients with cranio-facial fractures (10 cases of the nasofrontal-ethmoid region, 32 cases of the orbit-malar region, eight cases with complex lesions) were evaluated with conventional radiology, and two-dimensional (2D) and three-dimensional (3D) computed tomography (CT). The axial CT and the 2D reconstructions allowed us to define precisely lesions of the endocavitary orbita in seven cases not detected by conventional radiography. The 3D reconstructions modified the surgical plan in 20 cases. The axial CT and 2D and 3D reconstructions represent indispensable procedures in the evaluation of the major trauma in the cranio-facial region, often modifying both the diagnosis and the therapeutic approach when these were only evaluated on conventional radiology.

Instant MRI diagnosis and exclusion of occult femoral neck fractures

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Whilst the majority of femoral neck fractures are readily diagnosed by clinical evaluation and plain radiography, a minority have normal radiographs but are unable to bear weight. ^{99}Tc MDP bone scanning is recognized as a sensitive method of fracture detection, but it is time consuming and may be non-specific. In an attempt to facilitate early diagnosis of occult femoral neck fractures magnetic resonance imaging (MRI) (0.5 T) was utilized in 11 consecutive patients with normal radiographs and positive clinical findings. T_1-weighted spin-echo (SE) coronal images were obtained in all patients — a 5 min sequence. All patients subsequently had a radionuclide bone scan. Where MRI and bone scan showed no femoral neck fracture, the patient was mobilized and plain films obtained at 6 weeks. On MRI, five patients had femoral neck fractures. One patient had a normal MRI and bone scan. In addition, MRI differentiated a fracture of the greater trochanter from an intertrochanteric fracture when the bone scan was non-specific, demonstrated avascular necrosis where the bone scan showed non-specific uptake, demonstrated fractures of the sacrum and/or pubic rami in three patients all of which explained their symptoms and did not require surgical

intervention. No patient with a normal femoral neck on MRI was subsequently shown to have a fracture. MRI where available can quickly and accurately diagnose and exclude occult femoral neck fractures and should be the investigation of choice when plain radiography is negative.

MR imaging in vertebra compression fractures

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The present study assesses the ability of magnetic resonance (MR) imaging to identify the pathological basis of vertebral compression fractures correctly. The MR examinations of 65 patients with wedge compression fractures of the spine were reviewed. 35 were secondary to trauma or osteopenia, 20 to neoplasm and five to infection. In fractures of less than 3 weeks, a half showed increased signal in the vertebral body on T_2-weighted sequences and the short tau inversion recovery (STIR) sequence with a reduced signal on T_1-weighted sequences and these appearances presumably represent oedema/haemorrhage in the marrow cavity. A similar pattern is seen in neoplasm and it is frequently associated with multifocal disease, destruction of the posterior elements and extradural spread of tumour. In old fractures and osteopenia the signal returned from the vertebral body is the same as that from normal marrow on all pulse sequences. In pyogenic osteomyelitis a high signal in the whole of the disc space on T_2-weighted sequences and the STIR sequence and a low signal on T_1-weighted sequences accompanied similar signal intensities in the marrow space. Evidence of extension of pathological changes into the paravertebral soft tissues and extradural space were also seen. The appearances in tuberculosis, however, can closely mimic those of neoplasm. We conclude that the distinction by MR imaging between vertebral body compression fractures secondary to trauma, infection, osteopenia and neoplasm requires attention to detail and is not as straightforward as some authors have suggested.

Is unilateral facet dislocation of the cervical spine a stable injury?

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Unilateral facet dislocation (UFD) of the cervical spine following a flexion/rotation injury is reported and classified as a stable injury. A retrospective analysis of 28 patients with typical radiological criteria of UFD admitted to the Midlands Centre for Spinal Injuries over a 6 year period was undertaken to assses the natural history of this injury. The plain radiographs obtained on admission, during closed reduction with skull traction, and on follow-up were analysed. In addition, 23 patients also had computed tomography (CT) assessment while four patients had magnetic resonance imaging scans available. Criteria of instability were seen on the initial plain films with wide interspinous distance or facet joints (43%), anterior listhesis > 3.5 mm (40%), and a narrowed or widened intervertebral disc (48%). Subluxation of the contralateral facet joint was seen in 65%, and posterior neural arch fractures in 45% of cases. Radiographic assessment during traction/reduction in 23 patients revealed abnormal widening of the intervertebral disc, interlaminar and interspinous spaces at the injured level in 48%. Of these, follow-up radiographs showed that virtually all proved unstable after reduction, requiring surgical fusion. There was no deterioration in the neurological status following reduction or surgery. UFD should not be regarded a diagnostic entity, but a "radiographic status" of the post-traumatized spine with a high incidence of extensive soft tissue damage. Interlocking of the facets provides stability to the injured level which is removed during and following traction/reduction rendering the injured level unstable in 48% of instances.

Missed fractures in children from an accident service department

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Fractures in children are often difficult to diagnose in view of the variable appearances of the development and fusion of the epiphyses. Many studies have looked at the incidence of missed injuries in accident service departments, but not specifically documented the fractures most commonly missed in children. A study was undertaken to identify the most commonly missed injuries in the accident service department over a 6 month period. From 25 798 attendances, 16 246 X-ray examinations were performed. There were 57 fractures missed and 18 suspected in children under the age of 16 years. The most common sites for missed fractures in children are the fingers (26%), elbow (21%), distal radius (12%) and metacarpals (11%). Of the 18 suspected fractures (*e.g.* owing to elbow effusions or opaque maxillary antra, where no definite fracture could be visualized), seven (39%) were in the elbow and five (28%) were of the skull or face. Improved training of the casualty officers on the distal arm is required with particular reference to the importance of fat pad signs and subtle angula-

tion of the cortex. The metaphysis at the base of the proximal phalanges of the fingers warrants special attention.

Analysis of lateral cervical spine X ray in the assessment of 134 consecutive multiply injured trauma patients from the Helicopter Emergency Service

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During the first year of the Helicopter Emergency Service (HEMS) at The Royal London Hospital, 134 patients were admitted. All patients were clinically evaluated initially. Routine X rays of the lateral cervical spine, antero-posterior (AP) chest X ray, and AP pelvis were then performed. The quality of the cervical spine films was assessed for completeness of anatomical demonstration and the presence of bony and soft tissue abnormality. 12 patients (11%) required further assessment with computed tomographic cervical spine views. Other imaging modalities such as "swimmers" were monitored. A prospective study was commenced for patients where an initial lateral cervical spine view failed to demonstrate C7/T1. These patients were randomized to either a further attempt at a lateral or a swimmers view. Radiographic factors, time to obtain X rays and diagnostic information were assessed and results will be presented. The principal findings suggest that the lateral cervical spine alone is necessary in initial assessment and a guide to further imaging management.

The value of radiograph audit in an accident service department

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A study was undertaken to assess the numbers and outcome of patients whose initial trauma radiographs had been misinterpreted by the casualty officer when reported by a radiologist and establish the most common errors to improve performance and teaching. In our accident service department all trauma radiographs are reported acutely and those misinterpreted by the casualty officers presented at the daily clinico-radiological conference. Reviewing the 25 798 patients attending the accident service over a 6 month period, 16 246 radiographs were requested and reported. Of these 456 (2.8%) were considered to have been potentially misinterpreted. The errors included 167 (1%) missed fractures, 55 (0.3%) suspected fractures and 72 (0.45) false positive diagnoses of fracture. Subsequently 114 (0.7%) patients required recall for treatment or further imaging. Incorrect diagnoses were seen most frequently in the more commonly injured anatomical sites — the ankle, wrist, foot, elbow and hand. However, the incidence of misinterpretation was highest in examination of the fingers, especially in children. We believe these low figures are principally the result of involving orthopaedic surgeons and radiologists at the formal daily conference. We regard our system of audit as beneficial to patients' care and anticipate reduced litigation which may offset the increased cost of audit.

Computed tomography in blunt abdominal trauma: how helpful for management?

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The computed tomography (CT) findings in 92 patients who had suffered blunt abdominal trauma have been correlated with the surgical findings and/or clinical follow-up. In 16 patients surgery followed CT within 24 h; in 10 there was good correlation between CT and operative findings. However, CT failed to detect significant injury in five patients and was falsely positive in another. 67 haemodynamically stable patients were initially managed conservatively in the light of the CT results. 52 of these patients had CT evidence of intraabdominal trauma: 46 were managed conservatively throughout; six underwent subsequent (> 24 h) surgery with good concordance with the CT findings (apart from one missed renal injury). There were three deaths amongst these 52 patients, including one where an injury missed by CT was contributory. The 15 patients with normal CT examinations were all successfully managed conservatively (apart from one late unrelated laparotomy). In nine patients the first CT study followed emergency surgery. CT provided a useful baseline for further management and assessed complications, even though CT failed to demonstrate two small hepatic lacerations seen at previous surgery. Active non-operative management of blunt abdominal trauma is now widely advocated; this report shows how CT can support this policy of surgical restraint.

10.45 – 12.00

Breast Oncology

Hall 10a

Planning radiotherapy treatment for breast cancer

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Most current techniques are based on fixed tangential fields to the breast using cobalt gamma rays or 4–6 MeV X rays. Despite the use of wedges as simple tissue compensators, 20% variation in minimum and maximum doses is common, arising to a large extent from longitudinal contour changes and lung attenuation. Systematic and random errors introduced during planning or radiotherapy, *e.g.* from patient movement, will add to this variation although the magnitude is likely to be less than 5%. 20% variation in dose per fraction is expected to have a detectable impact on cosmesis, although it is not clear how important this is relative to other factors such as genetic susceptibility and electron boost. Field placement errors will be reduced in future by on-line megavoltage imaging using beam's eye view devices. The multileaf collimator will also be introduced over the next few years. It can be used as a customized compensator, using the megavoltage imaging system as a source of data for calculating compensator thickness. If these improvements are to be introduced, it will be important to evaluate them in the context of randomized trials, with breast cosmesis as an endpoint. Finally, the matching of an anterior field to the axilla/supraclavicular fossa is best achieved with half-beam blocks. This uses the upper half-beam for the anterior field and the lower half-beam for tangential fields, with a single isocentre located on the field junction in the infraclavicular fossa.

Patterns of axillary lymph node metastasis in breast cancer

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The patterns of axillary lymph node involvement are analysed in a review of 377 cases of T1–4 breast cancers. Clinical judgment of the axillary status proves wrong in approximately one-third of the cases. A strong correlation ($p < 0.01$) between the number of nodes involved, tumour size and blood vessel invasion is found. Other histological or clinical features of the primary (lymphatic invasion, degree of differentiation, presence of necrotic areas) are related to a lesser degree ($p < 0.05$), while others (age, site) are not at all significant. The more nodes resected, the more positives are seen. This is true as well concerning the simple distinction between negative and positive nodes ($p = 0.009$), and the number of nodes involved ($p = 0.003$). Skip metastases above level 1 and 2 are seen in 2% of the cases. A clear influence of the number of invaded nodes on survival can be demonstrated. Level of involvement (level 1 alone *vs.* all others involved except level 1) results in a 5 year survival of 86% *vs.* 76% and a 10 year survival of 84% *vs.* 19% ($p = 0.05$). These findings are discussed, especially concerning the technique, prognostic significance and therapeutic usefulness of axillary dissection.

Which imaging modality should be used in assessing response to treatment in breast cancer patients?

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The aim of this study was to assess the place of clinical examination, mammography and real-time ultrasound in the assessment of tumour size and to establish which technique could predict response to chemotherapy and final outcome at an early stage in the planned treatment. A cohort of women with T2–T4 breast cancer was given the tumour protein synthesis stimulator L-arginine prior to 4 cycles of CHOP chemotherapy followed by radiotherapy. We have undertaken detailed imaging using real-time ultrasound and mammography prior to each treatment cycle in an attempt to document tumour response. Correlation was made with clinical findings, fine-needle aspiration cytology and histological findings, all patients proceeding to either mastectomy or excision biopsy. 16 patients (18 tumours)

with breast cancer have completed the regime. The overall clinical response rate was 39% complete response (CR) and 61% partial response (PR). This compares with a mammographic response of 33.3% CR and 27.8% PR and an ultrasound response of 27.8% CR and 44% PR. Ultrasound or mammography confirmed complete response where this was present clinically. Pathological correlation was made with the final ultrasound and mammographic appearances. An imaging protocol is discussed in patients undergoing extended treatment prior to surgery with the inherent pitfalls and drawbacks of the various imaging methods highlighted.

Imaging of local recurrence of breast carcinoma

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Because of the increasing incidence of breast carcinoma and the increasing proportion of early-state carcinomas with low mortality found by clinical or screening mammography, the prevalence of breast carcinoma in Finland is estimated to increase by more than 2.5-fold in 2006 compared with 1983. Breast-conserving operations have also increased as breast carcinoma is more often diagnosed at an early stage. A local recurrence after partial breast resection has a good prognosis. It has become a great challenge for both oncologists and radiologists to diagnose local recurrence at a curable stage. In order to evaluate the imaging methods in the diagnosis of the local recurrences of breast carcinoma, we studied all the operated carcinoma cases with the post-operative imaging follow-up sent from the Department of Oncology to the mammographic unit of the Department of Diagnostic Radiology during 1989–1991. This material consists of 89 patients (by the end of October 1991) with breast carcinoma treated with partial or total mastectomy, with or without radiotherapy. The breast operated or the scar after mastectomy and axilla were examined clinically and by imaging methods (mammography and/or ultrasound), and the findings were confirmed by fine-needle aspiration biopsy, histological examination, or clinical and radiological follow-up. The results of this study concerning the sensitivity and accuracy of each of these methods will be presented.

High dose-rate breast implants

C. G. Rowland
FORCE Cancer Centre, Exeter, UK

The dose-rate effect is low for tumour control but high for normal tissue. The critical organ in the breast is skin (rarely involved with tumour in the earlier presentation seen these days) and great effort must be made to reduce the dose as low as possible when working at high dose rate (HDR). The use of a rigid applicator/needle system allows reduction of the skin dose to about 10% of the tumour dose. Also the breast is compressed allowing treatment of a volume approximating a surgical quadrantectomy. In breast cancer, demolitive treatment of the primary complex appears to have little influence on survival and thus the issue is one of cosmesis and local control. Our aim should be to achieve minimal effective treatment and avoidance of overtreatment with its associated side-effects. The data presented suggests that HDR implants used as a boost or primary treatment allow excellent cosmesis with satisfactory local control. Breast conserving procedures have higher rates of local recurrence but approximately 50% of these can be salvaged by further surgery or radiation therapy (if only local treatment has been given) thus achieving results comparable with radical mastectomy. Many women, if fully and honestly informed, may opt for this more pragmatic approach.

Breast conservative therapy: preliminary report with HDR afterloading iridium–192 implants

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Conservative breast cancer therapy is a rapidly developing technique. It is as efficacious as mastectomy. In March 1990, we started using the high dose rate (HDR) afterloading technique for ^{192}Ir implants in combination with surgery and external beam radiation. 20 patients with T1–T3 tumour, after tumour excision and radical axillary dissection, received an external dose of 45–50 Gy to the whole breast using megavoltage X rays or ^{60}Co gamma ray in conventional fraction. An additional dose of 20 Gy to the tumour bed was delivered by interstitial irradiation with HDR ^{192}Ir afterloading unit according to the Paris system. Preliminary results are satisfactory. The patients feel well themselves. Puncture biopsies to tumour bed were performed 3 months after the therapy and no cancer cells could be found. The results will be discussed.

Breast cancer and thyroid dysfunction — risk and influence on the prognosis

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A group of women who have previously undergone surgery of the thyroid, and who subsequently present with breast

cancer, are the subject of this study. These patients were treated with surgery, radiotherapy and tamoxifen in a multi-modality approach to their breast cancer. The study has documented the course of both the thyroid disease and the breast cancer and tried to analyse the effect of thyroid hormone status on outcome from breast cancer. A mechanism whereby deficiency, or excess, of thyroid hormones may alter the metabolism of sex steroids and prolactin has been proposed. The interaction of these pathways with tamoxifen is also addressed.

Notes

10.45 – 12.00

Developments of Products for Radiology

Hall 11a

Non-ionic contrast media — the golden idea that was hard to sell

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It was the pain during peripheral angiographies that got the young Swedish radiologist Torsten Almén to think about ways to reduce contrast media osmolality and led to his proposal to develop non-ionic contrast media. The contrast medium companies were, however, not interested in this idea before he met Dr Hugo Holtermann from Nycomed. The first result was Amipaque® (metrizamide). Most of the pharmaceutical companies working with X ray contrast media are now supplying non-ionic contrast media. Today this group of products has taken over a major part of the use of contrast media because of their lower toxicity, improved safety and less discomfort than ionic contrast media. The different stages from the ideas of Dr Almén to the present situation will be presented and discussed.

Development of new X-ray films: experience and opportunity

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The objective of this presentation is to gain radiologists' understanding and active support of the crucial role they have in new product development. The European Du Pont diagnostic imaging organization uses ISO 9001 methodology in product development and has received corresponding official certification from the German affiliate of ISO, the International Standards Organisation, in January 1991, as the first X-ray film manufacturer in the world. The Du Pont methodology includes a tool called Quality Function Deployment (QFD) for identifying and specifying radiologists' needs, converting their needs into product design requirements and following a disciplined path towards product robustness in manufacturing. Experiences gained in a recent development of a high-resolution blue-sensitive "full speed" screen film — Cronex* 4 Improved — are described to highlight both the strong benefits, as well as some limitations of QFD. It is concluded that successful product development requires a delicate balance of "widely" creative thinking supported by related scouting research, and of meticulously following a methodology with well-defined phases, the methodology itself being continuously improved based on experiences gained.

10.45 – 12.00

Radiobiology Day: Session I

In memory of Dr N. McNally

Hall 11b

Theoretical and experimental aspects of fractionation

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The study of fractionation has developed from the need to understand the scientific basis of clinical radiotherapy. It is therefore a broad subject with a long history; however, the most important advances have taken place during the past 20 years as a result of the development of endpoints for normal tissue damage in laboratory studies. An emphasis on normal tissue as well as tumour radiobiology results directly from the concern of radiotherapists to treat cancer by the maximum dose possible that will not cause irreversible long-term damage to normal tissues in the radiation field. From this research it has emerged that the relationship between the total tissue-tolerance dose and the dose per fraction is different for tissues which react acutely after radiotherapy (*e.g.* skin, gut, mucosa and marrow), and the late-reacting tissues (*e.g.* lung, spinal cord and kidney). Tumours behave like acutely responding tissues. The conclusion is that use of lower doses per fraction (< 2 Gy) is therapeutically beneficial because it spares critical late normal tissue damage more than damage to tumours. However, this approach (hyperfractionation) is really only clinically viable if doses are given more than once per day. It is then important to know what interfraction interval should be used. Halftimes of repair of sublethal damage in tissues are generally between 0.5 and 2 h so that intervals of > 6 h should allow most repair to occur. Intervals less than 6 h should definitely not be used and clinical disasters have occurred in such trials, with excessive late tissue damage. However, in some tissues, notably the spinal cord, repair is more complicated with a "slow" component acting out to 24 h. In these cases extreme caution is needed when giving multiple doses per day and biological treatment planning based on the modern linear-quadratic and incomplete repair models should be used to check that tissue tolerance is not exceeded. Multiple doses per day are also given to reduce the overall treatment time. This approach (accelerated fractionation) has emerged from the study of tumour cell kinetics which has shown that significant cell proliferation during a treatment course can substantially offset the effect of radiotherapy. However, the extent of this proliferation varies between patients and so methods are being developed to assess tumour cell proliferation in each patient before therapy. The balancing of overall treatment time, number of fractions and interfraction interval to maximize the effect of therapy for each patient, is currently a challenge to both radiobiologists and radiotherapists.

Effects of repopulation of an HDR-, MDR- and LDR-radiotherapy on epidermoidal cervix carcinoma cells (Ca-Ski Cells) and primary human keratinocytes (HPK-cells)

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We carried out experiments on epidermoidal cervix carcinoma cells (Ca-Ski cells) and primary human keratinocytes (HPK-cells) obtained after transfection with human papillomavirus type 16 DNA, varying the dose rate (28–8000 cGy/h), the doses (1–100 Gy) and the fractioning (protracted, 3, 6 and 12 fractions) to verify the effects of repopulation. Overall, we made 50 000 measurements. Our conclusions are: (1) At dose rates of 75 cGy/h (Ca-Ski cells) and 110 cGy/h (HPK-cells) respectively, we found that the cells "fall asleep" at doses up to 100 Gy; the rate of cell mortality is insignificantly higher than the proliferation rate. (2) A first-time proof of an accumulation of repopulation effects (recovery from the sublethal radiation damage, progression of the cells during the partial cycle/proliferation and the acts of redistribution), if the radiation exposure reaches the median time of the cell cycle (HPK-cells, dose rate: 110 cGy/h, doses: 1–100 Gy). (3) At dose rates higher than 300 cGy/h (range of a percutaneous radiotherapy), we found that the survival rates of the cells could only be increased insignificantly in spite of a fractionated therapy (3, 6 or 12 fractions; doses: 1–100 Gy); the repopu-

lation effects almost vanished. The results will be discussed with regard to the clinical relevance.

Tumour-dependent changes in the metabolic steady-state of CaNT tumours

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T_1 (spin lattice) and T_2 (spin spin) relaxation times were determined at 0.5 T for CaNT tumours in CBA mice. Tumours of different sizes were studied. The variation in the activities of hexokinase (HK), lactate dehydrogenase (LDH) and ATP concentration with tumour volume were also measured under normoxic conditions. The tumours were maintained by serial passage by the inoculation of 0.1 ml of a tumour cell suspension in McCoy's 5A medium and containing approximately 2×10^6 cells, subcutaneously into the sternal area of the mice. Tumours were assumed to be spherical and their volumes calculated by measurement in three perpendicular directions with a Vernier calipers. The T_1 and T_2 values, determined from regions of interest which excluded normal tissue, can reflect degrees of heterogeneity of tumour tissue and molecular levels of organization. A decreasing trend of both T_1 and T_2 values with tumour size was seen. Changes in the levels of the compounds with increasing tumour volume indicate energy deprivation associated with the degree of hypoxia in the tumour. Hypoxia, a typical solid tumour feature, is rare in normal tissue and arises from solid tumour blood vessels being more disorganized than those of normal tissue. Depletion of O_2 and other nutrients therefore occurs and in larger tumours circulation may cease in whole sections. Cells furthest from capillaries are hypoxic and anoxic. Hence averaged T_1 and T_2 can reflect the fraction of hypoxic and anoxic tissue. These values are also influenced by the tumour growth rate and ratio of free and bound water in the tissue. So this study may allow for better understanding of the degree of tumour hypoxia and hence radioresistance, with practical consequences for more effective radiotherapy.

Chemical protection of normal rodent tissue by exogenous ATP after neutron irradiation

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This work is concerned with the radioprotective role of ATP to reduce radiation damage to normal tissue. Male BALB/c mice aged from 6 to 8 weeks, were used for all the experiments. To obtain survival data after a lethal dose of neutron irradiation, they were divided into two groups. Group 1 received a dose of 6 Gy of neutrons only. Group 2 was treated with exogenous ATP prior to receiving the same dose of neutrons. The effect of exogenous ATP to protect the mice against neutron beam exposure was examined by using survival for 30 days post-irradiation as the end-point. The irradiation was carried out at the NAC cyclotron, Faure, using neutrons of the radiotherapy beam, produced by the reaction p(66 MeV)/Be. At selected times after 6 Gy neutron irradiation, the mice were killed for determination of the activities of acid phosphatase, hexokinase, glucose-6-phosphatase dehydrogenase (G6P-DH) and lactate dehydrogenase (LDH) in the testes. Exogenous ATP was administered by slow intraperitoneal injection of aqueous solution at 700 mg/kg body weight, 20 min before irradiation to study mice survival and the glycolytic enzymes post-irradiation. The dose modification factor in the activity of acid phosphatase as a feature of cell injury was determined by using the following ATP concentrations: 8, 25, 80, 250 and 700 mg/kg body weight. Survival of the mice, using 30 days post-irradiation as the end-point, was increased from 40% to 85% by action of the exogenous ATP. Furthermore, ATP's glucoregulatory effects, which modify basal physiological regulatory processes were studied in the testes and caused significant augmentation in the activities of the glycolytic enzymes HK, G6P-DH and LDH when compared with neutron radiation alone. Finally ATP reduced the activity of testicular acid phosphatase. The response of the activity of the enzyme acts as an indicator of lytic processes in the tissues damaged. These radioprotection actions in BALB/c mice reflect an adaptive defence mechanism to maintain homeostasis in response to the radiation injury.

The interaction of radiation and cisplatin in a transplantable hepatocarcinoma

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The L10 hepatocarcinoma in the guinea pig is a slow growing tumour with a T_{pot} of 43 h, which was transplanted into the flank of the animal from an ascitic form. Tumour growth delay curves were produced for cisplatin alone and radiation alone. The interaction of radiation and cisplatin was investigated using a clinically relevant dose (3 Gy X rays). Radiation was administered to the tumour locally using 250 kVp X rays; cisplatin (2.5 mg/kg or 5 mg/kg) was injected intraperitoneally either immediately preceding or 6 h following the radiation. Tumour growth delay was assessed. All treatment was given 6 days after the inoculation of 10^6 tumour cells. An isobologram was constructed

using the method described by Steel and Peckham, taking a growth delay of 10 days as the iso-effective dose. The dose of cisplatin, when injected 6 h after radiation, required to produce this degree of growth delay fell within the envelope of additivity. However a supra-additive response was observed when cisplatin was given immediately before the radiation. The clinical implication of this study is that when combining cisplatin with radiotherapy the two agents should be administered together. Frequently cisplatin is given after radiation because of its emetogenic potential, when additivity alone might be expected.

Effect of transfected EBV EBNA-1 on the radiation survival curve of BALB/C 3T3 cell line

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Epstein–Barr virus (EBV) is a human herpesvirus. This virus can infect both lymphoid and epithelial cells *in vitro* and can be found in many tumours such as Burkitt's lymphoma, lymphoma in immunocompromised patients, and in nasopharyngeal carcinoma (NPC). Although the direct evidence of EBV being the aetiological agent of NPC has yet to be established, biochemical and immunological evidence suggested that NPC is closely associated with EBV. For example, EBV-encoded nuclear antigen 1 (EBNA-1) was found in all the NPC tissues and latent membrane protein (LMP) was found in 65% of the NPC biopsies examined. If the radiosensitivity of NPC clinically is caused by the presence of EBV, this effect must be determined by one (or both) of these two proteins. This study used the cloned EBV EBNA-1 to co-transfect the mouse fibroblast cell line BALB/C3T3 with a G418-resistant plasmid pN2. The effect of EBNA-1 on the radiation survival curve of this cell line and its implications will be discussed.

***In vivo* study of rabbit irradiated skeletal muscle by NMR imaging**

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Surgical treatment of an irradiated area needs an exact and sensitive imaging technique. We investigated the possible use of magnetic resonance imaging (MRI). Two groups of 16 rabbits were irradiated on the left iliospinalis muscle with an iridium-192 scaled source (E_γ = 0.38 MeV). The dose rate at 2 cm depth was 10 Gy for Group 1 and 20 Gy for Group 2. Proton imaging was performed regularly during 8 months for each rabbit in a 2.35 T imaging system with a special probe including a half saddle coil and a restraining system for the anaesthetized rabbit. Transverse images (2DFT 3000/34) were obtained before and after intravenous administration of Gd-DOTA (0.3 mmol/kg). In Group 1, five out of eight rabbits had a superficial muscular lesion without atrophy at the 22nd week. In Group 2, six out of eight had an extended muscular lesion with an important atrophy at the 18th week. (Two rabbits died after anaesthesia at the 13th and 17th weeks.) Histological findings obtained on another group of rabbits have shown some necrosis with fibrosis in the irradiated area from the 30th week for Group 1 and the 20th week for Group 2, and an inflammatory lesion from the 10th week in Group 1 and the 4th week in Group 2. An MRI lesion could probably be better explained by necrosis and the progressive fibrosis substitution than by inflammation.

12.15 – 1.15

Silvanus Thompson Memorial Lecture

Hall 9

The gene as a theme in the paradigm of cancer

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An excess incidence of cancer and leukaemia was observed in the early radiation workers within a few years of the discovery of X rays. Thus, radiation was added to the bewildering array of physical, chemical and viral agents identified as able to cause cancer. The common mechanisms involved are only now becoming clear. There are four lines of research, rapidly converging, that illustrate how the function of specific genes can regulate cell behaviour — including transformation to a malignant state. (1) In the leukaemias and lymphomas, the activation of cellular oncogenes is important. The genes involved are present in all normal cells and are often associated with cell growth and regulation. When activated, they act in a dominant fashion to cause a cell to express the malignant phenotype. (2) In solid tumours, a more important mechanism may be the loss of a suppressor gene which acts in a recessive mode, *i.e.* both copies must be lost for a malignancy to be expressed. The classic example is retinoblastoma; the gene has been cloned and found to be associated with several other common cancers. It is likely to be one of a family of such genes. It may well be that the activation of one or more oncogenes, or the loss of one or more suppressor genes, or both is required for a tumour to progress from initiation through promotion to a metastasizing malignancy. (3) Recent studies indicate that heterozygotes of repair-deficient syndromes such as Ataxia Telangectasia are much more likely to develop cancer and may also be more sensitive to radiation induced malignancies. (4) The most recent candidate gene is the molecular checkpoint gene. This gene causes cells to stop in G_2 following exposure to DNA damaging agents, before proceeding with the complex task of mitosis. Mutants in which this gene is defective, missing or otherwise inoperative are exquisitely sensitive to killing by X rays or UV. To date these experiments are possible only in lower organisms, such as yeast, but homologues in mammalian cells are actively being sought. Defects in cell cycle regulating genes are likely to be the key to cancer induction.

2.15 – 3.45

Non-vascular Interventional Techniques

Hall 9

Non-vascular interventional radiology — biliary disease and stents

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Self expanding metallic stents with a diameter of 6–10 mm have been developed to improve long-term patency in benign and malignant biliary duct obstruction. We have treated 55 patients with the Wallstent-type endoprosthesis, 52 patients for malignant and three patients for benign disease. The stents were introduced percutaneously via a transhepatic approach in 44 patients and endoscopically in eight. Of the 52 patients with malignant disease, 44 died between 4 days and 19 months (mean survival 6 months). Eight patients are alive after 6 weeks to 14 months (mean 6 months). Stent obstructions occurred in 11 patients (21%). Nine of these patients were successfully treated with a secondary intervention. Treatment consisted of removing sludge or additional stent implantation. In three patients the obstruction was due to tumour overgrowth and in another three to tumour ingrowth through the mesh of the stent and in five patients due to sludge or food incrustations. Serious complications included cholangitis (six; 11.5%), and gallbladder hydrops (two; 3.8%). There was one procedure-related death due to cholangitis and bleeding (1.9%). The 30 day mortality was 15%. The three patients with benign disease were followed from 3 to 5 years. In two patients the stents occluded due to sludge and mucosal hyperplasia prompting a secondary percutaneous intervention. Use of the Wallstent is now our preferred method for palliation of malignant obstruction. The stent occlusion rate until death of 21% compares favourably with conventional plastic stents. For benign disease our experience is limited, however a conservative approach with stenting as the last non-surgical step seems advisable.

Fluoroscopically guided percutaneous gastrostomy

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We describe our experience with fluoroscopically guided percutaneous gastrostomy. A total of 16 patients was prospectively studied. The indication for gastrostomy was bulbar palsy in 12, head and neck carcinoma in three and duodeneo-enteric fistula in one patient. A COPE nephrostomy pigtail catheter (#10–#14 French in size) was inserted into the stomach under fluoroscopic guidance and local anaesthesia in all cases, and feeding via the tube commenced the following day. Two of the tubes (12%) became dislodged within a week of insertion, but with no complications. A further tube was removed due to patient dissatisfaction. In nine cases (56%), the tube remained patent until no longer needed, or is currently patent. Four tubes (25%) required changing because of wound site infection (2), tube blockage (1), or gastro-oesophageal reflux (1). Of these, one required a further tube change because of tube displacement and another required four further tube changes over several months because of tube blockage. All tube changes were performed along the mature tract of the original tube. Of the 25 tubes studied, the average patency rate is 9.2 weeks. We conclude that fluoroscopically guided percutaneous gastrostomy is a safe, successful method of enteral feeding.

The Holmium–YAG laser: safety in the biliary tract and elsewhere

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The Holmium laser has potential use in percutaneous cholecystectomy and gallstone lithotripsy. There is, however, a paucity of data regarding its effect on tissues and penetration in different media. We examined the effect of the laser on human gallbladder tissue at various energies with the laser fibre in direct contact with the tissue. Microscopic examination revealed zones of thermal damage with limited (< 1 mm) lateral extension from the ablation site. 20 shots at 130 mJ, caused near perforation of the gallbladder wall. Histological effects of tissue damage will be presented. We also examined penetration of the infrared beam through air, saline, bile, urine, blood, iohexol and diatrizoate solutions and admixtures. An exponential model of attenuation fitted the data very closely ($R^2 > 0.99$ for all media). All media, except blood had a similar

attenuation coefficient (range 2.1 to 2.8 mm^{-1}), blood had a coefficient of 4.6 mm^{-1}. We conclude that bile and other media strongly attenuate the laser's energy within a short distance, but when the fibre is in direct tissue contact, perforation is readily achieved. Therefore, clinical use of the Holmium laser in the biliary tract should be via a dual lumen catheter/basket system in order to prevent perforation. The results of the data will be discussed in relation to safety of the Holmium laser in different interventional radiological applications.

An assessment of the Holmium–YAG laser for fragmenting gallstones

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The feasibility of using a Holmium laser to fragment large gallstones was examined *in vitro*. The energy from this 2.1 μm pulsed laser is transmitted through a flexible, 0.6 mm diameter fibre, which can be passed down an endoscope. The fibre was placed in close proximity to a gallstone, grasped in an endoscopy basket and immersed in a saline-filled beaker. A metal grid with 3 mm diameter holes was placed mid-way in the beaker. Fragmentation was complete when all fragments passed through the grid. To date, 29 large gallstones (mean mass 1.26 g) have been fragmented. A mean of 515 shots was required at a frequency of 5 Hz. The number of shots required increases approximately linearly with the stone mass. Fibretip degradation was investigated; a statistically significant ($p < 0.05$) fall-off in power output was demonstrated; technical aspects are discussed. All stones underwent physico-chemical and computer tomographic analysis. Cross-correlation with fragmentation data will be presented, showing the difference in energy required to fragment different stone types (rimmed, cholesterol, pigment). The Holmium laser can effectively fragment gallstones and therefore has potential uses in fragmenting retained common duct stones at ERCP and gallbladder stones prior to percutaneous cholecystectomy, adding to its already established uses in surgery and laser angioplasty.

Pelvi-ureteric junction obstruction — treatment by balloon dilatation in 21 patients

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Pelvi-ureteric junction (PUJ) obstruction is surgically treated by open Anderson Hines or Culp pyeloplasty. Less invasive therapies have been developed including percutaneous endopyelotomy and balloon dilatation. A total of 21 patients (M:F 12:9; aged 23–78, mean 43 years) had radiological and renographic evidence of significant PUJ obstruction. Three patients were asymptomatic and 18 complained of intermittent loin pain. At cystoscopy, the ureteric orifice was catheterized with a guide wire and a 10 mm, 4 cm balloon passed over it into the PUJ. Dilatation was performed. Rupture of the PUJ, as evidenced by contrast extravasation, was seen in 16 cases. The ureter was stented for 6 weeks with a JJ stent. Technical success was achieved in all patients. Clinical improvement was seen in 17 patients at follow-up, supported by both renographic and radiological evidence. No improvement was seen in four and three of these went on to open pyeloplasty. Minor immediate post-operative complications were common. Major late complications occurred in one patient who developed a PUJ stricture that required open surgery. When compared with the success reported for percutaneous pyelolysis (80%) and Anderson Hines Pyeloplasty (85%), balloon dilatation compares well (76%). Complications are few and failure can be corrected by surgery or potentially a repeat dilatation. PUJ balloon dilatation is an effective, minimally invasive treatment for PUJ obstruction.

Renal biopsy in diffuse renal disease — experience with a 14 gauge biopsy gun

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We retrospectively review our experience of percutaneous renal biopsy (PRB) in native kidneys with diffuse disease to assess the efficacy and safety of a 14 gauge biopsy needle in an automated gun (Biopty TM, Uppsala). 104 biopsies in 103 patients (64 male, 39 female; age range 14–78 years, mean 45.4 years) were performed by single radiologists (one consultant or one of a number of senior registrars) using a 14 gauge Biopty needle with continuous ultrasound guidance. 103 of 104 (99%) procedures resulted in sufficient tissue for light and electron microscopy and immunofluorescence allowing a definitive diagnosis. An average of 2.6 passes were made at each procedure with a mean of 13.4 glomeruli per tissue core. There were four (3.8%) minor complications of transient macroscopic haematuria. Three (2.9%) significant complications consisted of two symptomatic perirenal haematomas and one arterio-venous fistula which was successfully embolized. Our diagnostic and complication rate compare favourably with published rates using various techniques and different needles. The impor-

tance of sample size with regard to accurate diagnosis is discussed. We suggest that use of the 14 gauge Biopty gun guided by real-time ultrasound should currently be the method of choice for PRB in adults.

Mechanical and ultrasonic properties of urinary stones

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Urinary stones are now treated by extracorporeal shock-wave lithotripsy and/or percutaneous stone surgery. Some stones can prove remarkably resistant to these techniques. A study has been performed to examine the physico-chemical and acoustical parameters of kidney stones with the aim of predicting the ease of fragmentation. 30 intact urinary stones were rehydrated. Parallel surfaces were machined. One of the two offcuts from each stone was analysed for composition and structure by infrared spectroscopy and scanning electron microscopy; the other embedded in a polyester resin, polished and microhardness tested with a Shimadzu microhardness tester. The speed of ultrasound through the stones was measured using a pulse transit time technique. Stones were placed in a water bath between two 1 MHz transducers of 11 mm diameter, connected to a generator/digital receiver and PC IBM-compatible computer. Density of the stones was measured using Archimedes' principle and a theoretical modulus of elasticity calculated from:

$$E = C^2\sigma$$

where E is the Young's modulus and σ is the density. Compression testing with an Instron testing machine gave a direct measure of the modulus and compressive strength. Stone specimens were fragmented in the focus of the Dornier MPL 9000 lithotripter. Early results have shown an increase in the parameters for the series struvite to brushite as follows:

Stone type	Density (mg/mm³)	Modulus	Velocity (m/s)	Microhardness (Vickers)
Struvite	1.6	7.2	2116	43
Uric acid	1.8	11.9	2602	68
Calcium oxalate	2.1	11.9	3004	108
Brushite	2.2	32.6	3808	142

The relationship between ultrasound velocity and the modulus characteristics of stones may be useful in predicting the resistance of stones to fragmentation *in vitro*. Presently there is no satisfactory method for determining the composition and structure of stones before treatment. Clinical methods for measuring the velocity of sound through stones in the clinical situation are being investigated.

Percutaneous balloon dilatation for transport ureteral stenosis

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We have reviewed 15 patients who have undergone percutaneous dilatation of distal ureteric strictures following renal transplant. Obstruction was clinically suspected in all patients by rising blood creatinine levels and comparison ultrasound scans. The time from transplantation ranged from 2 to 48 months (mean 13 months), with 11 out of the 15 patients having had temporary stenting (4–7 weeks) following transplantation. In all cases dilatation was performed with 8 10 mm (larger than in most previous series), high pressure balloon catheters passed over a rigid guide wire. 12 strictures were fully dilated, with seven patients requiring more than one dilatation. 10 out of 15 patients were successfully managed with nephrostomy drainage and balloon dilatation only, all showing progressive reduction in creatinine levels; follow-up has ranged from 3 to 12 months. One complication of frank haematuria was encountered following dilatation; this was managed non-operatively. The remaining five patients required other procedures after partial balloon dilatation, including stent insertion and endoscopic ureterotomy. The success of balloon dilatation was not related to time from transplantation, however it appears that the late occurring strictures are more difficult to dilate requiring several balloon dilatations. Antegrade dilatation is successful in treatment of transplant ureteral stenosis. Post-dilatation stenting as advocated by other authors is not needed in the majority.

Complication rate of combined endoscopic and percutaneous stent insertion

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Endoscopic insertion of biliary stent has a success rate of 90% with a complication rate of approximately 10%. In those patients in whom endoscopic stenting fails, percutaneous transhepatic assistance (the combined procedure

(CP)) is used, although a high complication rate has been reported. We have reviewed our complication rate for CP in 40 consecutive patients. Following failure of endoscopic stent insertion, PTC with external drainage is performed within 72 h, followed by CP and stent insertion, again within 72 h. All procedures are performed under antibiotic cover and sedation using midazolam and nalbuphine. 39 patients had successful CP. The total procedure related complication rate was 32.5% with a 2.5% 30 day mortality. Cholangitis occurred in nine patients, haemobilia in one; one developed a right subphrenic collection and two developed severe right upper quadrant pain. All complications settled on conservative treatment. Our complication rate for ERCP, PTC and CP is higher than for endoscopic stenting alone, but complications were minor. We suggest that the complication rate for these procedures can be kept to a minimum by adherence to antibiotic and fluid regimes and by early recourse to staged CP.

Transuretheral ureteric stent retrieval using the Amplatz snare

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Internal ureteric stents are widely used transiently to maintain ureteric patency and removal/replacement usually requires general anaesthesia. The Amplatz goose neck snare enables non-operative transuretheral stent retrieval and a technique using the snare introduced via a haemostatic sheath is described. Stent retrieval has been performed in 20 female patients using mild intravenous sedation and topical uretheral anaesthesia. The length and course of the male urethera make manipulation more difficult but this has been successfully negotiated using a steerable catheter system. Procedural times are less than 20 min with screening times of approximately 2–3 min. In addition, stent replacement has been performed in five patients. There have been no post-procedural complications and the procedure was well tolerated by all patients. This technique offers a simple, safe cost-effective technique for transuretheral stent retrieval/replacement which can be performed under local anaesthesia.

Notes

2.15 – 3.45

Radiological History

Hall 10a

1927 and after: the Annual Congress in retrospect

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In Central Hall, Westminster, the amalgamation of the Röntgen Society and the then BIR to form the present Institute was celebrated on 17 and 18 November 1927 in our 1st Annual Congress, which included a Technical Exhibition by 20 firms. The story of those Congresses, the first 42 in London and subsequently on tour, can be traced in the *BJR* and BIR Annual Reports supplemented by personal recollections, especially since December 1952, the first post-war Congress. One reflects on the dinner in 1929, with the speeches reported in 5000 words in the *BJR:* notes a paper at that same Congress describing the overwhelming superiority of Germany over Britain in the quality and provision of radiological equipment; recalls that revolutionary presentation of 20 April 1972 by Ambrose and Hounsfield. Until recently, meetings at Congress consisted almost entirely of some 30–40 invited papers in prearranged Symposia. Manchester 1985 saw a transformation, a joint venture with other societies: 150 papers, many proffered, on the theme "Information Technology in Radiology" and, for the first time for many years, a large Technical Exhibition. But, all Congresses and their dinners come to an end: will Birmingham 1992 match the 1929 Burlesque, a Radiological Drama in One Act, "Blood and Whitewash"?

Encephalography, development and introduction into clinical (neuro-)radiology

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In 1919 Dandy reported on eight patients investigated by translumbar insufflated air into the ventricle system. With respect to possible complications, Dandy abandoned this procedure in favour of ventriculography: air insufflation through one or two holes in the dorsal parietal bone (1920) used before in children as transfontanellar access (1918). Wideroe tested the translumbar air filling of the ventricle system at about the same time but did not continue regarding the bad quality of contrast in some test cases. On the other hand, Bingel developed, independently of Dandy as well as Wideroe due to his own testimony (1921), the translumbar encephalography at the Medical Department, LKA Brunswick, Germany. Based on a trial of 30 patients as well as corpse tests he had done in 70 patients a translumbar encephalography without adverse reactions. The results have been published by Bingel (1921) mentioning references of Dandy's papers as well as Wideroe's paper. Based on this publication, 10 further papers, and some lectures, the translumbar encephalography was introduced into clinical routine (neuro-)radiology in Germany as well as Europe, probably all over the world. The abandonment by Dandy would have perhaps completely eradicated this procedure with respect to his reputation as leading neurosurgeon of the USA and probably the whole world at that time. Introductions of cerebral angiography (Moniz), later CT and last MRT as well as magnetic power measurement have displaced completely translumbar encephalography (Dandy, Bingel) as well as ventriculography (Dandy).

The birth and development of the X-ray motor car

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Pioneer motor cars and early X-ray sets grew up together at the end of the nineteenth century. For the first 20 years of this century the development of both was linked to provide mobile radiography. At first, the car was merely the means of transport for the equipment. Later the engine provided the source of electrical power. A civilian radiologist in England described one of the earliest X-ray motor cars. British, French, German and American engineers designed X-ray vehicles with some degree of sophistication during the First World War, mainly for military use.

The Nuffield Institute for medical research, Oxford, and the radiology of the throat

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This is a story of fortuitous combination of funding, facilities and talent. Lord Nuffield's benefaction to the University in 1936 and personal interest in the development of cineradiology provided conditions for the veteran pioneer radiologist from Manchester, Alfred Barclay, to establish the Institute as an important centre of cineradiological research, in particular of the fetal circulation. From this fertile ground grew the investigation of swallowing and the airway. In 1948 Dr Gordon Ardran arrived at the Institute to replace Barclay and formed a collaboration with Dr Fred Kemp, from Oxford's Radcliffe Infirmary. Both men were gifted with enquiring and scientific minds and almost immediately began a steady stream of fundamental observations on the functional anatomy of the throat. This continued for 30 years, despite Ardran's other major interest in radiological protection and quality control, and Kemp's increasing involvement in the development of the Radcliffe Infirmary as a teaching hospital. Today some of these publications are 40 years old, but they are still frequently cited in the literature and the accuracy of Ardran and Kemp's work has never been seriously disputed. This review describes their work and examines its significance to current practice in imaging the pharynx and larynx.

Dr John Hall Edwards: Birmingham's X-ray martyr and first radiologist

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Dr John Hall Edwards, born in 1858, followed in the footsteps of his father and grandfather who had also practised in the city of Birmingham. Setting himself up in a practice in Moseley, he became very much involved with photography, and on the evening that the news of Roentgen's discoveries were leaked to the Vienna press he decided with his friend Dr Ratcliffe to assemble a unit and radiographed his hand. In February 1896 a needle was successfully removed from the hand of Mrs Berry, which Edwards had located. From this his work expanded and he moved to some rooms close to the Medical School and the General Hospital to which he was appointed surgeon radiographer, a post he held until 1919. Came the Boer War and after much persuasion the War Office allowed him to set up a unit in the 1st Yeomanry Hospital in Deelfontein. His articles to local papers both from South Africa and from home were much appreciated and he was awarded membership of the Press Council. He also continued with his photography. Alas he noticed that his hands were becoming affected by the rays and because of a cancerous skin lesion his hand was amputated. He continued to work, painted, wrote articles, edited the Archives of Roentgen Ray. During the First World War he supervised the X-ray facilities not only for Birmingham but also for southern command. After the War, he entered local politics as member from Rotton Park, but ill-health gradually rendered him less and less mobile so that near the end he was confined to a wheelchair. His name is inscribed on the memorial to the X-ray martyrs in Hamburg and his efforts to introduce radiation protection have been of immense value to following generations of radiation workers.

2.15 – 3.45

Musculoskeletal Imaging

Hall 10b

Ultrasound of the spine in infants with lumbosacral skin lesions

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A total of 30 infants with lumbosacral skin lesions referred for neurospinal ultrasound over an 18 month period was studied retrospectively to assess which cutaneous markers were most often associated with closed spinal dysraphism. 20 infants with a simple low-lying dimple and one with a pilonidal sinus had normal scans. Two infants with sacral skin swelling had a subcutaneous abscess but no neurospinal abnormality. Three of four infants with hairy patches had anormal scans (one with multiple vertebral abnormalities, one with a conal cyst and one with a tethered cord). Capillary naevi were seen in one otherwise normal infant and in the infant with a hairy patch and vertebral abnormalities. A high-positioned dimple was present in a second infant with tethered cord syndrome. A case of lipoma of the filum terminale presented with a skin tag offset from the midline. In conclusion, ultrasound is a reliable and non-invasive technique for the early screening of lumbosacral skin lesions for closed spinal dysraphism with the prognosis varying from very good for low-lying simple dimples to relatively poor for most hairy patches. However, the early identification of closed spinal dysraphism has allowed more successful management of these patients.

Ankylosing spondylitis: a comparison of clinical and radiographic features in men and women

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The clinical and radiographic features of ankylosing spondylitis in men and women are felt to differ. Reisnick concluded that women presented at an earlier age, with more peripheral and cervical spine arthritis and tended to have more benign disease. This study was undertaken to compare clinical presentation, radiographic features, course and complications in 83 patients conforming to the Rome criteria. There were 64 males and 19 females, mean ages at presentation of 23 years and 26 years, followed for a mean of 13 and 11 years. At presentation, females had more peripheral arthritis and asymptomatic sacroilitis ($p < 0.001$). Males had more symptomatic sacroilitis ($p < 0.001$). Initial views of sacro-iliac joints were scored grades 0–4 in 42 patients, eight patients had Grade 4 sacroilitis at presentation. 35 patients had lumbar spine changes and nine patients had cervical spine changes. No difference in the rate of lumbar and cervical spine involvement in men and women was identified. Five patients developed spinal fusion (four males, one female). One male patient developed upper lobe pulmonary fibrosis, one male patient developed the cauda equina syndrome, one male patient required joint replacements. However, no significant difference in the rate of complications occurring in men and women was demonstrated.

First metatarsal pronation in hallux valgus

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The aetiology of hallux valgus is unclear. Previous authors have correlated development of hallux valgus with convexity and width of the first metatarsal head, others have highlighted the importance of metatarsus prima varus. Pronation in the first metatarsal is to date unreported primarily because clear markers of rotation in that bone have not been identified. 20 metatarsals were dissected from cadavers and radiographed in degrees of rotation (0°, 10°, 20°, 30°, to 90°). The inferior tuberosity of the base moved laterally as the bone pronated, position correlating to degree of rotation. This model was applied to 40 controls with clinically normal feet and 40 patients with hallux valgus. 38 of 40 controls had less than 10° of first metatarsal pronation. 37 of 40 patients with hallux valgus had

20° or more first metatarsal pronation ($p < 0.001$). We have identified features that enable assessment of rotation in the first metatarsal. We have proved that patients with hallux valgus have first metatarsal pronation. Preliminary evaluation suggests that this rotation may be reversed by orthotic insoles. Incorporation of a derotational manoeuvre into standard oesteotomy may reduce the current 20% post-surgical recurrence rate.

The influence of clinical data on the interpretation of MRI scans of the lumbar spine in disc disease

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A total of 100 patients with suspected lumbar disc disease was investigated by magnetic resonance imaging in the sagittal and transverse axial plane employing a variety of pulse sequences. The resulting scans were reported independently by three different radiologists firstly without any clinical data and again after an interval of several weeks with knowledge of the history and clinical findings. 50 of the patients have come to surgery and the degree of complete concordance between the radiological and operative findings in the initial reports was 67%, 63% and 64% respectively. The three observers gave a different report in over 10% of the cases when they had access to clinical findings. In most cases this was to give a positive interpretation to questionable features in the presence of corroborating clinical data. We conclude that whilst access to clinical data may reduce the number of false negative and equivocal scan reports this is at the expense of an increase in the number of false positives.

Cervical spondylosis: correlation of MR imaging and plain film findings

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It has been stated that magnetic resonance imaging (MRI) is unreliable in the demonstration of osteophytic and other bony lesions, and that plain film changes correlate poorly with clinical features in cervical spondylosis. To assess the validity of these beliefs, balanced and T_2-weighted sagittal MRI was prospectively compared with cervical radiography in 45 patients (270 disc levels) presenting with spondylotic myelopathy. The commonest level affected by osteophyte and/or narrow disc was C5–6. Offsets occurred with equal frequency at C3–4, C4–5 and C5–6, with very few outwith these levels. 147 levels (54%) were normal on both examinations. Osteophyte occurred at 52 levels (19%) – of these, MRI was abnormal in 90%. Offset was present at 39 levels (14%) — MRI was abnormal in 64%. Narrow disc, 23 levels (9%) — MRI was abnormal at all but one (96%). 85% of osteophytes demonstrated on radiographs were seen on MRI. On MRI, an annular bulge was demonstrated at 33 levels (12%) — 13 (39%) having normal radiographs. Posterior extension touching the cord occurred at 32 levels (12%) — 10 (31%) having normal radiographs. Cord indentation was seen at 34 levels (13%), four (12%) with normal radiographs. Of 147 levels normal on radiography, MRI abnormality was demonstrated at 29 (20%), but in only four was cord indentation present. Thus, MRI demonstrated bony abnormalities such as osteophytes and changes related to narrow disc spaces. Radiographs reliably predicted normality as demonstrated on MRI, and can therefore be used to screen patients with clinical features suggesting cervical spondylotic myelopathy.

MRI of discitis/osteomyelitis

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Magnetic resonance (MR) imaging is establishing an important role in the investigation of musculoskeletal abnormalities. Most interest has been in diagnosing and staging tumours. We have looked at its application in investigating osteomyelitis and discitis. Notes and MR scans of 35 consecutive patients with suspected osteomyelitis or discitis were examined. 23 studies were performed for back pain, seven post-surgical intervention. Each scan was re-interpreted looking specifically at vertebral body and disc signal, inflammatory mass effect, and any enhancement post-gadolinium when given. Each case was categorized as either inactive, active or infective discitis, or negative. Five were felt to be inactive; seven active; six infective; one sacral osteomyelitis; one poor quality image where a repeat was suggested; and three negative. The negative results showed degenerative disease (2) and metastases (1). All six infective cases were confirmed by blood culture, serological tests or biopsy. One of the inactive, and three of the active cases have been confirmed. 12 other cases have been investigated due to suspected osteomyelitis in the hip (3), lower limb (6), mandible (1), skull (1) and sternum (1). Results were positive for neoplasia in one, infection in three, equivocal in two, and negative in six. The use of MR in discitis/osteomyelitis is discussed. We feel that it is helpful in diagnosing and categorizing discitis, in assessing bony involvement in known osteomyelitis, and in the follow-up of the infective complications of surgery.

CT scanning of L3/4 in suspected disc prolapse: is it necessary?

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A retrospective study of all orthopaedic referrals for computed tomography (CT) scanning of suspected lumbar disc disease to the Hallamshire Hospital for a 2 year period from July 1989 to July 1991 was done to assess the necessity for scanning the L3/4 level. Of a total of 723 lumbar spine scans performed, 511 were from the orthopaedic services in the Hallamshire and Northern General Hospitals. 460 were for clinically suspected disc disease. There was clinical suspicion of L3/4 pathology in 29 cases (6.3%). Of these 29, CT abnormality was found in 18 (62%) but in only seven was an L3/4 abnormality found (24%), two of which were diagnosed as a prolapsed disc (7%). Four cases had abnormal CT scans at the L3/4 level with no related clinical findings (0.9%). In one of these a significant disc prolapsed was also found at L5/S1 which was thought to be the significant lesion while the other three findings were not thought to be significant and the symptoms resolved on conservative treatment. None of these four patients went to surgery and in none did the L3/4 CT abnormality affect management. These findings have changed the practice in the Hallamshire CT department and only the two lowest lumbar levels are now scanned unless a higher level is clinically suspected or other factors necessitate wider scanning, *e.g.* disordered segmentation. This results in reduced radiation dosage, scanning time and overall cost.

The influence of smoking on adverse effects following iohexol lumbar myelography

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A prospective trial to evaluate the influence of smoking on the incidence of headache, nausea, vomiting and dizziness in 50 consecutive patients referred for lumbar myelography. All patients had suspected lumbar disc disease. The needle size was standardized at 22 G and 12–15 ml Iohexol (240 mg/ml) was injected intrathecally. Following the procedure, the patients were routinely ambulatory and were requested to complete a questionnaire the following day. The incidence of headaches graded as moderate or severe was significantly increased in smokers when compared to non-smokers. Smokers experienced more nausea, vomiting and dizziness than non-smokers (borderline significance). A statistically significant number of smokers did not feel well enough to be discharged on the day of the procedure.'These results suggest that smokers have an increased tendency to suffer adverse effects, particularly moderate and severe headaches, following lumbar myelograms. This may have relevance when selecting patients for day case myelography.

Sonographic features of plantar fasciitis

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Plantar fasciitis is a common cause of heel pain either as an overuse phenomenon or related to an inflammatory arthropathy, particularly the seronegative arthropathies. We have examined 24 patients with clinical plantar fasciitis or unexplained heel pain using a 7.5 MHz linear array transducer. The investigator was "blind" as to side of symptomatic heel and relevant clinical history. The thickness of the plantar fascia at its point of crossing the anterior calcaneal border was 1.5 to 4.1 mm (mean 3.0 mm) for the asymptomatic and 2.9 to 6.7 mm (mean 4.7 mm) for the symptomatic heels, respectively. A thickness difference of 1.0 to 3.8 mm (mean 1.45 mm) was demonstrated when comparing opposite limbs of the same individual with a relative percentage difference of 32% to 100% (mean 64%). We also demonstrated qualitative changes either diffusely along the plantar fascia or locally at calcaneal insertion. These appearances correspond well with the recognized sonographic features of tendon disease. We discuss these sonographic features and their clinical relevance with reference to objective evidence of diagnosis and monitoring the natural history of this condition.

CT anatomy of the pelvis following hindquarter amputation

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The current management for the majority of musculoskeletal sarcomas is reconstructive surgery with or without chemotherapy. Pelvic lesions tend to present late and, in a minority of cases, surgery requires a hindquarter amputation (HQA). The role of cross-section imaging in the preoperative assessment of these cases is well established. Mutilating surgery deforms the normal symmetrical anatomical relationships in the pelvis. The purpose of this study

is to review the computed tomography (CT) appearances of the pelvis following HQA. CT was performed in 14 cases; 12 primary bone and two soft tissue sarcomas. In the normal cases CT showed that, following removal of the normal skeletal support from one half of the pelvis, the bladder and small bowel "herniated" towards the side of surgery. The remaining ipsilateral musculature comprising the gluteal flap and pyriformis muscle, forming the lateral pelvic wall, and the psoas and erector spinae muscles posteriorly all show varying degrees of wasting. The surgical scar highlighted by surrounding fat is easily identified. In six cases recurrent tumour was identified arising at the resection margin. Recurrent tumour could be distinguished from scar tissue by the presence of a mass such that any focal enlargement of the muscles within the surgical field invariably denoted tumour. The attenuation value of recurrent tumour approximates to that of muscle apart from the chondrosarcomas which had a low attenuation which should not be mistaken for a cystic collection. Examples of the normal and abnormal anatomy of the pelvis after HQA are shown and the value of CT in this clinical context is discussed.

If it isn't a soft tissue sarcoma, what is it? A review of 1 year's referrals to the sarcoma unit — CT findings with pathological correlation

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Soft tissue sarcomas (STS) are rare; they comprise less than 1% of all malignant tumours with approximately 1000 new cases arising per year in the UK. Clinically, the commonest presentation is that of an enlarging mass, usually within a lower extremity but their rarity, diverse biological behaviour and heterogeneous histological appearances may give rise to considerable diagnostic difficulty. A review of all new patients referred for treatment to the sarcoma unit at the Royal Marsden Hospital with a clinical diagnosis of soft tissue sarcoma (STS) during the course of 1 year (1989–1990) was undertaken. Of 118 patients, 65 (55.1%) had primary STS, 26 (22.0%) had recurrent STS, 19 (16.1%) had benign soft tissue tumours and eight (6.8%) had malignant tumours other than STS involving and presenting as soft tissue tumours. All patients underwent computed tomography (CT) scanning which was used to assist diagnosis, assess operability and for radiotherapy planning where indicated. The CT findings in the non-sarcomatous tumours, both benign and malignant, are discussed and the key role of CT in aiding diagnosis in these clinically confusing cases is emphasized. Benign soft tissue tumours encountered included fibromatosis, myxoma, arteriovenous malformations, lipomas, myositis ossificans and a psoas abscess. The malignant tumours mimicking STS included lymphoma, osteogenic sarcoma and a soft-tissue metastasis from an undiagnosed bronchogenic primary carcinoma.

Bone cortical and periosteal changes as seen on MRI

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Magnetic resonance imaging (MRI) is now widely accepted as a means of demonstrating bone marrow and soft tissue detail. Its ability to elucidate bony changes has been less well appreciated. The basic changes of cortical destruction with geographic or permeative destructive patterns, as well as erosion of the cortex can also be demonstrated. In some cases, cortical destruction can be better shown on MRI than on conventional films. The patterns of petriosteal reaction, including simple periosteal reaction, spiculated periosteal reaction, and laminated or "onion-skin" periosteal reaction can be well seen. The cortex is seen as a solid black line and interruptions of the cortex can be seen as high signal intensity on proton density and on T_2-weighted images. The various changes on MRI are illustrated and compared to conventional radiographs and computed tomography.

MRI of musculoskeletal tumours: a comparative study with X-ray and CT

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We evaluated 64 musculoskeletal tumours, 11 benign lesions and 53 malignant lesions. In the results, conventional radiograph remained a technique with specific diagnostic information. Computed tomography (CT) was superior in evaluating lesion in flat bones in all cases and provided valuable information about cortical integrity and presence of calcification in seven and nine cases, respectively. Magnetic resonance imaging (MRI) offered a high "sensitivity" in depicting tumour extent (88%), with acceptable rates of "accuracy" in defining the intramedullary extent of tumour (92%) and in the relationship of the tumour to adjacent neurovascular bundle (82%). In summary, although CT is useful, MRI should be regarded as the examination of choice of "staging" musculoskeletal tumours.

The accessory navicular — a cause of medial foot pain

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Many different accessory ossicles occur around the foot. Occasionally these ossicles are the direct cause of a patient's symptoms. This is most commonly recognized in the os-trigonum syndrome. We present 10 cases of a seemingly less familiar, but equally important clinical scenario related to the accessory navicular. There are three types of accessory navicular, the most frequently occurring of which (type II) is united to the navicular by a synchondrosis. This is the type that causes pain due to a chronic stress reaction at the synchondrosis in physically active people. Over the last 18 months, 10 patients have been seen with a typical clinical history of chronic or acute on chronic pain over the medial aspect of the foot overlying the navicular. Seven of these were female and the mean age was 26.5 years (range 17–38 years). All the patients were physically active on their feet, either in leisure activities or as part of their occupation. All had Type II accessory naviculars on plain radiography and eight had localized increased uptake on $^{99}Tc^{m}$ MDP bone scan. Two patients had surgical excision of the accessory navicular with relief of their symptoms. In summary the diagnosis is made by finding a Type II accessory navicular in the context of a typical clinical history and can be confirmed by a positive bone scan.

Notes

2.15 – 5.30

Workshop: Greening the Radiology Department

Hall 11a

E. Ison
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Over the last 3 years, there has been a significant drive to "green" the National Health Service; green groups are developing in many units throughout the UK, and the parliamentary under-secretary of state for health, Mr Stephen Dorrell, has addressed the issues of energy use and waste management in the NHS by setting targets and incorporating them into regional reviews. In this session, our objective is to determine what constitutes good practice in a radiology department when environmental impact is used as a quality criterion. In order to provide baseline information for the session, a questionnaire about current practice in relation to environmental considerations has been circulated to BIR members. The results of the questionnaire will be presented, and taken as a starting point for the discussion. Areas of practice that may be examined include administration and good-housekeeping practices, the disposal and recycling of processing chemicals, indoor air pollution, energy efficiency and age of equipment, use of resources, and compliance with legal and regulatory requirements with respect to radioactive substances and hazardous chemicals. Other areas for discussion may arise as a result of the responses to the questionnaire and the particular interests of the delegates attending this particular consensus session. It is envisaged that there will be an iterative process after the session in order to refine the outcomes of the debate for publication. We hope to produce guidelines for staff working in radiology departments that will reduce the overall impact of this discipline, not only on the environment, but also on those organisms, human or otherwise, who are dependent upon it.

2.15 – 3.45

Radiobiology Day: Session II

In memory of Dr N. McNally

Hall 11b

Clinical experience with CHART in the UK

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In 1984 continuous hyperfractionated accelerated radiotherapy (CHART) was devised utilizing the radiobiological data regarding normal tissues and tumours available at that time. The aim was to maximize cure and minimize normal tissue injury in patients with cancer. Pilot studies in squamous cell carcinoma of the head and neck and non-small cell carcinoma of the lung (NSCLC) were commenced in January 1985 and completed in April 1991, when multicentre randomized controlled trials were commenced. The probability of local tumour control at 3 years in T3 and T4 patients with head and neck tumours is 44% compared to 24% previously achieved. Likewise, in 76 patients with NSCLC the probability of local tumour control at 2 years is 22% compared with 4% previously. In 18–80 months of follow-up the normal tissue changes have been less than expected, except for spinal cord. New work is continuing whereby CHART is combined with radiotherapy and chemotherapy. Carbogen and nicotinamide are to be employed to overcome hypoxia which may be associated with such accelerated radiotherapy. Further quantitative measurements of normal tissues are proceeding.

Hyperfractionated accelerated radiotherapy for carcinoma of the oesophagus

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We report on 73 patients with carcinoma of the oesophagus treated by hyperfractionated accelerated radiotherapy as an update of an earlier report (Sule-Suso et al, 1991). The patients, aged 46–93 years, were considered suitable for radiotherapy on their performance status irrespective of the presence of metastases. The radiotherapy was given three times a day over 2 weeks with a minimum of 3 h between treatments. The treatment was well tolerated acutely and to date there have been no unacceptable long-term side-effects. Dysphagia was improved in 54 (74.0%) patients for a mean of 40 weeks (range 2–206). Product-limit survival for all 73 patients was 34.7%, 20.4%, 14.6% and 7.3% at 1, 2, 3 and 4 years, respectively. Product-limit survival for those without obvious metastasis was 46.4%, 31.2%, 22.2% and 16.7% at 1, 2, 3 and 4 years, respectively. We conclude that this regime is feasible within the normal working day, well tolerated, effective and the short overall treatment duration desirable.

Reference

SULE-SUSO, J., BRUNT, A. M., LINDUP, R. & SCOBLE, J. E., 1991. Hyperfractionated accelerated radiotherapy for carcinoma of the oesophagus. *Clinical Oncology, 3,* 209–213.

Early changes in flow and pH of saliva when treating with radiotherapy

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The early changes in salivary gland function of 47 patients undergoing radical radiotherapy (37 continuous hyperfractionated accelerated radiotherapy (CHART) and 10 conventionally fractionated treatment) for head and neck cancer have been studied. Resting whole saliva and stimulated parotid saliva have been collected from these patients before, during and up to 12 weeks from the start of treatment. Marked falls in salivary flow can be detected within a week of the start of treatment and the fall is more marked for the stimulated parotid flow as opposed to the resting whole flow which is predominantly the product of the submandibular glands. The reduction in parotid flow is related to the proportion of the gland in the treatment volume and the dose it receives. Corresponding falls in salivary pH are found. The early effects of radiation on salivary gland function is as marked and is seen earlier in the patients receiving CHART compared with those treated by conventionally fractionated radiotherapy. We have

previously demonstrated a greater preservation of late parotid function in patients treated by CHART as compared with conventionally fractionated radiotherapy. This cohort of patients is being assessed further in follow-up to determine any relationship between early and late changes in function.

Tumour cell kinetics in lung cancer

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In vivo tumour cell kinetics were performed in 28 patients with lung cancer. 200 mg bromodeoxyuridine (BUdR) were administered by intravenous injection 6 h prior to surgery. Resections were performed in 25 cases but in three biopsy only was possible. Immediately adjacent samples were taken for analysis by flow cytometry and for immunohistochemical staining for incorporated BUdR. Of 27 non-small cell lung cancer patients, only four were diploid. The median potential doubling time was 7 days, duration of S-phase (T_S) 15.3 h and labelling index (LI) 8.3%. In 17 patients multiple samples were taken from the resection specimens and showed the doubling times in the periphery of the tumours to be significantly faster than in the centre (median values 5.7 and 8.0 days). The LI was also significantly higher in the periphery (median values 9.6% and 7.7%). Light microscopic examination showed heterogeneity of tumour cell labelling. Manual cell counting gave average LIs (median 19%) higher than those obtained by flow cytometry. Maximum and average LIs combined with the T_S obtained by flow cytometry gave faster doubling times, median values 1.2 and 3.5 days, respectively. Studies with antibodies to Ki67 and PCNA were compared with the BUdR results and the kinetic indices were correlated with outcome.

Tumour proliferation assessed by combined histological and flow cytometric analysis: implications for therapy in squamous cell carcinoma in the head and neck

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The two techniques of flow cytometry analysis (FCM) and immunohistochemical localization of bromodeoxyuridine (BrdUrd) incorporation after *in vivo* administration, were combined to study proliferation in squamous cell carcinoma of the head and neck region. Care was taken in this study to ensure that similar material was processed using both techniques such that comparisons could be made. FCM underestimated the labelling index (LI) in tumours classified as diploid compared with the histological evaluation of the tumour cells within those tumours (4.6% *vs.* 17.1%). However, in aneuploid tumours, the FCM LI (10.7%) was similar to that obtained from histology (13.5%). Indeed, proliferation assessed by the combination of histology LI and FCM duration of S-phase (T_S) indicated that diploid tumours had a shorter median potential doubling time (T_{pot}) of 2.1 days compared with aneuploid (2.8 days). Despite the heterogeneity of proliferation evident histologically within the specimens, there was not a wide variation in the results of FCM analysis when multiple samples from resections were studied. Using FCM data alone, 46% of the tumours showed a T_{pot} of less than 5 days. When the T_S from the FCM data was combined with the average histological LI, 84% were less than 5 days and with the maximum LI, 99% were within this time interval. Compared with previous estimates, the proportion of tumours possessing proliferative characteristics indicating the need for acceleration of treatment seems to be much larger.

TGFß$_1$, collagen I and III gene expression in human skin fibrosis induced by therapeutic irradiation

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The genetic aspects of radiation-induced fibrosis in humans have not been well characterized. We studied collagen Type I, III and transforming growth factor ß$_1$ gene expression in dermal skin samples from women with no evidence of local disease after prior irradiation therapy for breast cancer. The samples were obtained surgically 7 months to 4 years (irradiated dermis = ID) and 20 years (late fibrosis = LF) after treatment, and compared with unirradiated skin samples (control dermis). We used a modified "rapid" Chomczynski method to extract total RNA from powdered frozen tissue samples. Northern blot analysis and successive hybridizations were performed. (1) Total RNA was 2–3 times higher in irradiated tissues. In "early fibrosis" (ID), this corresponds with the increased cell proliferation. In (LF), however, since few cells are present, elevated RNA levels could correspond to increased cellular metabolism. (2) Collagen I and III genes are highly expressed (2–3 times) in both ID and LF, probably following increased transcrip-

tion of the genes. (3) TGFß$_1$ is overexpressed in both ID and LF (2–3 times, respectively). We propose that in highly cellular ID, TGFß may be secreted by various inflammatory cells, while in LF fibroblasts, autocrine stimulation may play a predominant role.

Significance of carbohydrate metabolism control during pre-operative beam therapy of colorectal cancer on the background of short-term artificial hyperglycemia and synchronization of tumour cells on division cycle

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Growth of malignant tumours, morbidity of rectum and dissatisfaction with treatment results, especially of spread, forces elaboration of combined methods of treatment by using the most up-to-date achievements in radiobiology and experimental oncology. A new method of combined treatment of locally spread rectum cancer (T_{4b-1} M_0) using effects of short-term artificial hyperglycaemia and synchronization of tumour cell division rhythm on division cycle with 5 FU was worked out in the Oncological Research Centre. The treatment programme foresees the following succession of events: (a) synchronization of tumour cells by division cycle; (b) pre-operative beam therapy in the regime of dose dynamic fractioning; (c) short-term artificial hyperglycaemia; and (d) operation. If necessary adjuvant chemotherapy is also used in the pre-operative period. Our experience proved the high effectiveness of the method. Realization of short-term artificial hyperglycaemia necessitates the definition of glucose tolerance in these patients. The need for carbohydrate metabolism control was confirmed by diabetes mellitus in 14% cases. Tolerance test revealed 32% of patients with latent diabetes mellitus. High frequency of diabetes in patients with rectum cancer prevents artificial hyperglycaemia in those patients who need special pre-operative treatment as well. Retrospective analysis of case histories of patients with rectum cancer with accompanying diabetes mellitus does not confirm the literature data about interconnection of diabetes and age in this group of patients and brings to mind a defensive mechanism of carbohydrate metabolism in patients with rectum cancer.

Functional state of antioxidant system under the influence of low doses of radiation

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We have studied the state of the antioxidant system in liquidators of the consequences of Chernobyl AES crash 4–4.5 years ago and the effect of radiation influence in doses of 20–25 rem. The significant changes were observed in the thioldisulfide system which displayed by prevailing of reduced equivalents. The increasing of SH/SS ratio was revealed both in protein and non-protein fractions of whole blood. At the same time the functional state of ascorbic redox system was characterized by oxidated components in plasma. Increased activity of catalase and glutathionreductase and reduced activity of superoxidedismutase were established in most patients. The level of malonic dialdehyde in blood was significantly raised in all cases. Thus, the adaptational failure of the antioxidant system may be regarded as one of the leading links in pathogenesis of damage by low doses of radiation. It may lead to development of various organ's pathology. Changes in thioldisulfide system may facilitate proliferation, differentiation disorders and neoplastic processes. On the basis of achieved results we are able to propose a pathogenetically founded metabolic therapy for the consequences of low doses of radiation with the employment of antioxidants.

4.15 – 5.30

Advances in Imaging the Liver

Hall 9

Imaging of liver tumours: Japanese experience in detection and characterization

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With advancement of non-invasive imaging modalities there has been a great progress in the detection and characterization of liver tumours. In Japan where hepatocellular carcinoma (HCC) is one of the most important cancers, non-invasive imaging diagnosis is positively applied to many patients especially at high risk of HCC to pick up tumours as small as possible. Ultrasound and/or incremental dynamic computed tomography (CT) actually detect many hepatic masses which need a correct diagnosis, if possible, with imaging alone. Thus single level dynamic CT, magnetic resonance (MR) imaging with or without Gd-DTPA, and colour Doppler have been used for this purpose. On the other hand, meticulous imaging techniques including a combination of non-invasive modality with angiography (lipiodol CT, CT during arterial portography, and ultrasound with CO_2) have also been developed for the detection of tiny lesions or for the characterization of liver tumours and non-cancerous hepatic lesions. In this lecture (1) detection of small liver cancer and (2) characterization of hepatic mass among HCC, cavernous hemangioma, metastatic tumour, cholangiocellular carcinoma and non-cancerous hepatic lesions will be discussed mainly based on the Japanese experience of CT, MR imaging and ultrasound.

Round flow defects in CT arterial portography — a potential pitfall in interpretation

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Recent clinical studies have demonstrated improved survival after resection of primary and secondary liver tumours. In order to select appropriate patients for surgery, accurate pre-operative evaluation of the liver is essential. Computed tomography (CT) with arterial portography (CTAP) has been shown to be more sensitive than conventional contrast-enhanced CT, CT with iodized oil or CT arteriography for the detection of focal liver lesions. A high incidence of perfusion defects has been reported with CTAP. These can be peripheral and wedge-shaped, geographical or may involve the whole of the right or left lobes (the "straight line" sign). In a series of 22 patients undergoing CTAP in our hospital, 18 of whom went on to have surgery, CTAP detected 92% of liver tumours compared with conventional contrast-enhanced CT which detected only 69%. Flow artefacts were detected in 82% of cases. These consisted of 14 geographical defects, six wedge-shaped defects and four cases of the straight line sign. In four cases, however, round flow defects mimicking tumours were seen. Intraoperative ultrasound and histological examination were negative for malignancy in these cases. To our knowledge, round perfusion defects have not been reported with CTAP previously and represent a potential cause of false-positive results. We conclude that round perfusion defects do not necessarily represent tumour deposits and should be investigated further before a patient is denied potentially curative surgery.

Dynamic and delayed contrast-enhanced MR scanning of hepatic haemangioma

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Liver haemangiomas, particularly large tumours with central necrosis and cystic change, still present a diagnostic challenge. Dynamic and delayed scanning after intravenous contrast enhancement has improved diagnostic specificity with computed tomography (CT). Similar techniques have not been applied to magnetic resonance (MR) because of long scan times. We report the use of a rapid acquisition

spin-echo (RASE) sequence which obtains 3–5 slices in 20 s, thus enabling the acquisition of sequential breath-holding abdominal scans following injection of intravenous Gd-DTPA. Preliminary work was performed to optimize the flip angle. 27 patients with hepatic haemangiomas were studied by ultrasound (US), dynamically enhanced CT and by MR. T_1-weighted spin-echo (SE) with electrocardiogram triggering and T_2-weighted SE sequences were performed. Sequential breath-holding RASE scans were performed at 2 min intervals for 15 min after injection of Gd-DTPA. Measurements of tumour signal intensity were made during enhancement and the enhancement time curves are described. Tumour appearances and enhancement characteristics were compared with US and CT and the results are reported. Using this technique MR is as sensitive and specific as CT and more specific than US. MR showed segmental involvement of tumour in the liver more reliably than either CT or US and therefore may be the imaging modality of choice for pre-operative assessment.

The detection, localization and characterization of hepatic mass lesions with MRI at 1.5 T

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Recent advances in computed tomography (CT) and magnetic resonance imaging (MRI) have greatly improved the detection and characterization of hepatic mass lesions. The subcentimetre lesion can now be regularly demonstrated and mass lesions can be characterized reliably. The role of pharmaceutical contrast agents both non-specific and targeted will play an increasingly important role in both lesion detection and characterization. Advances in surgical techniques now mean that patients with primary hepatoma and in certain cases, patients with metastatic liver disease are no longer considered as unsuitable for a potentially curative operation. For example, 5 year survival rates in operated patients with a suitable number and distribution of metastases from colorectal primaries, approach 30–40%. The precise radiological staging of hepatic neoplasms will become an increasingly routine request. This study addresses the following questions in relation to a series of 50% patients referred for radiological assessment of suspected hepatic mass lesions: (1) global detection of hepatic mass lesions; (2) individual lesion detection; (3) individual lesion characterization and (4) staging for possible surgical resection. The quantitative and qualitative results will be presented and discussed.

Differential diagnosis of space occupying lesions of the liver with MR imaging

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In a retrospective study we reviewed the records of 112 patients who underwent magnetic resonance (MR) examination of the liver. In 84 of them with a definitive diagnosis we studied 152 lesions, *i.e.* 48 hemangiomas, 54 secondary deposits, 23 hepatomas, 17 hydatid cysts, eight simple cysts, one abscess and one focal fatty infiltration. Parameters evaluated were the margin, capsule, shape, internal architecture and signal intensity. The following are the results in the most important of them. Hemangiomas: had smooth margins in 97.5%, no capsule, round or oval shape in 90%, homogeneous architecture in 96%, low density on T_1-weighted in 87% and very high density on T_2-weighted in 94%. Secondary deposits: had smooth margins in 59%, no capsule, round or oval shape in 78%, homogeneous architecture in 61%, low density on T_1-weighted 94.5% and 80% high density on T_2-weighted. Hepatomas: had smooth margins in 52.3%, complete or incomplete capsule in 43.5%, round or oval shape in 56.5%, inhomogeneous architecture in 91%, low density in 61% on T_1-weighted and high density in 87% on T_2-weighted. In conclusion, MR imaging is a very helpful method in the differential diagnosis of space-occupying lesions of the liver.

CT-fluoroscopy (CTF) in the diagnostic and therapeutic approach to hepatic lesions

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We have coupled a digital subtraction image intensifier to a computed tomography (CT) scanner. The patient is lying on the CT table and a usual Seldinger manoeuvre is performed for positioning the angiographic catheter into the superior mesenteric artery. Then a CT arterial portography is performed so that the liver is opacified from the portal system. After that a complete angiographic study is carried out; the X-ray unit is provided with a tape recorder and a multiformat camera for the documentation. If necessary, a pre-surgical or definitive chemoembolization can be carried out in the same session and CT provides an immediate control of the path of the emboli. This method has shown some advantages: (a) it allows the real-time fluoroscopic control of the angiographic manoeuvres; (b) it reduces the

time requested for the two studies; (c) the entire procedure can be carried out in one room without moving the patient; and (d) it allows a smoother handling of patients at risk.

The liver surface in cirrhosis

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Ultrasound diagnosis of cirrhosis of liver is fraught with difficulty because many of the signs commonly described are observer dependent. We present results of a prospective study in which patients with cirrhotic livers were assessed by additional examination of the anterior surface of the liver by 7.5 and 10 MHz frequency. The normal liver surface presents as a bright line due to specular reflection. Established cirrhosis causes irregularity in the liver surface which scatters ultrasound and this is manifest as a "broken" bright line or an undulating line. We shall attempt to correlate the ultrasonic liver appearances with biopsy findings, where available. We feel that ultrasonic examination of the surface of the liver is a useful adjunct to the routine liver examination in cirrhotic patients.

Liver fat estimation using magnetic resonance imaging

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We report early experience with a novel application of magnetic resonance imaging (MRI) to estimate the degree of liver fat infiltration. This technique is based on the 220 Hz difference in the resonant frequency of fat and water at 1.5 T. We have combined a chemical pre-saturation radiofrequency (RF) pulse centred on the resonant frequency of water with RF receive filters centred on the resonant frequency of fat to create an image comprising only the fat components of the body. 14 patients being investigated for biliary disease were studied. All patients had an MRI study within 48 h of a standard liver biopsy. The biopsy specimens were graded for the degree of fat infiltration (absent, mild, moderate, severe according to the number of fat vacuoles per high power field). The magnitude of the liver fat signal was measured using regions of interest (ROI) positioned peripherally over the right lobe, with background noise subtraction (an equivalent ROI positioned along the same phase encoding lines). At least 15 ROIs were measured and the mean value obtained. All patients with absent liver fat had signal intensity measurements of less than 25 units. There was a trend in which the more marked degrees of fat infiltration were mirrored by increasing signal intensity. This simple technique may provide a non-invasive method of liver fat estimation.

Sonography versus scintigraphy in chronic liver disease due to hepatitis B/schistosomiasis

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To compare ultrasonography with colloid scintigraphy in chronic liver disease (CLD) due to hepatitis B and/or *Schistosomiasis mansoni*, 412 patients were examined. All cases showed biochemical evidences of CLD, which was verified histologically in 234 patients. The aetiologic factors derived from liver biopsy, serology or sonography were virus B in 141, schistosomiasis only in nine, a mixture of both entities in 178 and were undetermined in 84 cases. Sonography provided specific features for schistosomiasis in 173 out of 370 patients with non-specific scintiscans (47%). However, it was less reliable in cirrhosis as it missed 69 out of 331 cases with characteristic scintiscans (21%). Scintigraphy was inferior to sonography in detection of ascites and missed 54 out of 96 cases with positive sonoscans (56%). There was no correlation between the portal vein diameter on sonoscans and the percentage portal venous flow estimated by dynamic colloid scintigraphy ($r = 0.09$, $p > 0.05$, $n = 122$). There was a significant association between extra-hepatic colloid shift on scintiscans and disease activity on liver biopsy ($p < 0.0001$) with scan sensitivity of 84%. In conclusion, both tests perfectly filled the diagnostic gaps of each other and are recommended for routine assessment of CLD due to hepatitis B/schistosomiasis.

Quantitative volumetric study of the liver

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All patients undergoing liver surgery are studied to assess the exact staging of the disease. All imaging techniques now available (ultrasound, computed tomography (CT), CT-LUF and CT-arterial portography (CT-AP)) are applied for determining the number, site, diameter and vascular

relationship of the tumour and its satellite nodules. When performing CT-AP, we usually evaluated the hepatic volume of the whole liver and of the tumour nodules. This procedure is very important in liver transplantation, as it allows an optimization for using the donors' organ, and in hepatic surgery, as it is likely to correlate the percentage of resected non-neoplastic parenchyma to the pre-surgical functional tests to give a predictive index of the remaining liver function and the regenerative index. In all cases of liver transplantation we compared our measurements with the actual weight of the explanted liver which was provided by the pathologist.

Notes

4.15 – 5.30

Audit, Teaching and Management Approaches in Radiology

Hall 10a

A computer-assisted method for teaching basic radiology

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Computer-assisted instruction (CAI) has been enthusiastically received in a number of areas of medical teaching not least because it encourages the student to take an active part in his/her own education. The presentation of images for radiology teaching offers a difficult challenge to the CAI process which has been only partially overcome by digital techniques such as interactive video-disc. A novel system has been developed employing a back-illuminated X/Y digitizer interfaced to a microcomputer running commercially available authoring and graphical software. This allows the use of standard radiographs in which anatomical or pathological features can be identified by mapping co-ordinates in relation to a fixed reference point. The student follows the text of the CAI module on a computer screen and is asked to point to these features using a cursor. Two teaching modules have been devised so far; one on lobar pneumonia and one on basic CT anatomy of the mediastinum. It is proposed to design a "shell" programme to enable modules to be written by radiologists with no computer expertise. The potential of the system will be demonstrated and results of an evaluation presented.

Awareness of the POPUMET regulations at a teaching hospital and medical school

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The Ionizing Radiation (protection of persons undergoing medical examination and treatment (POPUMET) Regulations 1988 set out a core of knowledge in radiation protection which is designed to ensure that patient exposures to ionizing radiation conform to the ALARA (as low as reasonably achievable) principle. This study has assessed understanding of the core of knowledge published by the local health boards amongst clinicians at a group of teaching hospitals and students at their affiliated medical school, by means of an anonymous multiple choice questionnaire. The results are presented in relation to stage of training, "user category" and possession or otherwise of a POPUMET certificate, and the implications for effective training in this area are discussed.

Clinical audit — developing solutions for the unreported film

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While general agreement exists amongst radiologists that all radiological examinations should be reported, it is recognized that this ideal is rarely attained. Computerized patient data allows precise quantification of reporting practices. The extent to which this goal was achieved in our department was assessed by audit of reporting practices over a 1 month period. For each of 14 examination areas the time taken for reports to be issued and incidence of unreported examinations was recorded. Of 7262 examinations performed in June 1991, 2251 (31%) were recorded as unreported. 75% of these unreported examinations were mobile and outpatient chest radiographs, casualty examinations and coronary angiograms. The unreported rates for each of them were chest X-rays (43%), mobiles (92%), coronary angiograms (76%) and casualty examinations (30%). The average unreported rate for remaining areas was 5%. True failed reporting most commonly resulted from failure of film retrieval. Incorrect data entry was responsible for a high incidence of apparent failed reporting. Failed entry of reports by operating cardiologists accounted for almost all unreported coronary angiograms. Changes implemented in film retrieval and computer data entry have substantially reduced unreported rates. To simplify and increase efficiency of coronary angiogram reporting, a new computer program is being developed. We conclude that computer-assisted clinical audit is of value in improving reporting practice.

Systematic audit of radiology reports by computer link with a pathology computer

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The White paper requires standards of quality as well as efficiency to be established by providers to allow purchasers a more rational choice than merely by cost. In a radiological report, quality is linked to the accuracy of the examination and its interpretation. A technique is described which provides systematic and independent verification of a radiological diagnosis if either surgery or a biopsy has been performed. Over a 3 month period in a district general hospital all the histology reports were transferred to a computerized X-ray reporting system and linked to the patients' radiology reports. The histology and radiology were then automatically displayed simultaneously on a computer screen for review by a radiologist. Cases of interest, disparity or confirmation were stored for later analysis. Of 1850 histology reports, 700 corresponding patients were found on the X-ray system. 96 cases of interest were identified of which 61 were helpful confirmation of a suggested diagnosis. A discrepancy was noted in 22 cases including four cases of appendicitis missed on ultrasound and five of mild colitis. Three cases showed up significant clinical management issues. Eight cases of negative histology despite a strong X-ray diagnosis were likely to result from an inadequate specimen. The ability to create a computer link as described depends on co-operation with software firms but need not be expensive with total costs of £900. Additional validation using ICD9 codes and potential further developments are also discussed.

The cost-effectiveness of duplex scanning in peripheral vascular disease

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Duplex scanning is a non-invasive method of assessing the femoral and popliteal arteries with an accuracy of 98% and 96% for detecting SFA/popliteal occlusions and stenoses respectively in our institution. In patients with symptoms of claudication not severe enough to merit bypass graft, duplex scanning can satisfactorily identify lesions morphologically unsuitable for angioplasty and thus avoid unnecessary angiography. 502 patients who presented for their first arteriogram to Bristol Royal Infirmary between December 1990 and December 1991 were assessed. These included patients with both iliac and SFA/popliteal disease and with symptoms ranging from intermittent claudication to rest pain and gangrene. 348 of these arteriograms were claudicants with SFA and popliteal disease. 163 of these had a bypass graft, 123 had an angioplasty and 62 had no surgical or radiological intervention. 123 patients had Gruntzig dilatation and 62 had neither bypass graft or angioplasty. Scans would have needed to be performed on all these patients with a cost of £9250 (£50 per duplex scan). A transfemoral arteriogram costs £330. 62 patients would not require angioplasty (£20 460). The total cost saving is thus £11 210. We conclude that duplex scanning of the superficial femoral and popliteal arteries is cost-effective and approximately 20% of claudicants with SFA/popliteal disease would be saved unnecessary arteriography.

Audit of MRI for internal derangement of the knee

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Magnetic resonance imaging (MRI), when available, is generally accepted as the primary imaging modality in the investigation of internal derangement of the knee (IDK). It has a reported sensitivity ranging from 69% to 88% and a specificity ranging from 57% to 84% in different series. Reasons for this variability include differing observer experience and non-standard imaging protocols. In our centre, once we had identified a suitable imaging protocol, MRI (0.5 T) replaced arthrography as the primary investigation of IDK. We have audited 250 consecutive examinations using our standard protocol: sagittal T_2-weighted GE 3 mm slices with interleaving slices through the intercondylar notch, coronal T_2-weighted GE 5 mm slices and axial T_2-weighted GE 5 mm slices through the patella if the patient had anterior knee-pain and compared the MRI findings with the arthroscopic findings. All films were reported by two radiologists. The pitfalls, errors and discrepancies with arthroscopy will be discussed. The sensitivity and specificity in our unit will be presented.

A protocol for radiological investigation of the renal tract: 1 year on

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Owing to constantly increasing demand for intravenous urography (IVU), and the necessity for radiation protection practice, we devised a protocol to help referring clinicians choose between IVU and ultrasound scan of the renal tract. Where appropriate, a plain radiograph of the abdomen was advised. The protocol was widely discussed with referring

hospital clinicians and general practitioners prior to its introduction. The result of the introduction of the protocol was a 40% reduction in the number of IVU examinations performed during the following year. However, the number of requests then began to increase again and therefore we decided to audit the IVUs performed over a 6 month period to re-assess the effectiveness of the protocol. 189 IVU examinations were reviewed and the results are presented in the form of colour bar charts and pie graphs which illustrate the origin of the requests, main indications and findings. The indications were assessed for diagnostic yield and we concluded that the largest single group of IVUs with a low diagnostic yield were those performed for investigation of urinary tract infections and that we should enforce our protocol more vigorously as these would then be avoided.

The use of the CT scanner in ophthalmology

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An audit of 113 computed tomography (CT) scans carried out over a 12 month period was performed. The clinical details, scan result and patient outcome were assessed. 54% of the scans were requested to exclude other pathology. These scans were expected to be negative. 88.5% of these were indeed normal and of the remainder only one showed significant pathology. 46% of the scans were expected to yield a positive result such as an intracranial lesion, thyroid ophthalmoplegia, foreign bodies and tumours. 89% of this patient group yielded abnormal scans. This study demonstrates a high correlation between clinical expectations and CT findings. It is an overused investigation when the clinical probability of a lesion is low. We propose a series of guidelines for optimal use of CT scanning in ophthalmology.

Audit of mesenteric angiography for gastrointestinal haemorrhage

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We reviewed our cases of mesenteric angiography for gastrointestinal haemorrhage over the last 18 months. All our patients presented with acute haemorrhage and half the patients were haemodynamically unstable. We had a detection rate for the cause of haemorrhage in 90%. One third of our patients died during their admission. Angiodysplasia was the commonest cause of haemorrhage with warfarin being an important related factor. There were two false negative reports attributed to inexperienced radiologists. There was little agreement between the findings at angiography, surgery and pathology. We conclude that this group of patients require early referral for angiography by an experienced radiologist.

A simplified approach to the antenatal diagnosis of skeletal dysplasias

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In order to develop a systematic approach to the antenatal assessment of skeletal dysplasias we initially reviewed our experience at Queen's Medical Centre, Nottingham. Over a 4 year period 10 cases of skeletal dysplasias were encountered. The commonest was thanatophoric dysplasia — four cases, followed by one case each diastrophic dysplasia, camptomelic dysplasia, short rib polydactyly syndrome, achondroplasia, focal femoral dysplasia and the Jarcho Levin syndrome. An accurate diagnosis was made in nine out of 10 cases. We used this experience together with a literature review of the most frequent skeletal dysplasias to produce an algorithm for their assessment. The algorithm will be presented and involves a critical evaluation of the whole fetus. Emphasis is placed initially on the assessment of the distribution and degree of limb shortening together with the presence of bowing whether angulated, rounded or due to fractures. This is followed by an evaluation of the hands and feet looking for polydactyly, abduction of the thumb and talipes. In the face — facial clefting, micrognathia and frontal bossing. The fetal chest is scrutinized for reduction in chest size, the head for hydrocephalus and spine for demineralization and scoliosis. We present this algorithm as a logical and simplified assessment of skeletal dysplasias.

4.15 – 5.30

Teach-in: Thrombo-embolic Phenomena in Clinical Angiography — Role of Materials and Technique

Hall 10b

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Thrombo-embolism represents one of the most important complications of clinical angiography and may be disastrous. New attention has been focused on the subject since the suggestion emanating from the USA that non-ionic contrast agents might be implicated in the aetiology. Indeed, in the USA, one of the greatest controversies in the history of radiology has raged over this question. In fact, the role of contrast agents of all kinds is essentially an inhibitory one whereas catheters and guidewires represent (variably) thrombogenic foreign bodies inserted into the bloodstream. The role of materials, including contrast agents, and technique in the aetiology of this important complication will be discussed in detail.

4.15 – 5.30

Radiobiology Day: Session III

In memory of Dr N. McNally

Hall 11b

EORTC fractionation trials in head and neck cancer

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The EORTC Radiotherapy Group has performed a series of fractionation trials to explore the potential therapeutic gain of: (1) multiple fractions per day radiation in combination with high daily doses of an hypoxic cell sensitizer by reducing the number of treated weeks from seven to three with the same overall treatment time; (2) delivering higher radiation doses by reducing the dose per fraction from 2 to 1.15 Gy and increasing the number of fractions from 35 to 70; and (3) reduction of the overall treatment time from 7 to 5 weeks with multiple fractions per day. The hypoxic cell sensitizer misomidasol was tested in the three-arm trial comparing conventional fractionation alone with both multiple radiations per day and with multiple radiations per day in combination with misomidasol. This trial demonstrated that it was possible to give the treatment more concentrated with no increase in late toxicity and a similar local control, no gain has been seen from adding misomidasol to this treatment. The next hyperfractionation trial was carried out in patients with an oropharynx tumour. This trial demonstrated that an increased control can be achieved without an increase of late normal tissue toxicity. At present the accelerated fractionation trial is still going on. The preliminary results of this trial demonstrated that reduction of the overall treatment time is certainly possible without an increased late toxicity. An interesting aspect of this trial is the measurement of the potential tumour doubling time. Preliminary results are suggesting that selection of patients based upon the individual tumour growth rate for accelerated fractionation or hyperfractionation will increase the therapeutic efficacy of radiotherapy.

Hyperfractionated radiotherapy of head and neck cancers —preliminary results

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In the period January 1988 to June 1991, a total of 107 patients was irradiated hyperfractionally for cancer of the head and neck region. The mean age at the beginning of therapy was 55.6 years, the mean Karnofsky performance status 7.4. 69% of the patients had been operated on before, the remaining 31% had no pre-treatment. The T-classification was: T1 19.63%, T2 31.78%, T3 20.56% and T4 28.04%. The N-classification was: N0 40.19%, N1 18.69%, N2 34.58%, N3 6.54%. There were no distant metastases found. 44.86% of the patients had a cancer of the cavity of the mouth, the remaining of the oropharynx. 97 patients received standardized hyperfractionated radiotherapy with single doses of 1.2 Gy twice daily up to a total dose of 82.8 Gy. In the others, radiotherapy was abandoned due to deterioration of general status or intolerable acute side-effects. We observed a complete remission in 58%, a partial remission in 13% and a primary progression in 25% of the patients. In the remaining ones the local tumour status was not achievable. Using the Kaplan–Meier estimate we observed an overall 2-year survival of 52.2% (cavity of mouth 68.1% oropharynx 40%; this difference was statistically significant). Prognostic factors were T- and N-classification, the UICC-stage, the duration of therapy and the delay between biopsy and start of radiotherapy. Compared with a similar collective of conventionally treated patients (single dose 2 Gy once a day, total dose 70 Gy), we saw no difference in survival at any stage or localization. There were some more acute reactions in the mucous membranes, but a sparing effect in late reactions in the skin or subcutaneous tissues.

Prognostic factors for acute and long-term side effects after radiotherapy of head and neck tumours

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In the period October 1983 to June 1991, a total of 308 patients was irradiated for cancer in the cavity of the mouth or in the oropharynx. 126 of them received a total dose of 60 Gy in 30 fractions, 88 a total dose of 70 Gy in 35 fractions once a day and the remaining 94 patients were treated hyperfractionally twice a day with 69 fractions making a total dose of 82.8 Gy. We recorded the acute reactions of the skin and the mucous membranes and the late reactions of skin, subcutaneous connective tissue and salivary glands during follow-up. Using non-parametric tests no correlation was found between acute skin reaction and single or total dose; a positive correlation, however, between acute reactions of the mucous membranes and the use of small single doses and the total dose. Late reactions of the skin and subcutaneous tissue correlated negatively with the total dose, those of the salivary glands, however, positively. Using hyperfractionation we observed some more acute reactions in the mucous membranes but had a reduction of the late reactions of the skin and subcutaneous tissues.

Logical presentation and mechanical analogies in the development of mucositis in the oral cavity

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This is a way of depicting the function of interdiction on the geometrical model in the Boolean space (M). This is a distributive screen. If we indicate the erythema with "a", the oedema with "b", the epithelolysis with "c" etc., respectively in the presence Stage I of mucositis (p), in Stage II - (q) and in Stage III — with "r", each element of the space and each combination of the meaning of the characteristics of mucositis being represented by a separate cell. If $a = 1$, $b = 0$ and $c = 0$, we can write down this with a $a \wedge \bar{b} \wedge \bar{c}$ or else corresponds to the vector 1-0-0. This means that we have a Stage I mucositis and cannot have a Stage II or III. If $ab\bar{c}$ ($a \wedge b \wedge \bar{c}$), then $a = 1$, $c = 0$ and $b = 1$ and it is not possible to have a Stage III mucositis. The surface energy (E) of ionizing radiations appears as a universal function of speed (V) in the development of ulceration. In the development of ulceration, two kinds of fluctuations are observed: (1) mechanical (the epithelium area (A) a coefficient of friction, speed of growth of the epithelolysis (V), bending of the epithelium (c)); and (2) dose (energy-caused) fluctuations (resistance of the tissue (R), the force of energy transformed into an increase of the temperature (i), a magnitude contrary to the condensation capacity ($1/C_0$), induction for the formation of elastically folded edges of the ulceration (L). In figure can be seen the sequence of the graphical representation of the stages of the formation of ulceration. These useful analogies render practical guidelines for the inclusion of parenteral feeding.

Non-specific cellular resistance disorders induced by low doses of radiation

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Some integral proofs of non-specific cellular resistance were studied in liquidators of the consequences of Chernobyl AES crash 4 4.5 years ago exposed to radiation influence of 20 25 rem. The share of blood mononuclears with viral inclusion bodies and degree of its viral effect, metabolic and phagocytic monocyte activity in the NBT-test were appraised. A lysosomal-cationic test was used to reveal the functional state of granulocytes. It was established that in all patients influenced by low doses of radiation there was increased evidence of viral effect of mononuclears in comparison with control group of healthy donors. At the same time most liquidators had functional defects of monocytes and granulocytes. Consequently, there may occur non-specific (antiviral) cellular resistance disorders under the influence of radiation low doses which in turn may lead to development, unfavourable course, chronization of infection diseases, forming of immunocomplex pathology, neoplastic processes. (Olifen, Interlock).

Measurement of normal cell radiosensitivity — a possible path to improve tumour cure?

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Tumour control probability is related to the total dose delivered, but this dose is often limited by the tolerance of the surrounding normal tissues. More specifically, maxi-

mum doses are determined by a minority of patients who sustain significant, morbid normal tissue damage. Identification of this group of patients might allow dose increase in the majority, with potential increase in local control and cure, possibly by as much as 20%. In an attempt to utilize cellular radiosensitivity measures as a potential predictive assay of tissue response, fibroblast strains from seven patients have been irradiated at high dose-rate, and low dose-rate. Five of the strains showed similar relative recovery with low dose-rate. Two strains showed no recovery and these two were raised from patients who suffered severe normal tissue reactions to clinical radiotherapy. A further series of nine fibroblast strains from patients with a spectrum of well-defined radiation reactions is now being studied. Any relationship between normal tissue radioresponsiveness and relative cellular sensitivity in these patients may provide the basis for improved results from individualization of radiotherapy schedules.

Notes

Wednesday 20 May

9.00 – 10.15

Mammography — Quality Control and Screening

Hall 9

Excellence our only aim — total quality management in mammography

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The nature of breast cancer as an important and emotive cause of death and disease sharpens the motivation of those working in this field to raise standards of film quality and patient care to the very best levels that can be obtained. The variation in the results of trials indicate that there are aspects of quality that are critical to the implementation of a breast-screening programme, and may be the difference between effective mortality reduction and none at all. Quality principles must extend throughout the different professional disciplines involved so that there are no weak links in the quality chain. Pathology, surgery and radiotherapy are as much a part of this as the imaging disciplines. The quality culture must run through the service as a common belief so that clients, patients and their doctors perceive the high and caring standards of the organization. The Epping breast screening service has chosen to develop this culture by applying for registration under BS5750, a commercial quality standard. This is assessed by outside auditors, the British Standards Institute, who award the kite mark to registered companies.

National self-assessment of radiologists' film reading performance in breast screening

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A national self-assessment programme of radiologists' film-reading performance has been established by the NHSBSP and the Royal College of Radiologists. This programme will enable each radiologist involved in screening to learn how they interpret sets of known cases. This paper presents the full results of a trial carried out in three regions. A set of screening mammograms which encompass a diverse range of screening appearances has been established from screening training centres and a gold standard of radiological intepretation obtained. Individually some 40 screening radiologists in the three regions have reviewed these cases and measures of their film-reading performance recorded. Performance indices monitored include the number of cases recalled for assessment; sensitivity and specificity; identification of key radiological features; and ROC measures of detection and classification ability. Furthermore the data analyses allow identification of areas where an individual has particular difficulty which then permits the suggestion of appropriate revision strategies. Results demonstrate overall good performance of the participant radiologist in classifying the cases as compared with the gold standard. This self-assessment programme is currently being extended nationally.

Breast cancer and screening Asian populations

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Suggestive information from the national breast screening programme indicates that breast cancer is less prevalent amongst Asian than non-Asian women. This paper reports research which investigates whether this reflects a poorer attendance at screening centres or whether Asian women have a lower incidence of breast cancer. Data from two breast-screening centres over the past 2 years were reviewed. Information for some 17 500 women was examined and ethnic origin determined by a standardized name examination technique. Overall attendance rate was 69.1%. Non-Asian attendance rate was 71.3% and Asian 52%. Attendance rates at one centre were 67.4% overall; Asian 42% and non-Asian 69.9%. Overall attendance at the

second centre was 71%; with Asian 56% and non-Asian 72%. Additionally marked variation was found for attendance rates dependent on GP practice (range 39.5–81%) for both Asians and non-Asians. This demonstrates the important role of the primary care team in facilitating breast screening. Of 549 Asian women invited, 286 were screened with no cancers detected. This suggests that the actual cancer incidence is less in Asian women, within the screening age, even though fewer Asian women attend for screening.

Changes in mammographic image quality due to film processor variation

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In contrast to the majority of mammographic breast-screening programmes, film processing at this centre occurs on site in both hospital and mobile trailer units. Initial (1989) daily step-wedge tests revealed a large variation in film-processor performance at the latter. To assess the clinical significance of these findings and determine acceptance limits of processor performance, 10 abnormal mammograms were copied using high-definition 35 mm film. A range of optical densities for each original image was obtained. Copy film was then matched with test film variation using a densitometer. All films were subsequently ranked for spatial and contrast resolution. Acceptance limits for processing time (3 min $\pm$30 s) and temperature (34$\pm$1°C) were obtained. Longer times and higher temperatures are most advantageous in terms of patient dose and thus a regime of 3.5 min and 35°C is suggested as optimal. The use of film copies as a means of monitoring processor performance is discussed. Careful quality assurance has ensured steady mobile unit processor performance which is now comparable to the hospital-based unit. The advantages of on-site film processing are outlined, and its more widespread acceptance is recommended.

Image quality in contact and magnification mammography

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Magnification mammography is often used to improve visualization of fine detail, such as microcalcifications. Compared with contact mammography, the effective noise is reduced while resolution may be improved, as long as focal spot blurring does not dominate screen-film unsharpness. To investigate the interdependence of these factors affecting image quality, focal spot and screen-film modulation transfer functions (MTFs) and signal-to-noise ratios (SNRs) were measured under different magnification and scatter conditions on an IGE/CGR Senographe 600T. The MTFs were calculated from microdensitometer traces of slit images, while SNRs were determined from images of a specially designed test object containing details of varying size and contrast. Detailed results are presented which demonstrate, amongst other things, that the total MTFs for nominal magnifications of $\times$1.5 and $\times$1.85 are very similar, but better than in contact mammography. Image contrast is slightly better for $\times$1.85 magnification, compared with $\times$1.5, and is similar to that in contact mode, using a grid. However, $\times$1.85 magnification gives about a factor of two improvement in signal-to-noise ratio which, combined with the resolution data, gives optimum magnification performance for this particular type of X-ray set.

Patterns of breast calcification in patients on renal dialysis

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Patients undergoing renal dialysis have disturbed calcium metabolism which often leads to metastatic calcification. The aim of this study was to evaluate patterns of breast calcification in patients on dialysis with particular reference to the presence of any calcification which could simulate malignancy. We analysed the mammograms of 16 women on renal dialysis and compared them with a control group of 32 women attending for routine mammographic screening. We found a significant increase in vascular and parenchymal calcification in women on renal dialysis. Ductal calcifications were no more prevalent in the patients on dialysis and in no case did the calcification simulate malignancy. There were no significant correlations between breast vascular calcification and either calcium/phosphate product, PTH, duration of dialysis treatment or vascular calcification present on skeletal surveys.

Breast screening: deciphering the structure of mammographic microcalcification

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Differentiating between benign and malignant features of microcalcification in mammograms can be extremely difficult. This paper reports an investigation of the features of

microcalcification which experts consider important for differential diagnosis and the relative importance of the features for differential diagnosis. Several mammograms, for which the clinical outcome was known, were selected to represent the wide diversity of appearance of microcalcification. Experts, interviewed individually, viewed the mammograms under normal breast-screening conditions. They were asked to identify as many features as possible which they believed to be important for differential diagnosis, and scored each mammogram on every feature. Feedback was then given by calculating intercorrelations between scores, allowing an expert to identify further features to describe any differences still perceived between mammograms scored in a similar way. Common structures across experts were identified by multivariate analysis of the data for individuals; using the known clinical outcome for the mammograms, discriminant analysis was also carried out to determine the relative importance of features for differential diagnosis and the weightings that should be attached to them. The discussion examines the extent to which the common structures extracted and the relative importance and weightings of features accord with clinical experience.

Image analysis of microcalcifications in X-ray microscopy of paraffin-embedded breast tissues

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The mammographic appearance of clustered microcalcifications in breast tissue and its potential predictive value in carcinoma of the breast has long been a subject of interest. In the present investigation a retrospective study has been made of specimen blocks of paraffin-embedded breast tissues. Histological results are available. Contact X-ray microscopy of these paraffin-embedded breast tissue blocks has been performed using a low-kV X-ray unit operating at 5 kV. X-ray microscopy studies reveal clustered microcalcifications in a number of specimens in which malignancy is indicated, whilst for the specimens in which benign and non-neoplastic conditions have been observed lesser incidence of clustered microcalcifications have been noted. Digitization of radiographs has been carried out with an in-house developed image analysis system based on a PC/AT microcomputer and an 8-bit video digitizer. The image is digitized with a pixel resolution of 512 × 512 and 256 grey levels, processed and then converted into a binary image. A boundary-tracing algorithm is used to delineate the edges automatically of each calcification. Techniques are being developed to quantify individual calcification parameters such as size, perimeter and shape factor, and clustered parameters such as total number, number density and neighbour-to-neighbour distance.

Performance of mammography screening units in Finland

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Mammography screening of women aged 50–59 was initiated in Finland in 1987 and now encompasses all age groups. The first national results are available. They show quite good sensitivity and specificity. Most of the tumours are found in earlier stages. The performance of about 50 mammography screening units, including image receptors and film processing, was evaluated according to the Nordic recommendations for mammographic quality assurance. Image quality was studied with technical and clinical phantoms. Film processing was tested sensitometrically. Glandular dose was calculated from measured surface dose of 4.5 cm thick perspex phantom. Radiation risk from screening was estimated using the relative risk model of BEIR V. The main deficiencies in performance were the low power of the generators, inadequate performance of automatic exposure controls, large focal spot sizes and the use of stationary grids. These deficiencies are corrected in modern mammographic units. Optimized film processing was used in most of the screening centres. The main reasons for the wide dose range obtained were the use of slow image receptors, non-optimized film processing, high optical densities of the film and the use of an antiscatter grid.

9.00 – 10.15

Imaging and Investigation in Clinical Oncology

Hall 10a

Scrotal neoplasms — possibilities using real-time ultrasound

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More than 95% of testicular neoplasms are malignant. Testicular malignancies are seen in all age groups, but they are most common (75%) in males of 20–49 years of age. Extratesticular neoplasms are rare and almost always benign. Testicular neoplasms can be visualized by real-time ultrasound (US), but the method has been thought to be non-specific. Few papers about US findings of extratesticular neoplasms are available. We wanted to study the US findings of scrotal neoplasms, testicular and extratesticular. We also wanted to study the possibility of visualizing the possible invasion of the neoplasm through the tunica albuginea and the significance of the thickness of the scrotal wall in the differential diagnostic. We also wanted to study whether there are any clues to lead us to suspect an extratesticular neoplasm. The US examinations were made using Toshiba 77 A or Aloka 650 real-time US equipment by the direct contact method using a 7.5 MHz linear probe. The men were examined at Oulu University Hospital in Finland during 1985–1991. There were 75 scrotal neoplasms, 65 testicular (63 malignomas) and 10 extratesticular (two malignomas) neoplasms. In the paper the results presented will include: age groups; histological groups; US findings of neoplasms and differential diagnostic possibilities.

Prognosis of cystic change in residual masses following chemotherapy for metastatic teratoma

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Retroperitoneal lymph node dissection (RPLND) is often performed for the removal of residual masses after chemotherapy for metastatic teratoma. However, there is controversy regarding the indications for this operation. Morbidity from the operation is significant; most notable is retrograde ejaculation in these usually young patients. It would be advantageous to predict a subgroup in these patients in whom RPLND is unnecessary. Therefore, a retrospective review of the case notes of the patients on the Nottingham teratoma register was made. Of these, seven patients were identified who had residual masses which showed cystic change or decrease in attenuation on computered tomography in comparison with the pre-chemotherapy scan. All these patients are alive and well and none show any sign of active disease. Four of these patients had RPLND and no evidence of malignancy was found in the resected specimens. We advocate a more conservative approach to RPLND in patients with post-chemotherapy residual masses in which there is low attenuation and/or cystic changes.

Hepatoblastoma: CT findings pre- and post-therapy

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Successful treatment of hepatoblastoma depends on complete surgical resection which is facilitated by pre-operative chemotherapy. The changes on computed tomography (CT) after chemotherapy and surgery have not been described previously. A retrospective review was performed of CT of the chest and abdomen of 15 children with hepatoblastoma following pre-operative chemotherapy and surgery. 12 children had unresectable tumours on CT at diagnosis either because of bilobar tumour, metastatic disease or vascular involvement. Following chemotherapy, tumour volumes decreased by 20–98%. Tumours had increased areas of hypodensity and calcification and margins were better defined facilitating disease staging. However, staging of primary tumours was sometimes problematic and was overestimated in three children. Children with lung metastases improved after chemotherapy and the majority had normal chest CT pre-operatively. 14 of the 15

children survived surgery. All tumours had areas of necrosis on pathological examination but there was no correlation between the degree of hypodensity on CT and amount of tumour necrosis. Five children developed either low attenuation and calcification along liver resection margins or low attenuation areas in residual liver. None of these findings represented tumour recurrence. CT remains one of the most practical methods of documenting disease of the chest and abdomen post-therapy in hepatoblastoma.

Assessment of CT measurements of tumour volume as an indicator of response to chemotherapy in osteosarcoma

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Cross-sectional imaging is now an integral part of the pre-operative staging of bone sarcomas. In osteosarcoma most of the criteria for assessing tumour response to chemotherapy are qualitative. With Ewing's tumour, however, correlation between alterations in tumour size and response to chemotherapy are recognized. The purpose of this study is to review the CT data of a series of osteosarcomas to determine whether any quantitative measurement correlated with response to chemotherapy. The archived image data of 37 conventional osteosarcomas of the lower limb was reviewed and tumour length, cross-sectional areas and volumes both pre- and post-chemotherapy were measured. Tumour response to chemotherapy, expressed as % necrosis, was obtained from the histology of the excised specimen. Analysis of the results showed no correlation between all the CT measurements, including alterations in tumour volume, and % tumour necrosis. On CT qualitative observations (*e.g.* mineralization) remain a more accurate method of assessing tumour response to chemotherapy than absolute measurements.

MRI — as a predictor of tumour invasion of the mandible and oral region

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At present there is no accepted protocol for the use of magnetic resonance imaging (MRI) in squamous cell carcinomas affecting the oral region. Many surgeons decide on the appropriate mandibular resection purely on clinical grounds and claim that pre-operative investigations are unreliable and therefore oncologically unsafe. This prospective study was designed to assess the predictability of MRI in detecting the presence and extent of tumour invasion of the mandible and the oral region. 15 consecutive patients with squamous cell carcinoma of the oral region were investigated pre-operatively by MRI using T_1-weighted axial sections before and after contrast. These scans were examined by four radiologists and the extent of tumour invasion recorded. This was compared with the actual tumour invasion after a detailed histological investigation involving division of the mandible into 4 mm sections. We found that MRI was not helpful for small (T1 or T2) carcinomas in which early mandibular invasion was suspected. It gave important additional information, however, for T3 and T4 tumour in relation to mandibular involvement and in assessing patients with tongue fixity and trismus. In the same way, extension of the disease into the nasopharynx and hypopharynx can be predicted by MRI.

5 FU modulation and metabolism in colonic cancer monitored by 19 F MRS

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19 F magnetic resonance spectroscopy allows the metabolism of fluorinated drugs to be monitored directly in the patient. In this study, we have monitored the metabolism of 5 fluorouracil (5 FU) during low-dose continuous infusion, and have observed the effects on metabolism of modulation by alpha-interferon. We have performed serial studies in 25 patients with colonic cancer, monitoring metastatic disease in the liver with a 16 cm diameter surface coil. Despite the low rate of 5 FU infusion (300 mg/m^2/day) the spectra generally showed large peaks from fluoro-ureido-propionic acid (FUPA) and fluoro-beta-alanine (FBAL), the major catabolites. In addition: (1) during the initial phases of 5 FU infusion, both 5 FU and FUPA/FBAL were evident in some patients; (2) at maximum response, only catabolites were apparent; (3) with the addition of alpha-interferon, 5 FU and fluoronucleotides, from the anabolic pathway, were evident in some cases. Where 5 FU pooling was evident within the first 8 weeks, this correlated with response. Following addition of alpha-interferon, a decrease in catabolites and an increase in 5 FU and fluoronucleotide levels correlated with further response.

Interstitial laser hyperthermia: the importance of imaging in tumour therapy

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Percutaneous interstitial laser hyperthermia (ILH) is emerging as an alternative approach in the palliation of inoperable liver and pancreatic tumours. We report our experience in 17 patients treated with the neodymium: yttrium-aluminium-garnet laser (Nd:YAG) and outline the importance of detailed imaging at all stages of the therapy. Pre-procedural assessment included ultrasound (US) and computed tomography (CT) to determine the number, site, size and morphology of the lesions. Under ultrasound-guidance 1–4 19 gauge needles, each bearing a 0.2 mm laser fibre, were percutaneously positioned within the tumour at a separation of 1.5 cm. An output power of 1.5–2.0 W was applied for 500 s. Continuous US monitoring showed progressively enlarging hyperechoic foci at the treatment sites, which within a few minutes produced a confluent hyperechoic area. Enhanced CT scans were performed at 24 h. 12 liver and five pancreatic tumours have undergone a total of 52 treatment sessions without complications. Necrosis was identified as areas of non-enhancement at the treatment site. ILH in conjunction with detailed imaging is a safe and precise method of inducing necrosis in tumours of the liver and pancreas.

Accuracy of MRI in staging of prostate carcinoma. Cost-effective analysis

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We have determined the "accuracy" of magnetic resonance imaging (MRI) in evaluating patients with prostate cancer. The role of MRI was assessed in 27 patients. All MRI examinations were performed on a Magnetom Siemens 1.5 T MRI system. We used T_1 (600/20) and T_2(2500/40/80) weighted in a spin-echo sequence, with images in the axial, sagittal and coronal planes. Sometimes, use of a prone position decreases respiratory motion artifacts. Information was obtained about the presence, size, and location of the tumours, as well as periprostatic fat infiltration (neurovascular bundle), seminal vesicle involvement, and adenopathy. We compared imaging results with information obtained at the time of surgery and on pathological results, and MRI correctly staged 78% of the cases. In summary MRI was accurate for 78% of the patients. It may be cost-effective to perform MRI for staging carcinoma of the prostate.

Diagnosing prostate cancer at normal PSA levels: importance of clinico-sonographic correlation

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Prostate-specific antigen (PSA) levels increase in proportion to the stage of prostate cancer more accurately than prostate-specific acid phosphatase (PAP). PSA levels rise earlier than PAP and have proved extremely valuable in diagnosis of and screening for early stage disease. Our prospective study of the diagnostic efficacy of transrectal ultrasound (TRUS)-guided prostate biopsy in 460 men confirms this previously reported association between the level of PSA and the presence and stage of prostate cancer. They were referred for TRUS for a variety of indications including abnormal digital rectal examination (DRE). 86 of the 460 men (19%) who underwent guided biopsy had normal levels of PSA (< 4 ng/ml). Sonographic features suggestive of cancer in these men included focal hypoechoic lesions, areas of inhomogeneous echogenicity and focal areas of asymmetry. 23 of the 86 men (27%) had abnormal biopsy results: 16 (19%) cancer, three premalignant atypia and four prostatitis. 63 men had normal or other benign findings. There was overlap between the sonographic findings of men with normal and abnormal biopsy findings at normal PSA levels. Abnormalities corresponding to DRE findings correlated more strongly with the presence of cancer or atypia. Our findings are of major importance for the early diagnosis of prostate cancer, the second most common cause of cancer death among males.

Serum prostate-specific antigen: before, during and after radical radiotherapy in localized adenocarcinoma prostate

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Purpose: To study prospectively the effect of radical radiation therapy upon serum prostate specific antigen (PSA) levels during and after treatment of clinically localized carcinoma of the prostate. *Method:* A group of consecutive

patients, entered over a period of 15 months from February 1989 to July 1990, had one or more pre-treatment PSA levels, PSA levels weekly through treatment and at each follow-up visit. 117 patients were eligible for analysis if clinically localized adenocarcinoma of prostate (T_1-T_4, N_0, M_0) and fully compliant with the treatment and follow-up requirements of the protocol. Analysis date was 1 June 1991. *Results:* Serum PSA levels were found to correlate with advancing T stage and Gleason score. The trend throughout radiation therapy was for the level to fall. The ultimate time to decay post-therapy was as function of the pre-treatment value of PSA. As a result of study of the decay patterns it is possible to identify three patient subgroups: a group characterized by high initial PSA levels and early relapse, a group with persistently elevated PSA levels without evidence of relapse who might benefit from earlier hormone manipulation, and a third group who may represent local cure.

Neoplasia induced renal vascular changes: sonographic evaluation of 48 hypernephromas

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Pre-operative detection of tumour invasion within renal veins and inferior vena cava is important for planning of treatment of hypernephroma patients. This type of tumour invasion has been reported in 21% to 55% of surgically excised tumours. The ability of ultrasound to image vascular changes non-invasively makes it ideally suited for pre-operative evaluation of hypernephromas. Over a period of 8 years sonographic evaluation of 48 hypernephromas which were subsequently confirmed at surgery were undertaken with a real-time sector scanner and duplex Doppler ultrasound equipment. Intraluminal thrombus in renal veins and inferior vena cava were noted in eight patients (17%). In three patients (6%) renal veins were enlarged without any tumour invasion and in three patients (6%) the renal arteries supplying the tumour-bearing kidneys were found to be enlarged while compared with arteries on the non-affected side. High-velocity blood flow was seen in these renal vessels with high diastolic component, indicative of marked decrease of vascular impedance. In this project, an attempt has been made to determine the incidence of neoplastic vascular invasion and detail other vascular changes exhibited at the initial presentation of hypernephromas.

Quantitative T_1 and T_2 measurements of lumbar vertebrae in multiple myeloma

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A common clinical problem in the management of multiple myeloma is the failure of bone marrow sampling to provide an accurate reflection of disease as infiltration is frequently focal. This study evaluates quantitative T_1 and T_2 values in lumbar vertebral bodies as opposed to images alone. These magnetic resonance imaging values are compared with marrow histology and paraprotein levels. Quantitative T_2 values are helpful where low signal foci are studied and in individual patients parallel their clinical progess.

Notes

9.00 – 10.15

Genitourinary Imaging

Hall 10b

A modern imaging approach to pelvic malignancy

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Patients with cancer require the relevant investigations carried out as quickly and efficiently as possible. Different techniques are appropriate in initial assessment, staging, monitoring the response to treatment, and in the management of relapse. The new techniques like X-ray computed tomography, endo-luminal ultrasound and magnetic resonance imaging have usually been assessed by specialist groups and then introduced into general hospital practice on a patchy basis, and often with restricted patient access. Financial constraints are in part responsible for this, but the overall result is that patients are sometimes referred for oncological opinion without having had simple investigations on which major treatment decisions can be made. In other situations they may have been subjected to inappropriate investigations, incomplete studies which need to be repeated, or multiple unnecessary investigations. This creates extra work, wastes financial resources and may delay treatment. This talk will focus on the interrelationship between imaging techniques and the clinical status of the patient, and between the imaging techniques, with particular emphasis on carcinoma of the cervix and carcinoma of the bladder.

Clinical significance of prostate calcification. Transrectal ultrasound and plain film correlation

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Prostatic calcification is commonly seen on plain radiographs. Transrectal ultrasound (TRUS) precisely localizes the calcification to a specific prostatic zone, and combined with urodynamic, biopsy and clinical data, identifies five types of calcification. 100 patients (ages 22–89, mean 56 years) underwent clinical evaluation, bi-planar TRUS and a 30° caudal, pelvic radiograph. In 35, urodynamics were performed. Five types of calcification were identified. (1) Curvilinear, crossing the midline, symmetrical and positioned in corpora amylacea. This has no clinical significance and is seen on both plain films and TRUS. (2) Punctate and unilateral, localized to central and transitional zones, occurring in detrusor instability and patients with bladder neck dyssynergia. It is due to intraprostatic reflux and seen on both plain film and TRUS. (3) Block-like confined to transitional zones in benign prostatic hyperplasia and present on both plain films and TRUS. (4) Single calcific foci, unilateral, and confined to the ejaculatory ducts, representing duct calculi, more commonly seen on TRUS than plain films. (5) Small irregular foci associated with an echo poor area in the peripheral zone of the gland, seen only on TRUS and associated with carcinoma. TRUS specifically locates and identifies types of calcification. Plain films identify the type of calcification, but not location. Clinical conclusions may be derived from either technique.

MRI of solid renal mass lesions

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Over a 9 month period, 28 patients with solid renal lesions were examined by magnetic resonance (MR) and computed tomography (CT) imaging to evaluate their relative merit regarding the nature and extent of pathology, and to compare different MR imaging sequences. Operative correlation was available in 22, the other six were Stage IV on presentation and therefore not operated upon. MR imaging sequences included: VE 2000/30 and 90 (27 subjects): T_1 600/25 (18 subjects): post gadolinium (Gd) DTPA 90° GE (18 subjects) and short tau inversion recovery (STIR) (13 subjects). All patients underwent CT (21 with contrast enhancement). In the 22 patients with operative correlation the histology included: renal cell carcinoma (18); oncocytoma (3); angiomyolipoma (1) and haemorrhagic cyst (1). Comparison with operative staging showed both CT and

MR imaging to be accurate in 19 of the 22 cases (86%) with no advantage of T_1 or STIR over the VE. The post-Gd images provided no additional information, and in terms of speculating upon the histological diagnosis MR imaging shows no advantage over CT. In three patients overstaged by CT, the coronal plane of imaging available with MR imaging clearly showed no local invasion. It is concluded that apart from avoiding ionizing radiation, MR imaging has no advantage over CT in the investigation of solid renal lesions.

Observer error in pelvimetry

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Computed tomography (CT) pelvimetry is widely accepted as a simple low radiation dose technique for assessment of maternal pelvic dimensions. We have assessed the inter-observer and intraobserver error for our CT pelvimetry technique. Antero-posterior (AP) pelvic inlet and outlet diameters were measured from a lateral scanogram, transverse pelvic inlet diameter from a frontal scanogram and interspinous diameter from a single axial scan performed at the level of the foveae. We now present the results comparing measurements obtained on two separate occasions by three observers (two radiologists and one senior radiographer) for 17 women undergoing CT pelvimetry. The overall intraobserver error range was 0–42.8 mm with a mean of 2.9 mm. The interobserver error range was 0.1–35.1 mm with a mean of 7.2 mm. Both the intra-observer and interobserver errors were greatest for the AP outlet diameter and least for the transverse pelvic inlet diameter. We discuss possible causes and potential ways of minimizing these errors, and their clinical significance.

The age-dependency of the renal resistive index in healthy children

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The renal resistive index (RI) is known to be age-dependent in normal children, but this relationship has been incompletely studied to date. We undertook to determine this relationship, as knowledge of it will be crucial for the application of the RI to the evaluation of paediatric diseases. The mean RIs in peripheral renal arteries were prospectively evaluated in 71 healthy children, from newborns through 11 years. We found the normal mean renal RI to be age-dependent. It is commonly elevated above the adult upper limit of normal (0.70) in the first year of life, and, in general, from individual to individual, decrease with age. From 4 years onward, the likelihood is low (2% probability) that it is > 0.70. We conclude that renal RI criteria developed for the evaluation of adult renal disease, whereby an RI > 0.70 indicates abnormality, do not apply to children younger than 1 year, and are not as yet applicable to children from 1 to 4 years. These criteria should be applicable to children 4 years and older.

Assessment of Gd-DTPA as a CT contrast agent within the renal tract

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Gadolinium DTPA (Gd-DTPA) given intravenously in appropriate dosage is visible as a radiographic contrast agent on computed tomography (CT). Magnetic resonance imaging (MRI) installations are often in close proximity to a CT scanner. If a CT examination is performed soon after a Gd-DTPA enhanced MRI examination, confusing appearances may occur on CT because of enhancement within the renal tract. We present 12 cases of renal masses examined with both modalities. The amount of contrast enhancement is variable and not predictable. There was clear visualization of Gd-DTPA within the renal collecting systems on CT in four cases, vague visualization in four cases, and contrast was not apparent in four cases. There is no apparent relationship between contrast visualization and the time after injection (range 17–182 min), or to indices of renal function. Gd-DTPA in normal dosage may be visualized in the renal collecting systems on CT in 66% of cases.

Furosemide and fluid-load Doppler sonography in non-obstructive pyelocaliectasis

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Recent published literature describes an increase in the renal resistive index (RI) after oral fluid load and furosemide administration in obstructive pyelocaliectasis, relative to normal kidneys, in children. We evaluated the renal RI in six normal and eight non-obstructed, pyelocaliectatic kidneys in nine children, aged 3–18 years, before and 1–2 h after intravenous (IV) fluid load and furosemide. We found the RI decreased from a mean of 0.63 to a mean of 0.56 ± 0.05 SD (decrease significant to $p < 0.005$) in the

non-obstructed, pyelocaliectatic kidneys, while the RI decreased, but not statistically significantly, in the normal kidneys. Although the children in our study were studied under slightly different conditions than those described previously (IV *vs.* oral fluid, respectively, and different timing of furosemide administration and scanning), it is interesting to note that there is now evidence showing the RI goes up in obstructive pyelocaliectasis, and down in non-obstructive pyelocaliectasis, relative to normal kidneys, after fluid load and furosemide. It is hoped that these findings may lay the foundation for fluid-loaded furosemide challenge renal Doppler sonography for the evaluation of pediatric hydronephrosis, perhaps as an alternative to dynamic renal scintigraphy.

Ultrasound evaluation of the urethral sphincter in women with obstructed voiding dysfunction

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Obstructed voiding in females has been shown to be associated with abnormal electromyographic (EMG) activity within the urethral sphincter. Muscle displaying this activity will increase in volume due to the effects of work hypertrophy. The aim of this study has been to quantify urethral sphincter volume utilizing transrectal sonography (TRUS) thus providing a simpler and less invasive method of evaluating these patients. 15 female patients (mean age 29 ± 3.2 years) with obstructed voiding underwent videocystometry (VCMG), urethral sphincter EMG and TRUS. EMG was carried out using a concentric needle electrode placed into the para-urethral tissue and in all patients abnormal EMG activity (decelerating bursts and complex repetitive discharges) was identified. TRUS was undertaken with the patient in the left lateral position using a 7 MHz Aloka linear array probe. The sonographic findings were compared with those obtained from 15 age-matched females with normal urodynamics. In each of the patients studied, VCMG revealed obstructed voiding at the level of the urethral sphincter with widespread, spontaneous, abnormal EMG activity. The urethral sphincter was clearly seen on TRUS as an oval, echo-poor structure distal to the bladder outlet. The volume of the sphincter in those patients with abnormal EMG activity (mean 2.9 ± 0.14 cm^3) was significantly greater than in the control group (mean 1.26 ± 0.75 cm^3) ($p < 0.001$). These results suggest that there is a significant increase in the volume of the urethral sphincter with obstructed voiding and abnormal sphincter EMG activity and that TRUS provides a useful means of evaluating these patients.

Diagnostic features of bladder neck dyssynergia on ultrasonography: a new radiological sign?

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Bladder neck dyssynergia (BND) has long been recognized as a cause of outflow obstruction in male patients but the pathophysiology of the condition is poorly understood. The diagnosis is conventionally obtained by the characteristic features of high pressure/low flow voiding, a failure of bladder neck opening and a positive "Whiteside Sign" at videocystometrography (VCMG). The aim of this study was to quantify the appearances of the bladder neck using transrectal ultrasonography (TRUS). 58 male patients aged 24–67 years (mean $= 41 \pm 4.4$), with BND, underwent TRUS using a 7 MHz Aloka linear array probe. The findings have been compared with TRUS appearances in 170 male patients aged 21–85 years (mean $= 54 \pm 5.2$); prostate obstruction, $n = 95$; normal, VCMG $n = 75$. In 24 of the 58 patients studied, "trucut" biopsies of the bladder neck were taken under ultrasound control and were analysed using histological and electron microscopic techniques. In all of the patients studied with BND, an ovoid, echo-poor area was seen in the bladder neck region which was absent in the other patient groups. The area was predominantly anterior to the urethra and had a mean diameter of 16.8 ± 1.1 mm. Light microscopy demonstrated smooth muscle fibres interlaced with connective tissue and electron microscopy suggested that the connective tissue was predominantly collagen and elastic tissue. This report details a well-defined, poorly echogenic area at the level of the bladder neck, which has not been described previously. Histological analysis of this area suggests that the configuration of the smooth muscle in this region may play a role in the mechanism of bladder outflow obstruction in BND.

Ultrasonic appearance of the epididymis and chronic post-vasectomy testicular pain

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Several authors have described a "post-vasectomy syndrome" of chronic testicular pain, with symptoms putatively attributed to back pressure in the epididymis following ligation or division of the vas deferens. With local ethical committee approval, one of us performed scrotal ultrasound scans in 27 volunteers from a group of 172 respondents to a postal follow-up survey administered 4–4½ years after vasectomy. One-third of respondents reported

chronic testicular discomfort dating from their vasectomy ("symptomatic"), although few had sought further medical attention. Ultrasound scanning ("Acuson" 128 scanner, 7.5 MHz linear array transducer) was performed in 14 symptomatic and 13 asymptomatic men: single or multiple epididymal cysts were seen in seven of the symptomatic group and four of the asymptomatic group. We conclude that epididymal cysts are commonly present in men who have undergone vasectomy, but we have shown no significant association with chronic testicular discomfort.

Evaluation of impotence by pharmaco-cavernosometrography

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We report our experience with pharmaco-cavernosometrograms in 40 patients being investigated for impotence. The mean age of the group was 49 years and patients with obvious psychogenic or hormonal abnormalities were not studied. Papaverine was used as the vasoactive agent in all cases (range 30–80 mg). Two 23 G butterfly needles were inserted to the corpora cavernosa, one connected to the pressure transducer, the other being used for papaverine, saline or contrast infusion. Parameters documented were the pressure rise occurring in the 15 min following papaverine injection and the erectile grade obtained. After 15 min the corpora were perfused with saline at rates varying from 40–300 ml/min as necessary to produce erect corpora. The rate of decay of the erection and the maintenance rate of infusion were also documented. If venous leakage (VL) was implied by a poor response to papaverine and a maintenance rate > 50 ml/min the saline infusion was replaced with 50% urograffin. Spot films were taken to confirm leakage and to document the anatomy of the veins. Arterial insufficiency (AI) was implied by a poor response to papaverine in the absence of venous leakage. A normal response was obtained in 10 patients, AI was diagnosed in 10 and VL confirmed fluoroscopically in 18. Two patients were considered to have a picture of mixed disease. The high rate of venous leakage is consistent with patterns being reported elsewhere, if these patients are to have surgery more information about the arterial inflow must be obtained from colour Doppler imaging or from arteriography.

Notes

9.00 – 10.15

Angioplasty

Hall 11a

Current trends in PTA

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Angioplasty was introduced as a therapeutic procedure of vascular disease more than 25 years ago. The primary success rate, the risk of percutaneous transluminal angioplasty (PTA) and hopefully the long-term results have been changed by the technical progress of the X-ray equipment (digital subtraction angiography mobile C-arm units with subtraction facilities), the further development of guide wires, balloons, rotating systems, lasers and stents. The influence of the individual points will be discussed, validated and the question "who will and can perform PTA in the future?" will finish the presentation.

Monitoring platelet deposition following angioplasty using a platelet-specific monoclonal antibody

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Platelet activation at the site of angioplasty has been implicated as a cause of subsequent arterial re-stenosis. Current techniques for assessing platelet deposition rely on *in vitro* platelet labelling techniques. We have investigated the use of a platelet-specific monoclonal antibody for *in vitro* platelet labelling to monitor platelet deposition following angioplasty. 30 patients undergoing femoral and popliteal artery angioplasty received an intravenous injection of 100 μg (20 MBq) ^{111}In-P256 Fab' antibody. Gamma camera images of both lower limbs were obtained at 2, 6 and 24 h following angioplasty and recorded by computer. Deposition was expressed as a ratio of the count rate over the uptake site to that over the contralateral site. In all patients accumulation of labelled platelets was seen at the puncture site demonstrating the functional viability of the radiolabelled platelets. In 12 patients no sites of uptake were visualized. Platelet deposition was seen at sites of angioplasty or distal emboli in 17 patients and in one patient with thrombophlebitis, not clinically apparent until 8 days later. Uptake ratios of the order of 2:1 were measured at the angioplasty site. This antibody has proven to be valuable for monitoring platelet deposition following angioplasty and should be useful in the assessment of adjuvant antiplatelet therapy.

Use of human tissue type plasminogen activator in the prevention of early rethrombosis following the treatment of femoral occlusions by percutaneous angioplasty

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Prophylatic infusion of tissue plasminogen activator (rtPA) for the prevention of early rethrombosis after recanalization and angioplasty of femoral arterial occlusion. Patency rates for femoral artery occlusions treated by angioplasty are inferior to those for similarly treated stenoses. Thrombosis following angioplasty may occur within hours and is found more commonly following the recanalization of occlusions than following the dilatation of stenoses. Some success has been achieved in preventing this by infusion of rtPA into the dilated segment of artery, isolated from the circulation by two balloons. All patients with occluded superficial femoral arteries successfully recanalized by angioplasty receive perfusion of the angioplasty site with 0.5 mg per hour of rtPA for 24 h. Early results suggest this may be beneficial.

Thermal angioplasty using high-frequency ablator

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Thermal angioplasty has been shown to be of some value in recanalization of arterial occlusions. Systems based on laser energy sources are expensive. High-frequency ablation (HAT) is inexpensive and has been previously used in His bundle ablation and more recently to produce thermal recanalization for percutaneous transluminal angioplasty (PTA). We have conducted a study to assess the value of HAT in PTA of occlusions in the superficial femoral artery, where angioplasty by conventional means (guidewire and

catheter) had failed. Recanalization was attempted using a 0.035 in monopolar guidewire electrode passed through a 5 French catheter. Between 2.5 and 50 W could be delivered, generating tip temperatures which produce tissue vaporization. Of 60 occlusions in 60 patients, 39 (65%) were recanalized with technical and clinical evidence of a successful result; follow-up is available in 18 patients up to 17 months. Problems encountered include pain and subintimal and transmural passage of the electrode. No complication was of long-term significance. Recanalization using HAT could frequently be achieved in occlusions where conventional PTA techniques had failed.

Angioplasty of long femoral occlusions — can the success rates be improved?

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Initial reports of the treatment of long femoral occlusions indicated that the primary success rate was only 59% and the 1 year patency was only 64%. The development of newer guidewires with hydrophilic coatings have improved the primary success rates but the 1 year patency rates remain unchanged. Over a 2 year period, 17 long femoral occlusions were treated by percutaneous transminimal angioplasty (PTA), and all were primarily successful. The lengths of the occlusions varied between 12 cm and 28 cm (mean length 18.7 cm). Three of the first eight occlusions reoccurred within 3 months. The subsequent nine cases have been carefully monitored at 1, 3, 6, 9 and 12 months following the angioplasty and their ankle–arm indices are recorded. Fine needle digital arteriograms are performed if there is a 15% reduction in the ankle–arm index and, where there are recurrent stenoses, they are treated by PTA. Two of the nine patients required repeat angioplasties and all nine patients show a maintained improvement in the ankle–arm index and are symptom-free. Careful follow-up, with repeat angioplasties at an early stage when indicated, appears to improve the patency rates of long femoral occlusions.

Changes in lower limb blood flow following angioplasty: assessment with duplex Doppler ultrasound

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Complex local changes in blood flow occur following angioplasty which are assumed to be due to residual plaque, thrombus or intimal flaps. Recent work has shown that assessment of residual stenosis with duplex Doppler ultrasound is often misleading in comparison with the angiographic appearances and clinical measurements. We have examined the pattern of blood flow in the legs of 35 patients before angioplasty, at 24 h afterwards and, where possible, at 6 weeks. Maximum systolic velocity, average velocity, pulsatility and resistive indices were measured at various sites in the limb. Successful angioplasty in the iliac/common femoral segments was associated with an increase in all parameters when measured at the common femoral artery but changes at lower levels were often modified by more distal lesions. Successful angioplasty in the superficial femoral or popliteal arteries was associated with an increase in peak systolic velocity in the proximal superficial femoral and distal popliteal arteries, and with a decrease in the deep to superficial femoral peak systolic velocity ratio. Other parameters and velocity measurements at other sites showed inconsistent changes. Changes in the velocity gradient at the site of angioplasty were also assessed. A residual velocity increase was detected at the site of angioplasty in half the patients, but was significant (*i.e.* > 2) in only two. We conclude that duplex Doppler ultrasound is a useful method of quantifying the changes in regional blood flow following angioplasty.

Percutaneous transluminal angioplasty of crural arteries — results in 32 patients

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Percutaneous transluminal angioplasty (PTA) of the intrapopliteal arteries is an alternative to surgical treatment, and improves outflow when performed with proximal interventions. We present the results of 48 angioplasties in 32 patients (26 males and six females). 20 anterior tibial, eight posterior tibial, five tibio-peroneal, five peroneal and trifurcation lesions were dilated. 28 angioplasties were carried out in conjunction with proximal angioplasties to improve the outflow. There were six isolated interventions of the tibial vessels. In seven procedures associated thrombolysis was carried out and in two procedures thrombolysis was combined with a 5 French Trac system to re-open occluded arteries. Immediate complications included dissections with flow impairment in two cases, thrombosis in two cases and one case of spasm. There were five cases of late complications, two occlusions and three restenosis. In four cases the repeat angioplasties were successful. The overall technical success rate was 96%. Most of the patients fell into Fontaine classification Group 2b and 3 (18 and 13 cases, respectively) and one case in Group 4. Patients were

followed-up with Doppler studies and isotope limb blood flow studies at 3 weeks, 3 months and 6 months after initial PTA and then at 6 monthly intervals. Maximum follow-up time was 3 years. We will present the results of our angioplasties and analyse some of the technical and anatomical factors that influenced the outcome.

Prospective randomized trial of PTA versus supervised exercise therapy for intermittent claudication

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The purpose of this study was to compare percutaneous transluminal angioplasty (PTA) with supervised exercise therapy, as treatment modalities for patients with unilateral intermittent claudication who had lesions suitable for treatment by PTA. A total of 56 patients was recruited and randomized; 30 to PTA and 26 to supervised exercise therapy. Mean ankle brachial pressure indices (ABPI), mean treadmill claudicating and maximum walking distances were measured prior to treatment and at regular intervals up to 2 years. All PTAs were performed or supervised by a single specialist vascular radiologist. Graduated exercise therapy was supervised by a physiotherapist. In each treatment group there was a similar and significant increase in both mean treadmill claudicating and maximum walking distances at review, though this was achieved without an increase in mean ABPI in the exercise group. However, subdivision of patients according to the level of disease ("iliac" *vs.* "femoropopliteal") showed PTA to be more effective in patients with iliac disease and supervised exercise therapy to be better in patients with femoropopliteal disease.

Angioplasty above the arch

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Although the first report of percutaneous transluminal angioplasty (PTA) in the supra-aortic territory was as far back as 1980, the technique has not been widely used in the carotid or subclavian arteries because of the perceived risk of cerebral thrombo-embolism. Recent reports have suggested increasing enthusiasm for PTA in the vessels supplying the head and upper limb, particularly in Europe and the USA. These workers report a success rate of 95% and a major complication rate of 0.5%. We have performed PTA in seven supra-aortic stenoses including the treatment of one stenosis of a carotid artery by PTA in a patient with a developing stroke. All procedures were successful and without complication. Our results are presented with illustrative examples and description of the method used. The literature is reviewed, indications for PTA of the carotid and subclavian arteries discussed, and the important requirements of a comprehensive imaging work-up prior to angioplasty also stated.

9.00 – 10.15

Physics I — Body Composition

Hall 11b

Radiological assessment of body composition

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Depending on the high precision in the new type of measurements, which have been developed, there is a renewed interest in applying body composition methods to clinical medicine. The objective of this paper is to review the field and compare the techniques in terms of precision, accuracy, patient exposure, complexity, etc. Body protein can be directly measured by prompt gamma *in vivo* neutron activation analysis of nitrogen as can bone using various types of *in vivo* photon absorption techniques. Body water can be directly assessed by isotope dilution. This makes it possible to describe the body composition in terms of protein, bone, water and fat. As there is no established method of measuring fat directly it has to be estimated as the difference between body weight and the three other body component masses. Together with the above mentioned methods, a range of indirect methods (total body potassium, electrical impedance, anthropometry, etc.) are widely used. These methods are based on the fact that for "normal" adults, there are relationships between the different components in the body, for example, between total body potassium and lean body mass. These relations are however seldom applicable in sick people, in very thin or very obese, or very young or old persons. In limited groups of persons, computed tomography and magnetic resonance imaging have also been used for cross-sectional characterization of soft tissue distribution *in vivo*. The paper will also cover *in vivo* measurements of toxic trace elements like lead, cadmium, mercury and aluminium.

Energy-dispersive X-ray scattering for assessment of crystalline tissues

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A new technique has been developed for assessing the state of crystalline body tissues. The method can provide information on the state of trabecular bone during osteoporosis, which could be used for diagnosis, and on the identification of calculi. A collimated X-ray beam focused on the object causes interference effects between coherently scattered photons. In objects with a crystalline nature the interference causes peaks at certain momentum transfer values, making the scattered pattern unique for a particular material. Patterns are recorded with an energy-dispersive X-ray detector. Measurements of trabecular bone have shown two main peaks in the scattered spectrum: a peak at 0.0175 nm $^{-1}$ caused by the crystalline calcium salt component within the bone network, the other is a broader spread (0.0203–0.0228 nm^{-1}) caused mainly by homogeneous scattering from the water content of the marrow. Quantitative analysis of the pattern can determine the ratio of bone to marrow and so indicate the presence of osteoporosis. Gallstone patterns show clear peaks at positions relating to the constituent components; results characterize the stones into the three main categories. Main advantages of this technique are its ability to focus on a small volume within the object and the capability of *in vivo* measurement.

Comparison between radionuclide and polarized X-ray sources for *in vivo* X-ray fluorescence

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The use of polarized X rays (PXR) for *in vivo* X-ray fluorescence analysis of heavy metals in organs such as the kidney and liver has theoretical advantages in reducing the background due to scatter. To provide a more mobile apparatus, alternative radionuclide sources in different geometries were explored and compared with PXR, which were generated by scattering of 160 kVp X rays from aluminium. The radionuclide sources considered were ^{57}Co, ^{99}Tc^{m}, ^{153}Gd and ^{133}Xe used in 90° and backscatter (approximately 155°) geometries and ^{99}Tc^{m} as a kidney-seeking radiopharmaceutical. The minimum detectable concentration (MDC) of platinum, gold or lead at the depth of the kidney was limited by the counting-rate characteristics of the electronic equipment, rather than the radiation dose to

the patient. The best radionuclide set-up used the 100 keV gamma rays from ^{153}Gd in a 90° geometry and the MDC was not greatly inferior to PXR.

The long-term retention of platinum in human tissues following cancer chemotherapy

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The highly sensitive and specific technique of inductively coupled plasma source mass spectrometry has been used to extend studies of the distribution and retention of platinum in the tissues of patients following the administration of cisplatin or carboplatin. Measurements of blood platinum were made up to 2 years and renal excretion up to 5 years after treatment. The pattern of disappearance of platinum followed a power law, with a steeper slope for plasma and red cells than for urine. Autopsy samples were used to examine the distribution of platinum in various human organs up to 17 months after treatment. By far the highest concentrations were found in the liver. Although there was much scatter of results between patients, there seemed to be little loss of platinum with time after about 1 month. In comparison with our previous studies in experimental animals, we conclude that the pig is a better model of platinum retention and distribution for humans than the rat. The prolonged retention of platinum may be relevant to long-term toxicity.

X-ray fluorescence for the determination of gold *in vivo*

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X-ray fluorescence is now a fairly well-established technique for the determination of heavy metals *in vivo*. The technique is now fairly extensively used for measuring metals in organs near the skin surface such as lead in tibia. Methods of determining the concentration in organs lying at a depth, such as platinum in kidneys, have also been described in the literature. These methods have described a number of excitation sources and geometries. Our interest has been in the determination of low levels of gold in the kidney following chrysotherapy. A description of our clinical work to date is presented, together with the results from computer-modelling studies, to determine sensitivity variation with kidney position. A summary of how gold distribution within the kidney might affect the results is also presented. The work described uses an excitation source of ^{153}Gd in a 90° geometry, with a 32 mm diameter germanium detector. The measurement time is between 20 and 30 min, and the patient receives an equivalent dose not exceeding 30 μSv with our current apparatus.

Determination of body fat by DEXA: a comparison with neutron activation

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Recent developments of dual-energy X-ray absorptiometry (DEXA) instrumentation and software have enabled rapid measurements of body fat. The objective of this study was to compare body fat computed from DEXA (Lunar DPX, software V3.1) with that derived from *in vivo* neutron activation analysis (IVNAA). 11 female subjects (covering a wide range of BMI) were measured by both methods on two occasions approximately 11 weeks apart. During this time the subjects adhered to a very low calorie diet and had a mean weight reduction of 16.2 ($\pm$ 2.4) kg. A total of 22 measurements was obtained. The mean ($\pm$ SEM) total body fat evaluated from DEXA, 39.2 ($\pm$1.8)%, was not significantly different ($p = 0.28$) from that determined by IVNAA, 39.9 ($\pm$1.8)%. The results obtained by the two techniques were significantly correlated ($r = 0.94$, $p < 0.0001$). The bias ($\pm$2SD) of the DEXA measurement (*i.e.* IVNAA minus DEXA) was 0.7 ($\pm$5.9)% of fat. The agreement between the methods with increasing fat was evaluated by regression analysis relating the difference between measured values to the mean of the methods; the resulting slope ($\pm$ SE) and correlation coefficient were 0.03 ($\pm$ 0.08) and 0.07, respectively. From this study it is concluded that DEXA provides a measurement of total body fat comparable with that derived from IVNAA.

A comparison of techniques for the assessment of body fat

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*Department of Medical Physics, Singleton Hospital, Swansea SA2 8QA, and *Department of Physics, University College of Swansea, Swansea SA2 8PP, UK*

A knowledge of body composition is a diagnostic aid in many medical specialties. The objective of this study was to compare the estimation of fat in normal and obese subjects using a variety of radiological and other techniques and to assess the usefulness of those more recently introduced. A

total of 43 subjects was studied using eight techniques. The results showed significant ($p < 0.001$) differences between the estimates of fat in normal subjects by several methods, although highly significant ($p < 0.0001$) correlation coefficients were observed between all the methods used. Similar differences were noted in obese subjects but lower correlation coefficients were obtained between the site specific, and thereby localized, measurements using skinfold anthropometry and infrared interactance and those other measurements utilizing the whole or most of the body. This suggests that optimum results may not be obtained with some localized techniques in subjects who depart radically from normal composition and in whom the greatest clinical interest may be shown.

Approaches to the determination of total body protein

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Assessment of nutritional status is important in the management of a variety of chronic and acute conditions. Traditionally, a two-compartment model, comprising fat and non-fat, may be differentiated by measuring the total body density. However, the density of non-fat tissues is not constant, but depends on the relative amounts of protein, water and minerals which comprise the lean body mass. Measurements of total body nitrogen (TBN) by *in vivo* neutron activation analysis provide a direct measure of total body protein (TBP). Water (TBW) can be determined by radioisotope dilution, and minerals by neutron activation or X-ray absorptiometry. However, not all of these techniques are readily accessible. Recent work has shown that changes in TBP can be inferred from changes in total body density and TBW, assuming that any corresponding changes in mineral content are minimal or can be ignored. Current availability of dual energy X-ray absorptiometry (DEXA) instruments should enable this approach to be refined by providing measurements of total body bone mineral. Furthermore, the DEXA method also separates the non-bony tissues into fat and non-fat components. It is argued that this approach, allied to measurements of total body water can provide an indirect measure of TBP. Measurements on obese and non-obese volunteers are used to test this approach.

The effects of very low calorie diet on total body nitrogen

S. J. S. Ryde, J. L. Birks and D. W. Thomas (Swansea *In Vivo* Analysis Research Group)
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Recent developments in body composition research enable more direct measurements to be made of changes that occur during weight reduction programmes. The objective of this study was to evaluate the body composition change resulting from an 11 week period of adherence to a very low calorie (405 kcal) diet. The technique of *in vivo* neutron activation analysis was used to provide a non-invasive measurement of total body nitrogen, and hence protein, in a group of 11 female volunteers. Measurements were made immediately before and after the period of diet. During the diet, the mean weight loss was 16.2 ($\pm$2.4) kg, corresponding to a mean reduction in BMI from 32.1 to 26.2 kg/m^2. The mean loss of total body nitrogen was 125 ($\pm$57) g, equivalent to 781 ($\pm$356) g of protein. Assuming the nitrogen concentration of the fat-free mass to be 33 g/kg, the mean fat-free component of the weight loss was 23.7 ($\pm$3)%. Only four subjects recorded a fat-free loss of more than 25% and only one was greater than 32%. These results suggest that the use of a very low calorie diet as described above does not lead to a disproportionate loss of fat-free mass. The fat-free mass loss was not clearly related to BMI.

10.45 – 12.00

New Applications of MRI

Hall 9

New MRI techniques for musculoskeletal imaging

S. E. Harms and D. P. Flamig
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Methods have recently emerged that are expanding the capability of magnetic resonance imaging (MRI) in musculoskeletal diagnosis. These new techniques are reviewed with clinical examples. *Methods:* Images are acquired using a General Electric Signa 1.5 T imager with 4.6 level software. Image processing is provided by the General Electric Independent Console and the Sun 3/260 workstation. *Results:* New three-dimensional (3D) pulse sequences produce improved resolution and contrast. Joint imaging is optimized with a T_1-weighted sequence without spoiling so that fluid is hyperintense. Bone marrow disease is well visualized with new fat-suppressed 3D acquisitions. A variety of angiographic methods is used for extremity diagnosis depending upon the clinical needs. Patients with peripheral vascular disease and poor visualization of distal vasculature on conventional angiography can often benefit from two-dimensional time-of-flight imaging which is sensitive to slow flow. High-resolution vascular imaging can be achieved with a non-selective fat suppressed 3D acquisition. Phase contrast angiography is well suited for studying flow direction and velocity. Real-time image reformations and fast projection imaging are generated with dedicated viewing workstations. *Conclusions:* New acquisition and image procession techniques are used to improve diagnostic accuracy and clinical efficiency of musculoskeletal MRI.

MRI the evaluation of the thoracic outlet syndrome

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The thoracic outlet syndrome presents diagnostic and management difficulties, and imaging has not addressed these problems adequately. We used magnetic resonance imaging (MRI) to identify the anatomy of the brachial plexus and to display any deviation of the nerve roots or trunks. We used a 1.5 T machine and linked two surface coils anteriorly and posteriorly to improve the spatial resolution and the signal to noise ratio. We obtained short time to repeat (TR)/short time to echo (TE) (T_1-weighted), contiguous 3 mm coronal sections and a T_1-weighted spoiled gradient recalled acquisition in the steady state (SPGR) volume acquisition. This produces 60 1.5 mm thick sections, which can be reformatted in any plane. 18 patients were referred with clinical and electrophysiological evidence of the thoracic outlet syndrome. On a prospective basis, blinded to the clinical features, we identified the affected side using MRI in 17 out of 21 sides (sensitivity = 81%), and identified normality in 13 out of 15 sides (specificity = 87%). On the spin-echo sequence cervical ribs were seen more clearly, and the gradient-echo sequence showed root and trunk displacement better. We believe that MRI has a clear role in the evaluation of the thoracic outlet syndrome.

Magnetic resonance imaging in the assessment of peripheral arterio-venous malformations

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Magnetic resonance (MR) scans were obtained in 11 patients with suspected peripheral arterio-venous malformations. T_1-weighted and short tau inversion recovery (STIR) sequences were performed in each case. In one patient no soft tissue or bony abnormality was demonstrated. Examples will be presented that show the value of MR in assessing the extent of the lesion and its relationship with surrounding structures. The STIR sequence acts to highlight the areas of vascular abnormality. MR scanning is the initial imaging method of choice if surgical excision of a peripheral venous malformation is being considered.

Initial experiences using fast spin echo

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This paper reports initial experience of a new sequence designed to improve patient throughput by reducing examination times, within the context of a high throughput service based on a 1.5 T Signa system. Fast spin echo (General Electric CGR) permits the collection of a range of phase-encoding values in a given time to repeat (TR) interval by producing multiple echoes. The effect in practice is to reduce the acquisition time for conventional T_2-weighted images to approximately a quarter. The images are similar to conventional spin-echo T_2-weighted images, although some difference in contrast exists. This sequence produces a small but significant increase in throughput. Other advantages of reducing acquisition time include reduced movement artefact and shortened-examination times in patients who have difficulty co-operating with the technique. The clinical applications where we have found this sequence of value are reviewed and areas of further development indicated.

Dynamic MRI of the pancreas — gadolinium enhancement in normal tissue

J. A. D. Brailsford, A. G. Chalmers, J. P. Ridgway, J. Ward and P. J. Robinson
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The purpose of this work was to measure signal enhancement in the normal pancreas following gadolinium injection with the aim of improving recognition of perfusion abnormalities in acute pancreatitis. We studied 25 patients before and after the rapid bolus injection of gadolinium DTPA (Magnevist 0.2 ml per kg). Images were obtained on a 1.0 T Siemens Magnetom using a multislice TurboFLASH sequence (time to repeat (TR) = 100; time to echo (TE) = 4; flip angle = 80). The very short echo time allows 11 5 mm slices to be acquired simultaneously during a breath hold period of 19 s. A block was obtained pre-contrast followed by dynamic post-contrast acquisitions starting 12–15 s after the bolus injection. There was a 10 s interval between the post-contrast blocks. Signal intensity was measured for the pancreatic head and tail and also for the liver. These figures were then normalized to fat values for each scan to allow for scaling factor variations. Peak enhancement in normal pancreatic tissue occurred in the first and second post-gadolinium acquisitions and declined on subsequent scans. The pattern of enhancement and normal pancreatic anatomy in the coronal and axial planes is described.

A fast technique for demonstrating vascular anatomy and patency using contrast-enhanced TurboFLASH

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Magnetic resonance angiography (MRA) performed without the use of contrast media has improved substantially over the past few years and both in-flow and phase contrast techniques give excellent results for certain applications. The acquisition times for MRA are still quite long, however, and variable results are common where the blood flow is poor or highly pulsatile. TurboFLASH imaging following bolus injection of gadolinium-DTPA (Gd-DTPA) offers a quick and easy method of demonstrating vascular anatomy and patency. The intrisically short echo time (4 ms) of TurboFLASH sequences, when used in simultaneous multislice acquisition mode, allows a relatively high number of slices to be acquired within an acceptable breath-hold period. Several such acquisitions are performed following bolus injection of Gd-DTPA allowing both the arterial and venous system to be imaged in just 2 min. Maximum intensity projection through the slices allows the full extent of all vessels included to be visualized on a single image. We have used a T_1-weighted TurboFLASH sequence (time to repeat = 100 ms; time to echo = 40 ms; flip angle = 80; 11 x 5 mm slices; acquisition time = 19 s) to image a range of vessels in the abdomen, thorax and pelvis. Details of the technique and resultant images are presented, and the advantages and limitations of the technique in comparison with MRA are discussed.

Fast MR angiography using TurboFLASH sequences in advanced aorto iliac disease

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We have employed two-dimensional TurboFLASH gradient echo sequences with gadolinium-DTPA enhancement to image advanced atherosclerotic aorto iliac disease in 20 patients. Three sets of 10, 4–5 mm thick slices were

acquired simultaneously during breath holding, 10 s after an intravenous bolus of gadolinium. A 400 mm field of view with 160 × 256 acquisition matrix was used. Time to repeat (TR) of approximately 100 ms and a fixed time to echo (TE) of 4 ms were employed. The images were post-processed for using the maximum intensity projection algorithm to produce projection images. In all patients the magnetic resonance (MR) angiography was comparable with that of the conventional angiography. Four aortic occlusions and seven iliac occlusions were all diagnosed correctly, although the MR imaging overestimated the length of the occlusions in almost all cases. Haemodynamically significant stenoses (more than 50%) were seen in 25 segments of the conventional and in 31 in the MR angiography group. High-grade stenoses (more than 80%) were shown as signal void just distal to the area of stenosis in the maximum intensity projection images. We will discuss the technique, the methods of improving image quality and also some of the artefacts. We conclude MR angiography using TurboFLASH sequences and gadolinium enhancement promises to be another non-invasive technique to assess advanced aorto iliac disease.

Quantitative T_1 and T_2 measurements of CSF in patients with multiple myeloma

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Involvement of the meninges in multiple myeloma is rare. However, an "M" band in the cerebrospinal fluid (CSF) of patients without other evidence of CSF or meningeal disease has been reported by Foronzo et al (1978). The T_2-weighted magnetic resonance signal is related to viscosity and hence quantitative T_2 measurements potentially provide a means for detecting CSF paraproteinaemia. We have measured the quantitative T_2 signal in the CSF of 30 patients with multiple myeloma. There is an inverse relationship between the serum paraprotein and CSF T_2 values. In five patients for whom serial measurements are available, a reduction in serum paraprotein due to treatment corresponded to a rising T_2 level.

Reference

FORONZO, R. A., COOKE, R., WRIGHT, J., HUMPHREY, R. 1978. *Medicine, 57*, 151.

Notes

10.45 – 12.00

Counselling and Quality of Care in Oncology

Hall 10a

Costs and benefits of counselling
E. J. Maher
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Cancer patients have many unrecognized psychosocial problems. A variety of interventions has been suggested to improve the detection and management of these, including teaching professional staff communications and counselling skills; improved information, particularly in written form or employment of trained counsellors. All these interventions have resource implications. A study was conducted at Mount Vernon Centre for Cancer Treatment to investigate the impact of a radiographer counsellor and clarify the answer to four questions: (1) how many routine radiotherapy patients might benefit from counselling? (2) how should need be assessed? (3) how much does it cost? and (4) how should the benefits be evaluated?

Comparison of methods for obtaining quality of life assessments in oncology
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There is an increasing awareness of the need to measure quality of life as an indicator of the success of a particular treatment as well as morbidity and mortality. Such information can be used to: (1) aid decision making where different modes of treatment result in similar clinical outcomes; (2) quantify the extent to which treatment affects adversely patients' quality of life and thus provide a focus for additional support; and (3) together with cost data provide more comprehensive information on the costs and effectiveness of different forms of treatment. The method of choice for collecting quality of life information will depend largely upon the resources available for a study and, more importantly, the rationale for collecting such data. This paper highlights the advantages and disadvantages of obtaining data from (i) interviews, and (ii) questionnaires, and also illustrates how quality of life questionnaires can be selected for use in cancer clinical trials.

Treatment of oesophageal carcinoma with combined external beam and intracavitary radiotherapy
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Prognosis for patients with inoperable oesophageal carcinoma remains poor and the optimal treatment remains to be defined. Between April 1987 and December 1990, 131 patients (72 male, 59 female, age range 36–91 years, median 70 years) with histologically proven (98 squamous, 30 adenocarcinoma, two adenosquamous, one malignant on cytology) advanced or metastatic oesophageal carcinoma unsuitable for surgery were referred for radiotherapy. Megavoltage external radiotherapy (20–50 Gy in 4–20 fractions, the majority receiving 30 Gy in 10 fractions) was followed by endoscopically inserted afterloading oesophageal applicator (10 Gy at 1 cm in 1.66 h) in 123 patients. In eight patients the intracavitary dose was modified, the procedure was abandoned in one patient and there was one procedure-related death. Swallowing (Grade II or better) was restored in 107 patients (82%) with 55 patients subsequently requiring dilatation. Median survival was 11 months (range 1–43 months); actuarial survival at 6, 12, 24 months being 71%, 36% and 16%, respectively. Combined external beam and intracavitary radiotherapy is well tolerated, associated with few complications, provides good palliation and may improve survival in this group of poor prognosis patients.

Radiological audit in oncology; improving the diagnostic algorithm for today's cancer patient
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Imaging and monitoring response to therapy is becoming increasingly complex and expensive in all branches of medicine. New diagnostic modalities are introduced almost daily

presenting both the clinician and radiologist with a bewildering array of tests, the merits of which may not be established. This dilemma is particularly acute in the cancer patient, for whom the price of an invasive investigation may be high in terms of morbidity and low in long-term gain. The aim of a modern oncological imaging department must be to provide its patients with a prompt, specific and highly accurate diagnostic service; completely tailored to individual disease categories thereby conserving valuable economic resources and sparing both unnecessary radiation and patient morbidity. Provision for continuing research must not be neglected. With these principles in mind, the following projects have been undertaken by this department and the results used to improve the quality of our service: (1) chest X ray in the follow-up of breast cancer, (2) the role of computed tomography (CT) scanning of the brachial plexus, (3) the monitoring of ovarian cancer: serum CA125 or CT scanning? (4) the current value of lymphography, (5) the provision of mammography outside the national screening cohort, and (6) the accuracy of X-ray request form data.

Percutaneous nephrostomy in malignant disease

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Percutaneous nephrostomy has become a well established technique for rapid relief of ureteric obstruction and improvement of renal function. This procedure is both invasive and uncomfortable and its role in renal failure resulting from abdominopelvic malignancy is often controversial. There are currently no clear guidelines available for the prediction of which of these patients will gain real benefit from such intervention and an emergency decision in favour of drainage may not always be in the long-term interest of the subject. Quality of life with resumption of a normal lifestyle, at least in the short term, is paramount in such patients and a useful therapeutic option must be available after nephrostomy in order to justify its implementation. In an attempt to establish a protocol for selection of patients with malignant disease suitable for nephrostomy the medical records and radiographs of 74 consecutive nephrostomy patients at this institution were reviewed. The results will be presented and discussed with reference to the patient's age, histology, grade and stage of tumour both at presentation and at the time of nephrostomy and an analysis of the factors affecting outcome will be made.

The role of pulmonary computed tomography in the management of Wilms' tumour. 1: Clinical management

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The staging and therapy of Wilms' tumour is based on data collected before the availability of computed tomography (CT). It is established in the adult population that chest CT may reveal metastatic lesions not apparent on chest radiographs; no such data has been published regarding childhood malignancies. 453 children with Wilms' tumour were entered into the United Kingdom Children's Cancer Study Group (UKCCSG), between June 1986 and October 1991. 359 had normal chest films at presentation of which 165 had pulmonary CT performed at that time. 36 of the 165 (22%) patients with normal chest radiographs had abnormal CT, and on review 16 (10%) had intrapulmonary nodules. Of these 16 patients, 10 relapsed, nine with pulmonary lesions, giving a pulmonary relapse rate of 56%. The current pulmonary relapse rate of all 453 patients is approximately 8%. Although this result may not achieve statistical significance in our data, it may demonstrate a subgroup that are at higher risk of pulmonary relapse. Whether this affects the final clinical outcome will be discussed.

The role of pulmonary computed tomography in the management of Wilms' tumour. 2: Cost–benefit analysis

S. J. D. Burnett, C. M. Owens and C. Dicks-Mireaux
The Hospital for Sick Children, Great Ormond Street, London, UK

The staging and therapy of Wilms' tumour is based on data collected before the availability of computed tomography (CT). The current use of imaging makes certain assumptions about the sensitivity of plain chest radiography. Review of the United Kingdom Children's Cancer Study Group (UKCCSG) data shows that of 453 patients entered between June 1986 and October 1991, 359 had normal chest films at presentation. We have examined the impact that routine chest CT has on staging. 165 had pulmonary CT performed at that time of which 22% had abnormal CT despite normal plain films, and of these 10% had pulmonary nodules. Of these latter patients, 10 relapsed, nine in the lungs, giving pulmonary relapse rate of 56%. The overall pulmonary relapse rate approximated 8%. Therefore the information obtained at CT may demonstrate a subgroup that is at higher risk of pulmonary relapse. However, this may not be reflected in the final clinical outcome; the data suggests that there may be no significant difference in the percentage of disease-free patients in each group. We discuss this data in the form of a cost–benefit analysis to explore the value of chest CT in Wilms' tumour.

10.45 – 12.00

Measurements of Bone Mineral

Hall 10b

Measurement of bone mineral

D. Felsenberg
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The necessity for osteodensitometric measurements can be explained by the inability to diagnose reliably a decrease of bone in various other ways. Clinical symptoms are unspecific and just as few typical serum parameters exist. Osteodensitometry is the only non-invasive procedure, until now, that is able to give reliable information about bone mineral density. The conventional X ray, for a long time the only instrument capable of diagnosing osteoporosis, no longer complies with today's technology. The aim of the modern diagnosis of osteoporosis is the early and precise measurement of bone mass deficiency. To meet these requirements there are two basic thoughts to keep in mind: a representative measuring area and a precise method. The methods in current use such as quantitative computed tomography of the spine and hip, peripheral quantitative computed tomography of the radius, dual-energy X-ray absorptiometry of the spine, the hip and the whole body, single photonabsorptiometry and ultrasound measurement of the heel will be introduced. The clinical validity, the boundaries, possibilities and errors of the above mentioned methods will be compared with one another.

Non-invasive vertebral texture analysis based on HRCT — a new diagnostic tool in osteoporosis

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Osteoporosis is characterized by low bone mass and microarchitectural deterioration of bone tissue leading to enhanced bone fragility. Up to now changes of bone architecture could not be assessed non-invasively. The objective of our study was to introduce and apply clinically the new non-invasive technique of vertebral texture identification based on high resolution computed tomography (HRCT) and computer assisted imaging analysis of vertebral body texture. 189 women and 49 men were studied by one midvertebral HRCT scan through a non-fractured lumbar vertebra, and by osteodensitometry (SEQCT). Variations in the architecture were assessed by a computer assisted imaging analysis system, and statistically analysed. The total number and diameter of trabecular plates and intertrabecular spaces were the most relevant texture parameters and showed characteristic age and sex dependent changes ($p < 0.01$). Vertebral mineral content of patients with silent osteoporosis (without fractures) compared with patients suffering from manifest osteoporosis (with fractures) was similar. Both groups, however, showed a discriminating pattern of spongiosa texture changes ($p < 0.05$). We conclude that vertebral texture analysis can assess remodelling changes of the spongiosa architecture non-invasively, and in combination with osteodensitometry promises further prediction of individual risk for fractures and monitoring of treatment efficacy.

SPA, QCT and DXA reference range for British women and correlations between the techniques

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Methods (single photon absorptiometry (SPA), quantitative computed tomography (QCT) and dual-energy X-ray absorptiometry (DXA)) for bone mineral density measurement (BMD) are now widely available; reference ranges for interpretation of results are generally provided with the equipment by the manufacturers. It is recognized that ethnic and national differences in bone mass may occur, and our study was undertaken to ascertain if these reference data were generally applicable to the local community. *Methods:* Over 6 months, 200 women (aged 45–75 years), drawn at random from a local medical practice, were invited to attend for BMD measurement. To date, 142

women of 200 invited (response rate 71%) have attended. SPA was performed in two sites of the forearm (proximal and ultra distal). Single and dual energy QCT was performed in the spine (T12–L3) and DXA measurements were made in the spine and both femoral necks. The data collected were compared with reference data provided. BMD measurements in the same patients by different techniques were compared. *Results:* SPA (distal) compared with reference data gave a significantly higher mean value (± 0.52 SD; $p < 0.001$). The proximal forearm measure was not significantly different from those of a European population (Brunner study). QCT results were not significantly different from published data (Block et al, 1989). DXA measurements in both the spine (± 0.294 SD; $p < 0.016$) and femoral neck (± 1.179 SD; $p < 0.001$) were significantly higher than American reference data provided. Correlations *(r)* between measuring techniques varied between 0.49 to 0.76. *Conclusion:* The results confirm significant differences in SPA and DXA reference data for forearm, hip and lumbar spine. Institutions providing BMD measurement should ensure that the reference BMD range which is used is appropriate to the local population and ethnic groups. Correlations confirmed that BMD measured by one technique could not be used to predict the BMD by another method in the same or different anatomical site.

Reference

BLOCK, J. E., SMITH, R., GLUEER, C.-C., STEIGER, P., ETTINGER, B. & GENANT, H. K., 1989. Models of spinal trabecular bone loss as determined by quantitative computed tomography. *Journal of Bone Mineral Research, 4*, 249–257.

Methods of assessment of spinal deformity

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This study compares and contrasts current methods for assessing the effects of osteoporosis on the spine by analysing the deformity produced by vertebral body collapse and fracture on lateral radiographs. The study compares subjective and objective digital methods to assess vertebral deformity and fracture indices. Two methods of assessing spinal deformity are examined; the Spinal Deformity Index and a system of comparing heights of neighbouring vertebral bodies to define fracture. 25 osteoporotic patients and 25 controls are compared using dual energy X-ray bone absorbtiometry and with questionnaire based assessments of the pain and disability. Results will be presented, assessed and discussed.

Assessment of axial osteopenia: plain radiography versus dual energy X-ray absorptiometry

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Osteopenia is frequently diagnosed on plain radiographs, although previous studies have suggested that this is a poor method of assessing bone mineral density (BMD). To study this further, standardized plain lateral radiographs of the thoraco-lumbar spine were compared with dual energy X-ray absorptiometry (DXA) scans of the antero-posterior (AP) lumbar spine in 99 (45 male) randomly selected subjects, aged 50–84 years. DXA measurements were made on a Norland XR26 bone densitometer; the precision of AP lumbar spine scans is good (c.v. 0.9%). Radiographs were reported blind by two independent senior radiologists, and given an "osteopenia score" based on the radiological criteria of demineralization or vertebral deformity (biconcavity, height loss or frank collapse). Patients with lumbar vertebra collapse (L2–4) were excluded from further analysis. About one-fifth of radiographs were reported as normal, and the interobserver correlation was moderate ($r = 0.63$, $p < 0.001$). The mean BMD of radiologically normal subjects was higher than that of osteopenic subjects ($1.20\ g/cm^2$ *vs.* $0.94\ g/cm^2$, $p = 0.002$). Using a fracture threshold of $0.75\ g/cm^2$, the predictive value of a normal radiograph was 100%, but of an osteopenic X ray was only 20%. In conclusion, normal radiographs may usefully exclude severe osteopenia, but abnormal X rays are nonspecific, reflecting the importance of factors other than BMD in determining fracture risk.

Spinal bone mass measurement: QCT or DXA?

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Quantitative computed tomography (QCT) and dual energy X-ray absorptiometry (DXA) are both used to measure spinal bone mineral density (BMD). QCT measures trabecular bone whilst DXA measures integral (cortical and trabecular) bone, but will include spinal degenerative changes in the measurement. The study was performed to assess the influence of age, scoliosis, fractures, osteophytes, facet joint disease, disc space narrowing and aortic calcification on the relationship between QCT and DXA. *Methods:* QCT and DXA results in 335 females were compared. The CT scout projection radiograph was used to score each subject for the presence or absence of the features listed above. The data were analysed by stepwise

multiple linear regression. *Results:* All the spinal features described became increasingly common with age, with osteophytes present in > 50% over 60 years. Where analysis was restricted to subjects without degenerative features, age remained a significant variable influencing the relationship between QCT and DXA. The presence of fractures in the lumbar spine caused considerable overestimation by DXA compared with QCT. Osteophytes, disc space narrowing and facet joint disease had smaller but significant effects. *Conclusions:* DXA is quick, precise, accurate and carries a negligible radiation burden but the results of spinal DXA may be misleading in older patients and those with spinal fractures and/or spinal degenerative disease. A conventional lumber radiograph may be necessary to assess these features but negates the low dose advantage of DXA.

Increased bone mineral density in the hip and spine by dual X-ray absorptiometry (DEXA)

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The dual energy X-ray absorptiometry (DEXA) technique for measuring *in vivo* bone mineral density (BMD) is of particular interest for the assessment of osteoporosis. Most of the literature is concerned with decrease in BMD compared with normal population data. High BMD is also found in certain diseases, especially in long-term ankylosing spondylitis (*e.g.* 2.87 SD above aged matched control mean: Z score). The formation of syndesmophytes falsely elevates spinal BMD, while the true BMD in patients without syndesmophytes is lower than aged matched controls. We have also reported high values for BMD of the hip in cases of osteoarthritis, with values for the femoral neck being significantly higher than controls or the unaffected hip $p < 0.001$ — with a mean Z score of +1.5. In Paget's disease of bone, very high values for spine BMD have been obtained, *e.g.* a Z score of +8.24. Artifactual elevation of BMD can also occur, especially in the spine. Disturbance of soft tissue "background" may occur from isotope investigation, or long-term gold therapy. Localized increases have been found in vertebral haemangioma and calcified aorta. More commonly crush fractures of one or more vertebrae, degenerative changes and osteophyte growth will have the effect of higher BMD values, which if not excluded can mask true osteoporosis. In such cases simple comparison of the patients' BMD result with reference population data can be misleading. Further radiological investigation may be indicated.

Assessment of bone growth activity in leg lengthening procedures, using DEXA

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The aim of this study is to determine the role of dual energy X-ray absorptiometry (DEXA) in monitoring the healing process to help determine the optimum timing of external fixation removal. Using a Hologic QDR-1000 absorptiometer, serial bone mineral densitometry (BMD) measurements in six patients were obtained through the entire process of leg lengthening from commencement of distraction through consolidation and removal of the external fixation device. Assessment of new bone formation during lengthening, compared with both ipsilateral and contralateral long bone shows a pattern of healing with identifiable characteristics to both the proliferative and consolidative stages. The BMD measurements were compared with the sonographic appearances particularly in the early stages of lengthening and with fracture stiffness measurement in the later stages of healing. The various methods of presenting this BMD data are described, together with their place in predicting rate of healing and fixation removal. The alternative and complementary methods of determining the characteristics of new bone formation are helpful in supporting the conclusions reached from the BMD data. We conclude that serial BMD estimation using DEXA promises to provide a reliable, safe and reproducible means of monitoring fracture healing providing an insight to the ideal timing of fixation removal.

10.45 – 12.00

Chest Radiology

Hall 11a

AIDS and the chest

M. McCarty
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Most patients with the acquired immune deficiency syndrome (AIDS) develop a pulmonary complication during the course of their disease. These complications include bacterial pneumonias, opportunistic infections and neoplasms such as Kaposi's sarcoma and lymphoma. The radiologist has an important role in the management of these patients, not only in the interpretation of radiographs but also in providing diagnostic tissue by means of guided biopsy where appropriate. Chest radiograph interpretation is a challenge; although certain patterns can suggest particular diagnoses, there is considerable overlap in radiographic appearances between conditions. The patient often has more than one pulmonary complication at any one time; this further complicates the picture. In this presentation, the typical patterns of chest radiograph abnormalities seen in AIDS are reviewed and some atypical cases are shown.

The terminology and radiology of cryptogenic organizing pneumonia (COP)

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Cryptogenic organizing pneumonia is an increasingly recognized condition with a distinctive constellation of clinical features and radiographic abnormalities, such that the radiologist may be the first to suggest the diagnosis. The term cryptogenic organizing pneumonia (COP) was first coined in the early 1980s. Subsequently another series of patients with a similar clinico-pathological condition was reported and the term bronchiolitis obliterans organizing pneumonia (BOOP) was used. The relative merits of the two terms (BOOP *vs.* COP) are considered. The diagnosis of COP is one of exclusion and requires histological confirmation. It has been suggested that the radiology of COP is too variable to be helpful but we present a series with uniformity of many of the radiographic abnormalities. The clinical findings, radiographic features and method of biopsy confirmation of nine patients with a histologically confirmed diagnosis of COP are presented. All patients complained of shortness of breath, cough and malaise; none had responded to antibiotics. Chest radiographs showed bilateral multifocal consolidation with a lower zone (6/9) and peripheral predominance (5/9). Relapsing shadows (3/9) and new areas of consolidation (3/9) occurred during the course of the disease with or without treatment. The importance of establishing an accurate diagnosis lies in the extreme responsiveness of COP to steroid treatment.

Organizing pneumonia – "BOOP" or "COP" — a review

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In 1983, Epler and Colby described a clinico-pathological syndrome, called "bronchiolitis obliterans organizing pneumonitis" (BOOP). It was characterized by cough, fever, malaise, raised erythrocyte sedimentation rate, patchy radiographic shadowing and a restrictive pattern on lung function testing. No response to antibiotics but a good response to steroids was seen. The same year, Davison et al described a similar clinical syndrome which they called "cryptogenic organizing pneumonitis" (COP). Histology in both series was similar, showing organizing pneumonitis without evidence of infection. An association has been described between organizing pneumonitis and rheumatoid disease, ulcerative colitis and human immunodeficiency virus infection, and drugs such as amiodarone, but in most cases there is no underlying cause. Since then, the condition has been the subject of many reports and of much confusion, particularly because of overlapping terminology between BOOP and bronchiolitis obliterans (an entirely different subject). Whichever terminology is used, histology

from open lung biopsy is identical in both groups. The terminology has recently been the subject of three editorials in medical journals but the topic seldom appears in British radiology journals. We feel that it is underdiagnosed radiologically and present here a spectrum of radiological appearances in 20 patients in whom histological proof of organizing pneumonia without infection is available.

Lymphocytic interstitial pneumonitis in HIV-infected children

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We describe the clinical presentation and radiological manifestations of human immunodeficiency virus (HIV) infected children with pulmonary lymphoid hyperplasia and lymphocytic interstitial pneumonitis (PLH–LIP) at the Hospital for Sick Children. All HIV infected children have a chest radiograph performed at first presentation, and if clinically indicated, the radiological abnormalities are pursued with more invasive investigations such as lung biopsy and broncheoalveolar lavage (BAL). 27 vertically HIV infected children are being followed in our unit, and nine (33%) had radiological ± clinical evidence of PLH–LIP at presentation (three of these patients in association with other respiratory infections). The diagnosis of PLH–LIP was made on lung biopsy in three symptomatic patients. The remaining six were diagnosed on clinical and radiological grounds. The spectrum of radiological features ranged from initial hyperinflation of the lungs, progressing to diffuse bilateral reticulonodular infiltrates, in a child without major respiratory symptoms. In conclusion, the clinical and radiological features, differential diagnoses and natural history of PLH-LIP will be discussed.

The role of computed tomography in stable cystic fibrosis

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Plain chest radiographs are the standard radiographic method of assessment in cystic fibrosis (CF) and quantitative assessment of the chest radiograph has been shown to correlate with pulmonary function and clinical examination. The aim of this study was to establish whether quantitative assessment of conventional and high resolution computed tomography (CT) give any added information over and above plain films, especially in those patients with haemoptysis or allergic broncho-pulmonary aspergillosis (ABPA). 30 stable adult CF patients participated. Each had, on the same day, full pulmonary function testing, clinical examination (scored using Shwachman's System) and radiological investigations — plain chest radiograph, conventional knowledge of patient identity using the Birmingham Scoring System. There was significant correlation ($p < 0.01$) between the scores for clinical examination, pulmonary function and all three radiographic modalities. We found no statistical difference in the radiographic scores of these patients with haemoptysis or ABPA over those who never had haemoptysis or were ABPA negative, respectively. We conclude that quantitative assessment of conventional CT and high-resolution CT correlate with pulmonary function and clinical examination. These correlations are similar, but no closer, to previously noted correlations using quantitative assessment of the chest radiograph. No added information results from CT in the subgroups of patients with haemoptysis or ABPA.

Ultrafast CT appearances of obliterative bronchiolitis and bronchomalacia in lung transplant recipients: early experience

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Obliterative bronchiolitis (OB) is a frequent complication and a cause of serious morbidity in lung transplantation. Recently bronchiomalacia (BM) with large airway collapsability has been described in association with OB in some patients. This leads to further severe airflow obstruction and increasingly poor respiratory function. Spirometric testing cannot distinguish between patients with OB alone or OB and BM; it is also inadequate for assessing function in single lung transplants. In this study we describe the appearances of OB and BM using an Ultrafast computed tomography (CT) scanner (Imatron C-100, San Francisco, USA). Six patients with biopsy-proven OB were studied. Four had received single lung transplants and two heart lung transplants. Dynamic scans were obtained at four levels (mid-trachea, carina, main bronchi, lung bases). At each level 15 50 ms axial scans were obtained over 5 s during normal respiration and forced expiration. The results will be displayed in real time as a video. Areas of OB were identified in all patients as patchy areas of air trapping. This could also be demonstrated graphically using time–density curves in selected regions of interest. In two patients, both single lung recipients, unsuspected large airway collapse consistent with BM was demonstrated. This is the first demonstration of OB and BM using ultrafast CT. This technique is useful in evaluating the extent and severity of OB and BM in patients after lung transplantation.

Chest magnetic resonance imaging in sarcoidosis

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The chest magnetic resonance imaging (MRI) findings of 15 patients with sarcoidosis are presented. Coronal T_1-weighted and short tau inversion recovery (STIR) sequences were used for imaging the chest. Mediastinal and hilar adenopathy is clearly demonstrated. Also, parenchymal disease (nodules and fibrosis) is apparent on these scans. The use of the STIR sequence in determining disease activity is discussed – comparison is made with gallium scans. Loss of parenchymal signal intensity on the STIR sequence following steroid therapy has been seen in two cases, indicating that this is an alternative method of demonstrating disease activity.

MRI of lung signal intensity and dimensions in patients with chronic lung disease before and after single lung transplantation

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A retrospective analysis of lung signal intensity normalized for fat (SI) and lung cross-sectional area normalized for body surface area was obtained from cardiac-gated spin echo (time to echo (TE) 40 ms) images before and after single-lung transplantation in 12 patients with pulmonary air way disease (PAD) and 14 with interstitial lung disease (ILD). Nine healthy volunteers were studied for comparison. The main results (MRI findings) are tabulated below. Blood flow (l/min) to the transplanted lung (3.4 ± 1.1) was higher than that of the control (2.3 ± 0.74) and of the native diseased lung (1.9 ± 0.7). Arterial flow had little effect on signal intensity in the control and PAD groups while in the ILD, the lesser the blood flow the higher is the signal intensity. The cross-sectional area of the transplanted lung was comparable with that of the control. The transplanted lung has a similar SI to that of the control except when there was a rejection reaction (one patient) or infection (two patients). Distinctive features of lung SI and cross-sectional area were demonstrated in patients with PAD and ILD before lung transplantation. These measurements could be useful non-invasive indices for assessment of the transplanted lung and for follow-up of patients without exposure to ionizing radiation.

Disease	Signal intensity	Area
Pulmonary air way disease	Low – > normal	Large
Fibrosing lung disease	High	Small
Lymphangioleiomyomatosis	High	Large

High-resolution CT appearances of the lung in alpha-1-antitrypsin deficiency

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Alpha-1-antitrypsin (AAT) deficiency is an inherited disorder characterized by low levels of serum alpha-1-antitrypsin. Clinical manifestations include pulmonary emphysema. Previous pathological and radiological studies have shown this to be characteristically panlobular involving predominantly the lower lobes. We have studied seven patients with homozygous AAT deficiency. (M:F = 2:5; age range 43–61; mean 55). All patients were examined on an IGE 9800 scanner with 3 mm thick sections at 10 mm increments obtained throughout the lungs during maximum inspiration. Five patients demonstrated computer tomography appearances of emphysema, in four of these there was lower zone predominance of disease, in one all three pulmonary zones were affected. The remaining two patients had no emphysema although one showed scattered thin-walled cysts and the other had multiple thick-walled cysts within the mid zones and lower zones of the lung. These findings support the hypothesis that patients with documented AAT deficiency may not have radiological demonstrable emphysema. Three patients showed features of bronchiectasis with bronchial dilatation and bronchial wall thickening. Bronchiectasis is a feature of AAT deficiency, having been described previously on bronchographic studies.

10.45 – 12.00

Physics II — Image Assessment

Hall 11b

Human visual perception and ROC methodology in medical imaging

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Receiver operating characteristic (ROC) analysis is among the most reliable methods currently available for measuring diagnostic performance. Among several factors influencing diagnostic decisions are: (1) the inherent diagnostic capability of the combined imaging system and user, and (2) the decision criterion adopted by the user. Only ROC analysis is able to distinguish between these two facets of performance. Alternative methods implicitly rely on the user maintaining a constant decision criterion, an assumption that may not always be justified. Unfortunately, however, ROC analysis is relatively more time consuming than alternative methods. ROC analysis can also provide a measure of the absolute efficiencies of the imaging system and the human user. Human efficiency in performing certain discrimination tasks has been shown to approach the maximum attainable although in other tasks the human user can be very inefficient. In this paper, the concepts underlying ROC analysis and the techniques for carrying out the analysis are briefly described. The relative advantages of ROC and alternative methods of analysis are discussed. The implications for imaging processing and machine vision of human efficiency are considered.

"All the better to see you with" – the use of a minifying lens in radiology

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The spatial frequency model of vision provides useful insights into the physiological limits of the eye brain system to perceive structures of different size and contrast in radiological images. Visual contrast sensitivity can be assessed using as a test object a grating pattern of alternating light and dark bars whose spatial frequency corresponds to the number of cycles subtended on one degree arc of retina. The eye–brain system has its maximum sensitivity to low contrast at three cycles to a degree but can detect up to 50 cycles per degree at high contrast. The presence of grain noise in radiographic images, which consists of relatively high spatial frequencies, causes randomization of density gradients with loss of boundary information. A minification lens can ensure the best match in the spatial frequency domain between low contrast detail of a given size and the performance capabilities of the visual system. Minification can improve visualization of edge detail since elements in the noise are effectively shifted below the threshold of visibility in the spatial frequency domain. The fact that a smaller image will require less fixations for full scrutiny is considered a less plausible rationalization for the use of a minifying lens.

The SDRD: a novel digital radiographic system

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The performance of the SDRD has been evaluated. It uses a multiwire proportional chamber detector in a configuration which gives good rejection of scattered photons. Standard test tools were exposed on the SDRD and the images were evaluated in comparison with screen-film images. Contrast-detail-dose diagrams were produced using thermoluminescent dosemeter (TLD) dosimetry, and showed comparable performance for all but the finest features of the test objects. Dose levels for clinical images with the SDRD were compared with a recently published UK survey. The two main advantages of the new system are: (a) that the wide dynamic range of the SDRD allows both soft tissue and bone to be imaged in one exposure, and (b) that some clinical examinations show significant dose savings with the SDRD.

Monte Carlo study of the design and performance of anti-scatter grids

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*Department of Physics, The Royal Marsden Hospital, London SW3 6JJ, UK and *Department of Radiation Physics, University Hospital, Linköping, Sweden*

A Monte Carlo computer program has been developed to study and optimize the design of anti-scatter grids used in diagnostic radiology. The program simulates the scatter from tissue slabs of various sizes and calculates image contrast and noise, energy imparted to the tissue slab and the conventional grid parameters, Bucky Factor and contrast improvement factor. Three examples are given of applications of the program. Firstly, the advantage of using low atomic number materials for the grid covers and interspace is quantified for four grid designs and four tube potentials. The dose reduction achievable varies between 10 to 50% depending upon operating parameters. Secondly, the results of a global optimization of grid design and tube potential are presented for a simulation of a paediatric examination. It is shown that grids with widely different line densities or grid ratios can have good performance provided that they have lead lamellae of appropriate thickness and are used with the correct tube potential. Lastly, the performances of various commercially available grids are compared for chest radiography. We are not aware of any other work which has made a detailed study of the influence of tube potential on grid performance.

Quantitative assessment of TV fluoroscopy

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Although the widespread use of the Leeds test objects has been beneficial in the quality assurance of fluoroscopy systems a number of difficulties has led us to develop an alternative approach. The basic drawbacks of the Leeds Test objects are the subjective aspect, the lack of a definitive signal-to-noise test and proper transfer functional analysis. An alternative approach is to analyse the video signals using a Leeds E1 test object. A trial has been carried out using a 40 MHz digital oscilloscope plus a video line selector connected via GPIB interface to a Toshiba portable computer. Algorithms have been written to analyse the system and quantum signal to noise ratios, low frequency contrast loss, Wiener spectrum and modulation transfer function. Initial results are encouraging showing, where applicable, good correlation with subjective assessments, but providing much more detailed information. Moreover, the tests are very quick to perform requiring a single X-ray exposure. A prototype dedicated device is being built with development funding from the British Technology Group.

First experiences with a DSI digital image review workstation

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Digital image workstations are becoming increasingly common in modern radiology departments. This increase is partly fuelled by the number of imaging modalities producing digital images, rather than (purely) film-based output, and partly by the possible advantages of an interactive review environment such as that provided by a workstation. Recently, Philips Medical Systems announced Easy-Vision, a clinical workstation designed specifically for the review of images produced by a digital spot imaging (DSI) modality. A prototype workstation was installed in the General Infirmary at Leeds during October 1991 initially in the Department of Medical Physics, to allow an initial trial before final installation in the Diagnostic X-Ray Department for evaluation by FAXIL as part of the Department of Health X-ray systems evaluation program. The results of a preliminary evaluation of the EasyVision workstation are presented, which include investigation in terms of its display quality, range of features, clinical relevance of these features, ergonomic acceptability and computational performance. The workstation is also assessed in terms of its aid to productivity in a clinical environment when coupled with the communication, storage and hardcopy products which form the family of products of which EasyVision is a part. *Acknowledgment:* Philip Medical Systems (Netherlands) and the Medical Devices Directorate of the UK Department of Health.

Density profile measurements for quality assurance in digital radiology

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Digital systems are capable of displaying images with a variable window level and width. This flexibility makes the contrast and resolution of images operator dependent and hence subjective. To ensure optimal image quality of the processed image it is desirable to have an objective measure. Image quality is conventionally assessed using the modulation transfer function (MTF). The theoretical complexity of this parameter makes it unsuitable for use in routine assessment. A method, which is particularly suitable for digital systems (CT, DSA, etc.) and based on the concept of MTF, is described which measures the loss of

modulation amplitude with increasing spatial frequency. The input signal is derived from imaging a resolution test object. The output signal is the density profile extracted from the processed image. In a similar manner to TV system assessment, the contrast modulation obtained from the density profiles is plotted against spatial frequency producing the contrast transfer function (CTF). Examples of the CTF are presented and discussed for high and low contrast test objects. Practically, CTF and MTF are closely comparable. CTF is a rapid, quantitative method for assessing image quality in digital systems. CTF can also be applied to other imaging modalities.

Development of a test object for evaluating image quality of photo-stimulable phosphor computed radiology systems in clinical service

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With the increasing availability of systems using photo-stimulable phosphor computed radiography (PPCR) technology, as opposed to conventional screen-film, there is an increasing need to set up quality assurance strategies for such systems. Aware of the different imaging requirements and unique properties of PPCR, we at FAXIL are designing and constructing a set of X-ray test objects for the purposes of facilitating computed radiography (CR) system set-up and routine quality assurance. The PPCR system can be split into several imaging components: the photostimulable phospor plates, the reading mechanism, the computer processing, the display and the hardcopy facilities, all requiring a new approach to image quality assessment. In this presentation we will describe progress so far with this project, illustrating various points with test images derived from CR systems in clinical use. Our ultimate aim will be to develop a generic package of test objects which can be used universally with all designs of CR system. This set will include tests to assess low contrast sensitivity, high contrast spatial resolution, exposure linearity and sensitivity, uniformity, dynamic range and a number of other PPCR specific parameters. *Acknowledgments:* This work is jointly supported by the Medical Devices Directorate of the UK Department of Health and Agfa-Gevaert NV, Belgium.

Variability of X-ray image intensifier — TV system performance

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The performance of all 178 fluoroscopy units in the North Western Region was measured over a 2 year period in order to determine the variability of factors affecting image quality and patient dose and to identify any trends with equipment design, manufacturer or age. Measurement protocols were based on HPA and Leeds procedures for safety and performance testing of image intensifer–TV systems. X-ray automatic dose rate control and automatic collimation performance were analysed to assess dose efficiency, while limiting resolution and perception of threshold contrast against detail size were used to indicate image quality. The results show, for example, that input dose rates vary by a factor of over 400, the variation increasing with age. 25% of units less than 1 year old did not meet the requirements for limiting resolution. However, only systems older than 10 years showed significant signs of deterioration in overall image quality. Further results are presented and the implications for quality assurance, maintenance and equipment replacement discussed.

Phosphor screens image characteristics

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We present the results of an experimental study concerning mainly the efficiency and the modulation transfer function (MTF) of granular X-ray phosphor screens. Measurements have been carried out on phosphor screens prepared by sedimentation of four different phosphor materials (YVO_4:Eu, La_2O_2S:Tb, $CdPO_3Cl$:Mn, ZnCdS:Au,Cu). The screens' densities ranged from 20 to 250 mg/cm^2 and the X-ray tube voltages from 50 to 250 kVp. In brief presentation the experimental results show considerable differences between the various screens both in efficiency and resolution, which in general are consistent with the Hamaker–Ludwig model predictions. Graphs of absolute values showing the dependence of these two quantities (efficiency and resolution) on various parameters (thickness, voltage, etc.) are presented for each one of the phosphor materials. All the experimental data are explained and discussed on the basis of appropriate theoretical models taking into account the granular structure of the screens as well as the beam quality and the optical properties of the phosphor material.

An approach to assessing the adequacy of fluoroscopy equipment to produce adequate images over a wide range of clinical conditions under automatic control

M. Holubinka
Radiation Physics Group, St Mary's Hospital, Portsmouth, UK

Image intensifier fluoroscopy equipment is expected to provide images of diagnostic quality over a very wide operating range, for example, locating fractures in the wrist

of a small child to a lateral pelvis view of a large adult. Systems may operate using manual control of kilovolts and milliamperes, automatic control of kilovolts or milliamperes or both, and with or without camera automatic gain control. The method described elucidates the interaction of the exposure factors and displayed image over the full range of simulated clinical conditions. Both an indication of image intensifier entrance dose rates, patient skin entrance absorbed dose and an indication of the acceptability of image quality are obtained irrespective of system design. Both methodology and phantom design are described with examples of results obtained for equipment operating clinically and at installation. The method is also suitable for demonstrating correct operation and adjustment as part of annual performance assessments. Findings from these evaluations are invaluable in assessing adequacy of equipment for new procedures and providing supporting evidence for adjustment or replacement of equipment.

Notes

12.15 – 1.15

3M Mayneord Memorial Lecture

Hall 9

Targeted magnetic resonance imaging

W. Vennart
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Clinical magnetic resonance imaging (MRI) is characterized by the use of large whole-body magnets and expensive proprietary computer systems. Use of such systems for research purposes (*e.g.* for tissue characterizations in normal and diseased states) can be prohibitively expensive; in addition certain parts of the body (*e.g.* fingers and hands) are relatively difficult to image in whole-body machines. In this talk imagers developed for visualizing limited parts of the body, *e.g.* fingers, wrists, head and knee will be discussed highlighting the technology that has enabled these developments. Further, the use of such systems to make relatively high resolution measurements *in vivo* will be outlined with illustrations of the elucidation of normal and abnormal anatomy as demonstrated by MRI.

2.15 – 3.45

Angiography and Interventional Radiology

Hall 9

Digital *versus* conventional angiography: a comparative study

E. Jurriaans, I. P. Wells, J. M. Wilkie, J. C. A. Pearn and T. A. Pratt
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Recent advances enable digital angiography (DA) to be performed in either subtracted or non-subtracted form, and digital peripheral scanning ("bolus chasing") to be undertaken. This has influenced the use and application of DA appreciably. The conventional angiographic equipment (Philips Angiodiagnost 2 with Puck film changer) at Derriford General Hospital, Plymouth, was recently replaced by a new DA system (Philips Integris C2000). This permitted a comparison of conventional and digital angiography within the same clinical setting to be performed. Approximately 50 consecutive peripheral arteriograms, 15 femoral angioplasties and 15 percutaneous nephrolithotomies undertaken with conventional angiography were compared with a similar group of examinations performed with DA. The following parameters were assessed: (1) duration of examination, (2) radiation dose to patient and radiologist, (3) cost of consumables, (4) image quality (subjective), (5) other factors, *e.g.* access to patient, ease of use of equipment. The results of this study will be presented. The implications with regard to the use of and need for DA in a district general hospital will be discussed.

Enhancing the thrombogenicity of embolization coils

D. A. Nicholson, J. Cockburn, P. Dawson and A. Bradshaw
Department of Diagnostic Radiology, Hammersmith Hospital, Du Cane Road, London W12 0HS, UK

Steel embolization coils are well established as embolic agents for the treatment of many conditions. Ineffective thrombosis is occasionally seen in high blood flow situations and patients with abnormal clotting. Several authors have commented on the increased thrombogenicity of coils following soaking in thrombin solutions. However no study has quantified this effect. We have carried out an *in vitro* study, carefully measuring the effect on whole blood clotting time (WBCT), of soaking coils in thrombin solutions of different concentrations (100, 200, 400, 1000 U/ml). Untreated coils are shown to be very thrombogenic, reducing normal WBCT from 14.85 min to 5.53 min. Passing coils down a saline-filled catheter (simulating *in vivo* technique) slightly reduces their thrombogenicity, but not significantly ($p = 0.21$). Soaking coils in thrombin solutions over 100 U/ml has the effect of further reducing WBCT significantly (2.1–2.6 min). Although there is a trend of increasing thrombogenicity with increasing thrombin concentration from 200–1000 U/ml, a plateau in WBCT is seen, and the difference is not significant. We conclude soaking coils in thrombin has a very beneficial effect on reducing WBCT and that only a small quantity of thrombin is required to elicit prompt coagulation, limiting the thrombin's potential systemic effects. We suggest the use of such thrombinized coils in the treatment of various conditions, which will be discussed.

A comparison of pulse-generated run-off and arteriographic assessment of the pedal arch in the outcome of femoro-distal bypass grafting

D. Kinsella, E. Horrocks, J. Scott and M. Horrocks
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The outcome of 100 non-reversed femoro-distal grafts, performed for critical ischaemia, were analysed. 16 grafts were to the above-knee popliteal artery, 36 to the distal popliteal artery, three to the tibio-peroneal trunk and 45 to a single calf vessel. The 1 year graft patency rates for grafts to a pulse-generated run-off derived complete, incomplete and occluded pedal arch were 88%, 75% and 9%, respectively ($p < 0.01$). Arteriographic scoring did not discriminate between successful and failed grafts. The reasons for this will be discussed. Pulse-generated run-off (PGR) derived pedal arch status does appear to be an excellent predictor of long-term graft function. In those patients with an occluded pedal arch on PGR, a primary amputation should be considered.

Calf vessel preservation in peripheral vascular disease — angiography *versus* pulse generated run-off

T. O'Brien, H. G. Thomas, A. Crow and P. Lamont
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Previous angiographic and anatomical studies have suggested that the peroneal artery is the best preserved of the calf vessels in peripheral vascular disease and should be the site of preference for femoro-distal by-pass grafts. Calf vessel run-off assessed by pulse generated run-off (PGR) provides a more accurate prediction of graft success or failure than angiography and may therefore give a better functional picture of vessel patency than angiography. This study compares the presence of and degree of preservation of the three calf vessels in patients with severe peripheral vascular disease using both intra-arterial digital subtraction angiography (DSA) and PGR. 34 limbs in patients with either ischaemic rest pain, ulceration or gangrene were studied and the results were scored according to the extent and severity of disease in the peroneal, posterior tibial and anterior tibial arteries. The peroneal is present, and seen as the best preserved vessel, on DSA in significantly more cases than the other vessels. The three vessels are seen more often and are equally well preserved on PGR. This study shows that angiography may be misleading because the more functional PGR studies show no significant differences in patency or preservation between the three calf vessels.

Colour duplex, impedance analysis and DSA in femorodistal vein bypass graft surveillance

D. Glew, *A. H. Davies, R. Parry, *T. R. Magee, *M. Wyatt, P. Murphy, *R. N. Baird and *M. Horrocks
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Graft surveillance has improved rates of graft patency and limb salvage. A technique of impedance analysis has been described previously, but no comparison of colour duplex scanning, impedance analysis and digital subtraction arteriography (DSA) has been reported. 45 patients have been followed-up with non-invasive tests at 1 week, 3 months and 6 months after femorodistal bypass surgery, using intra-arterial DSA as the gold standard. An impedance score of > 0.45 was used to identify "at risk" grafts, and a doubling of peak velocity on duplex was used to define a stenosis. DSA identified nine "at risk" grafts. Eight of these were identified by impedance analysis and eight by colour duplex. Mean impedance scores (95% confidence limits) were 0.39 (0.36–0.42) for the grafts without problems and 0.48 (0.43–0.53) for the "at risk" grafts ($p = 0.003$, Mann-Whitney U-test). Colour duplex failed to recognize one graft "at risk" from poor run-off, impedance analysis failed to identify one graft with a retained valve cusp. Impedance analysis is non-invasive and rapid to perform. As it compares well with more invasive and time-consuming tests, we suggest it is the test of choice for graft surveillance.

Intra-arterial femoral studies in anticoagulated patients using 3 French catheters

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Femoral arteriography is contraindicated in patients who are on anticoagulant therapy. Clotting profiles will therefore usually be normalized prior to the procedure. This sometimes results in complications or delay in the procedure, and may be hazardous for those patients in whom anticoagulation is vital. Intravenous digital angiography is a safer alternative procedure, however, the images are of inherently poorer quality and large doses of contrast media are required. As a result of using 3 F catheters in over 400 patients with peripheral vascular and renovascular disease, we aimed to study the safety of this technique without stopping anticoagulant therapy. 11 patients, (INR values of 1.7–3.4, mean 2.4) were studied using a standard 3 F catheter technique but prolonging post-procedure pressure haemostatis from the usual 5 min to 10 min. Studies were performed on both an in-patient and an outpatient basis without any complications. That is, there was no prolongation of hospital stay, no post-procedural bleeding, and only one very minor haematoma was reported. We conclude that 3 F catheterization would appear to be safe in patients who have been anticoagulated within the normal range, without the need to stop treatment first.

A comparative study of the effects of ionic and non-ionic contrast media on oxygen desaturation following intravenous intra-arterial administration

P. S. Sidhu, J. F. Cockburn, D. A. Nicholson, A. Kennedy and P. Dawson
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Transient oxygen desaturation following conventional radiographic contrast medium administration has been shown to occur both with intravenous and intra-arterial studies. The effects, if any, of the newer non-ionic contrast agents on oxygen desaturation have not been evaluated. To determine if non-ionic contrast media administration either intravenously or intra-arterially results in oxygen desaturation, we prospectively studied 100 patients undergoing radiological investigations requiring the administration of

contrast media. These patients were divided into two groups: one requiring ionic contrast; the other group non-ionic contrast. Arterial oxygen saturation was monitored for 3 min prior to, during and then for at least 20 min after the administration of contrast media. The results from the two groups will be compared with previous studies and the effects of the newer non-ionic contrast media on oxygen desaturation will be presented. The mechanisms of this phenomenon and its clinical relevance will be discussed.

Inoculation hazards during interventional radiological procedures

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An intact barrier between the operator's hands and the patient is important to prevent transmission of disease in either direction. Between 10% to 40% of surgical gloves develop punctures during general surgical cases. In this study, we determine if the incidence of glove perforation is higher during interventional radiological procedures and whether there is an indication for double gloving during specific procedures as recommended in other specialities (orthopaedics). 150 pairs of gloves were tested. The gloves tested were Ansell and Regent. The operator, first assistant, if present, and nurse completed questionnaires that specifically asked the nature of the operation (instrumentation or not), whether they were aware of a perforation and if so, how it happened. Gloves were tested for holes by inflating the glove with water and occluding the cuff. The total perforation rate was 8%, 3% of the gloves had unrecognized perforations. The operator was most at risk of perforations. Perforations were usually associated with guide wire studies. Double gloving should be undertaken during these studies on at-risk patients despite the minimal loss of manual dexterity.

Embolization of peri-pancreatic visceral artery pseudo-aneurysms

M. Blomley and J. E. Jackson
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Visceral artery pseudo-aneurysms are uncommon but potentially fatal lesions which are associated with a mortality of up to 80% depending upon their location. They most commonly occur secondary to chronic pancreatitis but may also be associated with trauma, surgery, or infection. Surgical management of these lesions is associated with a high mortality particularly when situated around the pancreatic head. Over the past 6 years we have treated 12 patients with visceral artery pseudo-aneurysms by transcatheter embolization. The pseudo-aneurysm involved the gastroduodenal artery in eight patients and the splenic artery, an hepatic artery, the transverse pancreatic artery and the superior mesenteric artery in one patient each. The majority of patients presented with gastrointestinal bleeding. Transcatheter embolization was technically successful in all patients. Three patients died within a month of embolization, one following recurrent bleeding from a second pseudo-aneurysm which was not amenable to embolization, one from intercurrent cardiac failure and one from generalized bleeding due to a profound coagulopathy following massive transfusion requirements prior to embolization. The technique of embolization of visceral artery pseudo-aneurysms will be discussed.

Approaching and lysing the thrombosed prosthetic graft

P. Guest and T. Buckenham
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Thrombosed prosthetic grafts continue to be both a clinical and radiological problem. Surgical management carries its own significant morbidity. The radiological approach has traditionally involved diagnostic studies and possibly thrombolysis with agents such as streptokinase. We treat all our thrombosed grafts aggressively with direct intra-thrombus administration of tissue plasminogen activator (TPA). Direct puncture of the graft and pulsed administration of the drug facilitates and accelerates the procedure. Supplementary angioplasties are usually required to prevent rethrombosis. We present the radiological management and our own results in a series of all patients (23 patients, 30 procedures) presenting with occluded grafts over a period of 1 year to our hospital. We discuss the factors influencing a successful procedure, the problems encountered and possible ways of overcoming these.

TIPSS: The Edinburgh experience

N. Chalmers, D. N. Redhead and P. C. Hayes
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Transjugular intrahepatic portosystemic shunt (TIPSS) is a recently described percutaneous technique for portosystemic shunting. We have undertaken the procedure in four patients to date, with success in three. These are patients with recurrent variceal bleeding not controllable by sclerotherapy. The technique involves creating a track through the liver parenchyma between hepatic and portal veins using a trans-septal needle via a jugular sheath. The track is dilated with an angioplasty balloon and one or more metallic stents inserted to maintain patency. We describe our experience of the technique, including various difficul-

ties and some modifications. Hepatic vein wedge pressure measurement following TIPSS has shown a substantial reduction in portal pressure gradient. One patient, whose portal pressure gradient prior to TIPSS was 29 mmHg, re-bled 3 weeks after the procedure and was found to have a persistently elevated pressure gradient at 19 mmHg, indicating an inadequate shunt. The shunt was dilated from 8 to 11 mm diameter with a satisfactory result. To date no other patient has re-bled following successful TIPSS and none has developed encephalopathy. Widespread adoption of TIPSS will depend on the long-term effectiveness. The mortality and cost of TIPSS compare favourably with surgical shunting.

Utility of trans-jugular intrahepatic portosystemic shunting for treatment of portal hypertension

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Aim: To determine the effectiveness of relieving portal hypertension by percutaneous transjugular portosystemic shunting with an expandable metal stent, and the role of sonography for shunt evaluation. 13 patients with portal hypertension and recurrent variceal bleeding were treated with transjugular intrahepatic portosystemic shunting (TIPS). A 16G Cooke transjugular liver biopsy needle was positioned in a hepatic vein and used to access the main or right portal vein. A 1 cm Schneider Wallstent was placed across the track. Pre- and post-procedure colour Doppler sonography and angiography were performed and portal pressure measured. Stents were successfully placed in all but one patient whose portal vein was thrombosed. Sonography correctly demonstrated shunt patency in 11/12 patients. In one patient stent thrombosis was correctly diagnosed. Mean peak shunt velocity was 90 cm/s (flow rate 21 ml/s) in eight patients. In two patients with portal or splenic vein stenosis MPV was 27.5 cm/s (flow rate 5 ml/s). Two patients died within 1 month: from variceal bleeding and from mediastinitis unrelated to the procedure. A fall in portal pressures and endoscopic evidence of variceal reduction were seen in the remainder. Their shunts have remained patent. Early results indicate transjugular portacaval shunting effectively relieves symptoms. Colour Doppler sonography is useful for establishing the integrity of the portal circulation and confirming shunt patency.

Notes

2.15 – 3.45

Teach-in: Imaging in Paediatric Oncology

Hall 10a

Orbital tumours in childhood and their differential diagnosis

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Primary malignant tumours of the eye and orbit are rare in childhood; benign and non-neoplastic swellings are more common and frequently mimic malignant disease. Clinical presentation is with disturbance of vision, proptosis, strabismus or buphthalmos. Classifications of diseases at this site may be based on clinical presentation, age at presentation or site of involvement. The paper discusses the radiological appearances of the most common primary malignant lesions — rhabdomyosarcoma, retinoblastoma and optic nerve glioma; the most common metastatic lesions — neuroblastoma and leukaemia; benign lesions — haemangioma and epidermoid, and non-neoplastic lesions — cellulitis, pseudotumour, arteriovenous malformations and bone dysplasias.

Neonatal tumours — antenatal and post-natal diagnosis

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Tumours diagnosed within the first month of life are rare (incidence 1: 12 500–1: 17 300 total births). Less than half of these are malignant but the type and behaviour of these tumours are different from those encountered in later childhood. The increasing use of ultrasound during the latter part of pregnancy now means that an increasing number of these cases are being diagnosed antenatally. *Teratomas* are the most frequent neonatal tumours accounting for between 15–33% of all cases. They are essentially all benign but prognosis depends on the site. *Soft tissue tumours*, both benign and malignant, are common and together form the largest group. Fibrous tissue tumours predominate comprising the fibromatoses (infantile fibromatosis and myofibromatosis) and fibrosarcomas. *Neuroblastoma* is the commonest malignant tumour in this age group although, again, prognosis is unusually good. Most neonates with disseminated disease have Stage IVS disease but many show spontaneous regression. *Leukaemia*. Acute non-lymphoblastic leukaemia predominates neonatally. Prognosis is generally poor and leukaemia accounts for the majority of deaths from neonatal malignancy. Brain tumours both supra- and infra-territorial are rare tumours. Examples of cases and the experience gained at Birmingham Maternity Hospital and Birmingham Children's Hospital will be discussed.

The role of radiology in the management of neuroblastoma

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Neuroblastoma is the most common solid malignant tumour in children and usually presents before 5 years of age. The tumour arises from the adrenal gland and the sympathetic nervous system. 65% of patients have an abdominal primary and present with an abdominal mass. The tumour may also rise in the chest and pelvis. The role of radiology is to diagnose the primary mass and to define the stage of disease by demonstrating the extent of the mass and the presence of metastases. This initial evaluation includes ultrasound, computerized tomography and magnetic resonance imaging. The relative merits of these techniques will be presented. Approximately 70% of children have metastases, usually to bone and bone marrow. The role of both $^{99}Tc^{m}$ MDP bone scanning and iodine-labelled metaiodobenzyl guanidine scanning will be discussed. The radiological features of more unusual cases of neuroblastoma, such as Stage 4S, the opsomyoclonus syndrome and the vasoactive intestinal peptide secreting form will be presented. The role of radiology in assessing response to treatment and recurrence will be discussed.

2.15 – 3.45

ENT Imaging

Hall 10b

The investigation of sinus disease and its intracranial complications

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Recent advances in endoscopic sinus surgery have called for an enormous increase in imaging requirements. Coronal CT scanning is now a mandatory, standard procedure providing the necessary anatomical and pathological information for successful surgery to be performed. This presentation will briefly present some of the common and important sinus pathologies demonstrated on CT and will relate these to known sinus physiology. It will then move on to cover those aspects of anatomy and pathology relevant to the intracranial complications of sinus disease. The illustrations will demonstrate the ways in which tumour and infection spread from the skull base into the intracranial compartments. Whilst CT is the most commonly used imaging modality, the role of MRI will be discussed.

Subtraction magnetic resonance imaging for tumours of the skull base and paranasal sinuses

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The subtraction method Ziedses des Plantes has been applied to gadolinium-enhanced magnetic resonance imaging (GdMR). Using short acquisition times T_1-weighted spin echo sequences are made immediately before and after 10 cm^3 of intravenous gadolinium DTPA. To avoid moving the patient from the scanning tunnel between sequences the venipuncture is made into the dorsum of the foot. 40 patients with histologically verified naso-sinus or skull base tumours have been investigated by this technique and satisfactory studies obtained on all patients other than the claustrophobic. The densities recorded on the subtraction image are dependent upon the blood supply of the tissues concerned, thus producing a record of their vascularity: in effect a vasculogram. Improved demonstration of tumour extent was recorded in 85% of patients examined. Because of their infiltrative nature adenoid cystic carcinoma is particularly well shown by this technique, as are nasopharyngeal tumours, glomus tumours and recurrent naso-sinus tumours. In summary subtraction is most advantageous in situations where the anatomy is complex as in the skull base, or where normal structures have been distorted by previous surgery. It provides a more accurate record of tumour extent than that shown on unsubtracted GdMR scans.

MR appearances of skull base lesions

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Lesions at the skull base are an important cause of morbidity and the extent of involvement of surrounding structures can be difficult to appreciate on computed tomography (CT). We have evaluated the role of magnetic resonance imaging (MRI) in 100 patients with suspected skull base lesions. Clinical presentations included headache, diplopia, facial pain and cranial nerve palsies. MR images were obtained at 1.5 T, T_2-weighted axial and T_1-weighted coronal and sagittal images before and after gadolinium (Gd)-DTPA enhancement were obtained, with short tau inversion recovery images in selected cases. The MR images were evaluated to determine the size, signal characteristics and involvement of surrounding structures. Comparison was made with CT where available. Lesions of the skull bases were demonstrated in 35 cases. The commonest lesions were metastases, particularly from breast, bronchogenic and prostatic carcinoma and lymphoma. Other lesions were myeloma, nasopharyngeal carcinoma, meningioma, chordoma and chondrosarcoma. The diagnosis was confirmed by biopsy or longitudinal follow-up. MR was of particular value in assessing vascular and cranial nerve involvement. Bone marrow involvement was well seen although bony destruction was less easily evaluated. Gadolinium enhanced images helped to demarcate tumour margins and, when they were viewed in

conjunction with unenhanced images, separation from surrounding high signal fat was not a problem.

Extension of malignant neoplasms upwards through the skull base: role of enhanced MRI

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The foramen lacerum is bounded by the sphenoid, basi-occiput and petrous temporal bones. The carotid canal opens into the postero-lateral side. Formerly bone erosion in the region of the foramen lacerum was often the only radiological sign of intracranial extension of a nasopharyngeal carcinoma. The onset of cranial nerve lesions will indicate this intracranial spread which upgrades the staging to T4 and alters the field for radiation therapy. Demonstration of this extension by imaging helps the assessment greatly. We studied the role of contrast enhanced magnetic resonance imaging (MRI) for showing extension of malignant neoplasms arising below the skull base and subsequently extending through the area of the foramen lacerum into the parasellar region. We identified this extension in 11 cases, comprising three nasopharyngeal carcinomas, one carcinoma of tonsil, three adenoid cystic carcinomas, one melanoma, one case of lymphoma and two sarcomas. Invasion of the cavernous sinus needs to be identified by careful comparison of pre- and post-contrast scans, if possible with subtraction. Narrowing of the engulfed carotid artery was shown in three cases. Pain in the face was a common symptom from involvement of the trigeminal nerve and we would suggest that such persistent and intractable pain warrants an enhanced MR assessment, particularly in the coronal plane.

Clinical evaluation of combined MRI, CT and MRA in skull-base surgery planning

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In our institution patients are routinely imaged using computed tomography (CT), conventional magnetic resonance imaging (MRI) and sometimes MR angiography in preparation for skull-base surgery. Recently we have been using an anatomical landmark based registration technique to produce three-dimensional (3D) combined multimodal datasets. We are undertaking a clinical evaluation to determine whether appropriate displays of these combined datasets provide the surgeon with useful additional information compared with conventional viewing. We present the results of two experiments. The first was a retrospective evaluation of two-dimensional slices incorporating MR and CT information. The surgeon who had performed the operation identified key questions which he had needed to answer from the images, such as extent of pathology and best surgical approach. Independent surgeons and a neuroradiologist were then asked to answer these questions from conventional viewing of the MR and CT films, then to view the combined images and document any change to, or increase in confidence in their answers. In the second experiment, pseudo 3D displays were generated from the combined datasets using volume rendering techniques. Surgeons were asked to assess whether these displays (which included MR, CT and MR angiograms) provided an improved means of visualizing the 3D relationship between anatomical structures compared with multislice displays.

Benign and malignant enlargement of the pterygo-masseteric muscle complex

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The masseter and pterygoid muscles comprise the major muscles of mastication. Isolated enlargement of these muscles is rare and is most frequently caused by benign masseter hypertrophy (BMH). Less frequently enlargement may be due to neoplastic or inflammatory processes. We present seven cases of unilateral enlargement of the pterygoid and/or masseter muscles. Two cases are of haemangioma and two of rhabdomyosarcoma. One case of BMH is presented and two cases of leukaemic infiltration of the masseter, mimicking BMH. The latter entity has, to our knowledge, not been described previously. The use of computed tomography in the differential diagnosis is emphasized and other rare differential diagnoses are discussed.

The basal turn of the cochlea

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The coils of the cochlea are now demonstrated readily by thin section high resolution computed tomography (CT) in the axial plane. This assessment has now become important in severely deaf patients who are candidates for cochlear implant surgery. The commonest abnormality shown in these cases is post-meningitic or tympanogenic labyrinthitis ossificans which can obstruct the passage of the electrode.

Severe otosclerosis can cause a similar problem. Congenital deformities of the labyrinth are rarely suitable for implantation, but the procedure may be indicated for the true Mondini deformity; implantation is contraindicated for severe dysplasia of the cochlea and for the recently described variety of X-linked deafness with deficient bone at the fundus of the internal auditory meatus. Recent studies in the USA have shown that thin section 3DFT magnetic resonance imaging (MRI) can give spatial resolution comparable with CT as well as showing some soft tissue detail especially after gadolinium enhancement. We have used these techniques to study the cochlea both in normal subjects and in patients with severe cochlear type deafness, including candidates for cochlear implant surgery. We found that although MRI can suggest inflammation of the nerves and membraneous labyrinth or fibrosis in the cochlear coils, it has little value for patient management at present.

The parotid node – a pitfall in diagnosis?

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Ultrasound is being increasingly used in the detection and localization of the parotid gland tumour. In our experience it is a highly sensitive technique to demonstrate the tumour and may often show multiple lesions not detected with other imaging even in the contra-lateral asymptomatic gland. However, the parotid gland lymph nodes may appear ultrasonically similar to the tumour. It is important to identify these as lymph nodes if possible to avoid an overestimation of tumour extent and a false positive diagnosis for malignancy as these nodes are commonly seen in simple head and neck inflammatory conditions. This paper describes the usual sonographic characteristics and distribution of the parotid lymph nodes to aid the sonologist in the differentiation of the nodes from the parotid tumour and the aetiology of the abnormal nodes is discussed.

Salivary gland scintigraphy — a suitable substitute for sialography?

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The paper describes the use of salivary gland scintigraphy to investigate patients presenting with a variety of salivary gland symptoms/signs. A total of 72 patients was examined over a 5 year period, the vast majority referred from an oral and maxillo-facial surgeon. The patients were split into the following groups. (a) *correlative sialography:* 32 patients who presented with ? sialadenitis ? duct blockage problem; a further eight patients were examined following unsuccessful sialography. (b) *? Sjogrens:* 15 patients had scintigraphy alone as part of the investigation of xerostomia and/or xerophthalmia. In this group a correlation is made with the clinical/biochemical findings. (c) *Scintigraphy alone:* seven patients had scintigraphy alone, *e.g.* following refusal to have sialography, duct trauma, etc. (d) *Normal scintigraphy and sialography:* 10 patients had both normal scintigraphy and sialography despite presenting with salivary gland symptomatology. The series does not describe the use of scintigraphy to investigate possible salivary gland tumours but discusses the contribution to the functional/secretory aspects in assessing salivary gland disease. The conclusion reached is that scintigraphy is an accurate study of the accumulation/secretory aspect of the four main glands and might be considered as a substitute for sialography as the initial study, *e.g.* if sialography is technically difficult or the functional aspect is considered the most important. Sialography is still essential to demonstrate the anatomical detail of the duct system.

CT in diagnosis of naso-pharyngeal carcinoma (NPC)

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Nasopharyngeal carcinoma (NPC) is frequently found in the South Chinese population and in Chinese living in South-East Asia and other parts of the world; men are more frequently affected than women (PRASAD). Therefore, all patients suffering "colds" or other symptoms of the naso-pharyngeal region for a long period, especially if they are resistant to therapy, or patients showing enlarged neck lymph nodes should be carefully investigated with respect to NPC. After clinical examination computed tomography (CT) should be the first imaging procedure used. In our experience this has been done using a bolus injection (50 ml i.c.m.) followed by a dynamic scan (50 ml i.c.m. 1 2 ml/s) Advanced cases do not cause problems as lymph node metastases of the neck are mostly palpable. The problem is that early NPC is at times difficult to separate from its surrounding area and this cannot be shown in a very early stage. CT is very important in controlling chemotherapy. In addition, in advanced stages an isotope bone scan is performed to exclude bone metastases. *Conclusion:* CT is a very useful imaging method for detecting NPC as well as looking for the effects of therapy on follow-up. Compared with ultrasound, bone invasion can be shown by CT. However, in the future MRI will probably replace CT.

Diagnostic — therapeutic possibilities of interventional sonography on pathologic processes of the neck

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The study reveals the current possibilities of interventional sonography concerning benign and malignant processes of the neck, divided into two groups: (1) engaging the thyroid gland, and (2) not engaging the thyroid gland. The authors present the results of 102 diagnostic fine-needle biopsies of solid formations and diagnostic-therapeutic fine-needle punctures of liquid collections, both made under ultrasound control. Improvements and modifications of the classic method are offered, including: (1) volumetric evaluation of the findings prior to, during and after the invasive manipulation; (2) automatic aspiration applied to liquid collections and very dense processes; (3) a modification of the ultrafine needle "Chiba" and (4) a device for the conventional linear transducer, used for narrowing the ultrasound (US) beam. The results received when using the above mentioned improvements and modifications are compared with those from the classic US method. The authors conclude that the new modified method increases the diagnostic possibilities and enriches the therapeutic effects.

The ultrasonic appearances of normal vocal cords

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There is much current research in laryngology with the appearance of voice clinics and the development of new phonosurgical techniques. Mirror examination with a protruded tongue and extended vocal cords does not give an accurate view of the cords in their normal position for voice production. New techniques such as endoscopic video straboscopy can achieve this but is expensive and not widely available. Little investigation has so far been performed on the ultrasonic appearances of the vocal cords. Using a 7.5 MHz linear array transducer, we examined the cords of adult males, adult females and pubertal boys. In all cases the cords were identified with clear delineation of both the membranous and cartilaginous components. Movement in respiration and vocalization can be observed and recorded for assessment and documentation. Measurements of the separate components can be obtained and these correspond to accepted anatomical values. This work demonstates that ultrasound can be applied to the evaluation of normal vocal cords. It is particularly useful in the demonstration of movement and previously undescribed changes with growth and development of the pubertal larynx. Further work on research into changes in the male larynx at puberty and on pathological conditions is envisaged.

2.15 – 3.45

Physics III — Radiation Protection and Risks after ICRP 60

Hall 11b

Reappraisal of risks to the patient in diagnostic radiology

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Even before the Adrian Committee report was published in 1966 there was a consuming interest in radiation doses to patients. 25 years later, the questions being asked on patient dose and risk can be answered with slightly more confidence but almost as much uncertainty. Allowing for the variability in the human race, there are still orders-of-magnitude differences in the doses delivered within a hospital as well as between hospitals for the same radiological examination. Causes of differences and systems to reduce these can be audited, and action taken leading to a reduction in risk to the patient. In the light of the new recommendations from the International Commission for Radiological Protection (ICRP), the effective dose equivalent values received by diagnostic radiology patients have been reduced. However, the overall risk has increased as the risks of radiation have been re-evaluated upwards. The question of acceptability of risks should be considered by all referring clinicians and especially by those clinically directing radiation exposures. Patient groups particularly at risk are children and perhaps young adults in that the expression of a cancer is more likely in the potential life-years remaining.

The dilemma of leakage radiation — how much should we accept?

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The IEC working party is considering proposals to increase the allowable leakage radiation through beam limiting devices, particularly as the area shielded by beam limiting devices increases. The pressures for this arise from the need to contain equipment costs and to limit the weight of electron applicators. This paper examines the risks associated with radiation treatment, from megavoltage X rays and electrons, for tissue in the radiation beam but outside the treatment volume, and for tissue irradiated by leakage and scattered radiation only. Measurements have been made of the absorbed dose arising from both leakage and scattered radiation for different field geometries. The risk to tissue adjacent to the treatment volume has been calculated using ICRP Publication 60 (1990), which gives the best estimates to date of mortality risks associated with irradiation of different organs. This risk is compared with that due to leakage radiation alone. Except for one or two field geometries the risk from leakage radiation is small compared with the overall risk. The case for increasing the allowable leakage radiation is discussed.

Direct measurement of the radiation doses to relations of nuclear medicine outpatients

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We have made direct measurements of radiation dose to relatives of patients who have had bone scans (measured over 24 h), or have been treated with ^{131}I for thyrotoxicosis (measured 2–3 days). Pocket dosemeters were issued to family members of the patient, and so as not to cause concern the digital readout was masked. At night they were asked to place them under the pillow. The maximum recorded radiation dose in 24 h to the relative of a patient having a bone scan was 19 μSv ($n = 22$). From the area under the activity time curves, based on ICRP 53, the maximum dose to the relative of a $^{99}Tc^{m}$ patient is calculated as 5 times this figure (for RBC cardiac study). In the case of patients treated with radioiodine ($n = 5$) the measured figures ranged from 7 to 37 μSv over 2–3 days in four of the patients, with corresponding figures corrected using the time activity curve, of 31–127 μSv. One relative showed a figure approximately 10 times this and the case is being investigated in more detail. Radiation doses to relatives following $^{99}Tc^{m}$ radiopharmaceuticals are small, compared with the annual dose limits for the general public

proposed by ICRP. For radioiodine, figures are an order of magnitude higher.

Practical application of ICRP Publication 60 dose quantities to personal monitoring of staff who wear protective aprons

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The problem of how to undertake personal dosimetry for staff who wear protective aprons in diagnostic X-ray departments has for many years caused considerable debate. When the 1977 recommendations of ICRP introduced the concept of effective dose equivalent, a simple formula was derived to estimate this quantity from measurements made on the body beneath the apron and on the collar or forehead. The issue of new recommendations by ICRP in Publication 60 has brought with it the new quantities equivalent dose and effective dose. If and when these recommendations are introduced into radiation protection practice in Great Britain, there will again be a need to estimate the dose quantities for staff who wear protective aprons. This paper will re-examine the earlier formula, taking into account the new tissue-weighting factors of ICRP Publication 60, and will recommend a simple approach to personal dosimetry when the new quantities are adopted.

Radiation beam alignment at the chest-wall in mammography

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National and IPSM standards specify that the radiation beam alignment with the edge of the cassette at the chest-wall should be coincident to within 0 to +3 mm. Unfortunately, measurement methods and tolerances are not specified and, in our experience, many X-ray units have poor alignment due to design limitations and poor servicing. We have developed a test tool that can be used to measure alignment to an accuracy of ±0.5 mm and a measurement procedure that gives clear unequivocal highly reproducible results. Results will be presented that specify the extent of the alignment problem, that illustrate the design of the test tool, the measurement method and that also support our proposal that the present limiting value (0 to +3 mm) should be changed (to +2 to +5 mm).

Comparison of high and low kVp techniques for PA chest radiographs

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As part of a patient dose measurement programme, running in the East Anglian Region since Autumn 1990, measurements on postero-anterior (PA) chest X rays were carried out. Results showed that, in general, entrance doses given during high kVp chest X rays were higher than those at low kVps; furthermore all those departments which exceeded the National Radiological Protection Board guidelines on entrance doses were using the high kVp technique. The implications for effective dose to the patient are addressed. Reasons for the increased skin dose were investigated and a study has been made into ways of reducing the doses. Priorities have been assessed for the various methods of dose reduction. The differences in image quality for the different techniques are briefly considered particularly bearing in mind dose differences.

Patient dose measurement and reduction — a collaborative experience in East Anglia

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In Regulation 4 of the Ionizing Radiation (Protection of Persons undergoing Medical Examination or Treatment) Regulations 1988 there is a requirement to ensure that the dose of ionizing radiation to the patient is as low as reasonably practicable to achieve the required diagnostic purpose. Furthermore Health Authorities in collaboration with clinicians have been encouraged to formulate a strategy for dose reduction (HC(89)18). In order to achieve these objectives it is necessary for X-ray departments to be aware of the patient doses being given using the department's current techniques and equipment. Areas where dose reduction is required can then be identified, priorities assessed and action evaluated. In East Anglia a programme has been in operation for over 15 months to measure skin entrance doses to patients undergoing four common diagnostic investigations. Measurements have been made on over 1000 patients X rayed in over 30 departments (in the public and private sector). The success of the programme has been dependent on the close collaboration between the Regional Radiation Protection Service and the X-ray departments. Organization of the survey will be described and results presented. Changes made, as a result of unnecessarily high doses being detected, will be evaluated and their cost effectiveness discussed. Proposals will be made

(including resource implications) for the running of the programme as an integral part of a department's quality assurance programme.

Validation of software designed to calculate patient entrance exposures in diagnostic radiology

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In order to regulate patient doses in diagnostic radiology, it has been recommended that periodic measurements of patient entrance skin dose are made, so as to make comparisons with previous results and national norms. Regulations recommend that exposure factors are inserted in the patient's record following an examination. A number of software packages have been developed that calculate entrance exposures from these factors. We have acquired and evaluated one such package, RADCOMP. This software employs an analytic function which can be scaled to calculate free air entrance exposures for a particular X-ray set. Physical verification of the package was accomplished by performing exposure measurements using a research X-ray set and a secondary standard ionization chamber at a variety of kilovoltages and filtrations. These measurements were compared with those calculated using RADCOMP. Results showed that when using a single calibration point for scaling, 94% of RADCOMP readings fell within 3 SD of the measured readings, with 53% falling within one standard deviation. Comparisons were also made between RADCOMP data and patient thermoluminescent dosimetry measurements for several X-ray units. Problems were encountered in obtaining the information necessary for the software on machines where automatic exposure control was in regular use.

A portable system for measuring area kerma product during fluoroscopic examinations

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This portable system has been developed as part of a Department of Health funded project to install a BS5750 quality system within a diagnostic radiology department. The measurement system consists of a PTW M2 Diamentor connected to a portable PC, all mounted onto a small trolley. A transmission ionization chamber is fitted onto the LBD of an X-ray tube, permanently or temporarily, then examinations may be monitored as required. The whole system can be operated easily and quickly by the radiographer present during the examination. The computer automatically logs the area kerma product (AKP) readings from the Diamentor and prompts for other input data such as examination, patient size/sex, radiologist, numbers and sizes of films and kVp set. Data are filed and later transferred to a database for analysis. Thus patient exposures may be monitored throughout the hospital without incurring the cost of permanent installations. All types of examinations may be sampled and, where possible, AKP and energy imparted measurements may be compared within the hospital and with respect to national guidelines. Graphical analysis of exposure/time data collected during the examination may also be helpful in the training of radiologists.

Radiation dose to the breast from screening mammography in the West Midlands

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Following an assessment of dose to the breast in terms of mean glandular dose (MGD) for each mammography unit involved in the Breast Screening Programme, an evaluation of the average dose received by the screened population was made. It was found that the average compressed breast thickness for these women was 5.5 ± 1.3 cm and the corresponding MGD approximately 60–70% greater than the value obtained using the standard breast thickness of 4.5 cm at 28 kV. Additional measurements have been carried out to determine: (1) how the exposure values in milliamperes obtained under AEC conditions at 28 kV over the range of breast thicknesses compared with the milliampere values obtained for different thicknesses of perspex phantom and (2) the effect of varying the selected kilovoltage on the dose to the breast. Separate assessments of MGD were made at 30 kV and 26 kV, for systems where these are used routinely. Use of a palladium or rhodium filter has been considered for thicker breasts. Acceptable image quality (Pritchard standards) has been obtained using a 25 micron palladium filter with a molybdenum target, giving an MGD approximately 60% less than the molybdenum target/molybdenum filtration combination. Further assessments of image quality are to be carried out.

Patient doses received using digital subtraction angiography and Puck serial film changer

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The use of digital subtraction angiography (DSA) and a Puck serial film changer as a diagnostic tool for the visuali-

zation of blood vessels throughout the body is now widely accepted. A typical examination involves both fluoroscopy and a large number of multiple images taken at different projections and over different regions of the body. The exposure factors used are selected automatically. The dose to different patients may vary enormously but the complexity of the procedure also makes dose measurement difficult. Patient doses received during such examinations were assessed in order to calculate the risk of developing fatal cancers. The effective dose equivalent (EDE) was estimated using both a Diamentor to record the area-exposure product and lithium borate thermoluminescent dosemeters to measure the entrance surface (skin) doses. Carotid, femoral, renal and hepatic angiograms were studied. EDEs ranged from 0.6 mSv (femoral) to 44 mSv (hepatic). With an associated risk factor of 5×10^{-2} Sv^{-1} for developing fatal cancer a dose of 44 mSv would carry a risk of 2.2×10^{-3}. Such examinations therefore need to be carefully justified.

Assessment of organ radiation dose and associated risk for digital femoral arteriography

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The RCR/NRPB Joint Working Party Report *Dose Reduction in Diagnostic Radiology* indicates the need to assess patient dose for investigations undertaken with ionizing radiation. At present no published data are available for the dose delivered during digital femoral arteriography, and as this investigation accounts for 85% of the annual workload of the department, it was deemed necessary to make an assessment of radiation dose. Bilateral femoral arteriography was undertaken on 20 patients, using a filmless 1024 matrix digital image acquisition system with a discrete stepping tubestand and 40 cm image intensifier. A protocol of manual patient/tubestand positioning under fluoroscopic control and automatic stepping digital acquisition was followed. Skin entry doses were measured with a diamentor for each stage of the procedure, and the total gonad dose was assessed with thermoluminescent dosemeters. Conventional methods are supplemented with Monte Carlo simulations to calculate organ doses from the diamentor results. Surface doses to the pelvis and legs are presented with assessments of gonad and red bone marrow dose. However, there are inherent problems associated with the calculations and these are discussed. Additionally, the associated risk is evaluated with respect to the potential hazards of peripheral vascular disease.

Radiation doses during cardiac catheterization

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In recent years there has been increasing concern about the use of ionizing radiation for diagnostic purposes. In particular, there is concern over those procedures which give a high radiation dose to the patient and which may be repeated on several occasions. Cardiac catheterization is one such procedure. Following the installation of a new catheter room in June 1990 complete with a Diamentor, we have been able to measure the radiation doses to patients undergoing cardiac catheterization and, in conjunction with thermoluminescent dosemeter measurements from the skin of some patients, we have calculated whole body dose equivalents for the different investigations performed during cardiac catheterization. We have also undertaken a review of operator techniques which were thought likely to relate to patient dose. We present the results of this audit and discuss its possible implications.

4.15 – 5.30

Advances in Doppler Ultrasound

Hall 9

Doppler ultrasound flow measurement in the assessment of arteriovenous access for haemodialysis

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Effective haemodialysis requires adequate blood flow rates in the access fistula. We describe a prospective study of 27 patients with forearm arteriovenous access in which we used two Doppler ultrasound techniques to measure volumetric flow rate. A new Doppler method in which colour M-mode is used to estimate velocity profiles was compared with the conventional duplex technique. Measurements of fistula flow rate were correlated with clinical measures of dialysis efficiency, including recirculation rates and urea kinetics. All measurements were made within 4 days of each other. 13 patients had Brescia-Cimino (B-C) fistulas, 12 loop saphenous vein grafts (SVG), and two straight SVGs. Graft age was 1–60 months. We find that volume flow rates by the colour M-mode technique correlate linearly with those of conventional pulsed Doppler. The latter show higher flow rates than colour M-mode, an error we attribute to partial insonation. Saphenous vein loop grafts have higher flow than either the B-C fistulas or straight SVGs. There is no correlation between dialysis venous pressure and fistula flow. The high volumetric flow rates of normally functioning fistulae are consistently associated with low recirculation rates. Technical factors in both Doppler methods have a critical effect on reproducibility. Sources of error in flow estimation in these vessels will be discussed. We conclude that with careful technique, it is possible to use this colour Doppler method to measure volumetric flow rate in access fistulae.

	Colour M-mode	Pulsed Doppler
Loop SVG	190–1200 ml/min	500–1840 ml/min
B-C, Straight SVG	60–325 ml/min	100–760 ml/min

Colour flow mapping: does variance correspond to turbulence?

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Turbulent flow is known to occur in association with high grade carotid stenosis and causes spectral broadening and fluttering in the Doppler spectral waveform distal to the stenosis. Variance mapping on the colour Doppler flow image has been proposed as a means of documenting its presence. We prospectively evaluated this hypothesis by studying 15 patients with high grade (> 50%) stenotic lesions in the internal carotid artery. In all 15 cases, the site of increased variance on the colour Doppler map corresponded to the point of maximum velocity. In 10 cases of greater than 75% stenosis, the point of aliasing on the traditional colour Doppler map corresponded to the site of maximal variance. In five patients with stenoses between 50–75% diameter narrowing, the PRF was purposely decreased to induce aliasing. This resulted in the development of an abnormal variance map at the site of aliasing. In all 15 stenoses, the site of maximum turbulence, defined as fluttering in the Doppler spectral waveform, was not apparent on the variance map. We conclude that the variance map reflects spectral broadening and is more likely to occur at the site of aliasing. It does not necessarily depict turbulent flow.

A simple device to demonstate heating patterns in pulsed Doppler ultrasound beams

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A simple and novel method of visualizing heating patterns generated in acoustic beams is presented. Heating was produced in a plastic layer, approximately 1.0 mm thick, placed in a beam at right angles to the direction of propagation. A thin liquid crystal layer was spray-painted onto the distal side of the plastic, which underwent temperature-dependent colour changes in the range 25.7°C to 42.3°C.

This technique was used to produce cross-sectional thermal images in the field of a pulsed Doppler beam at different depths and under different equipment set-up conditions. The effect of varying the location of the range gate on the thermal profile was investigated.

Transcutaneous Doppler ultrasound imaging of the internal mammary arteries

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32 adult patients admitted for elective cardiac surgery (26 males, age range 43–72 years) underwent pre-operative transcutaneous imaging of left and right internal mammary arteries (IMA) using a 7.5 MHz colour flow duplex scanner. The left internal mammary artery was satisfactorily visualized in all patients (mean diameter 2.2 ± 0.3 mm, peak systolic velocity 76.4 ± 23.4 cm/s) with a calculated mean flow of 43 ± 16.7 ml/min (range 21–90 ml/min). The right internal mammary artery was visualized satisfactorily in 91% of subjects (mean diameter 2.4 ± 0.4 mm, peak systolic velocity 72.7 ± 23.1 cm/s) with a mean calculated flow of 41 ± 16.7 ml/min (range 20–80 ml/min). Doppler velocity profiles were similar to those seen in other peripheral arteries and there was no difference in measured variables between internal mammary arteries. Intraoperative free flow measurements were made in 13 patients with a measured mean flow of 69 ml/min (range 36–140 ml/min). Intraoperative flows correlated poorly with calculated pre-operative flows ($r = 0.1$). Post-operative imaging of IMA grafts was attempted in six patients and satisfactory Doppler signals were obtained in four patients. These showed reduced peak systolic frequency and increased peak diastolic frequency compared to pre-operative measurements indicating increased diastolic blood flow. Duplex scanning provides a method of evaluating the internal mammary artery pre-operatively. Pre-operative flow measurements did not correlate with intraoperative measurements. Changes in the Doppler waveforms after grafting indicates that flow patterns adapt to the coronary vascular bed supplied.

Colour Doppler studies of axillary nodes in patients with breast cancer

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As malignant tumours increase in size they characteristically stimulate growth of new blood vessels by secretion of angionesis factor. Colour Doppler maps blood flow over an area of an ultrasound image and allows assessment of blood flow in and around lower axillary nodes. In the present study a positive scan was recorded if any clear colour Doppler signals were seen in or adjacent to axillary nodes visualized on ultrasound. 51 patients with 52 breast cancers have undergone an axillary colour Doppler scan and axillary nodes have been assessed histologically in 48 of these axillae. The results are shown below. The sensitivity of colour Doppler for axillary node involvement is 75%, with a specificity of 96%, a positive predictive value of 94% and a negative predictive value of 84%. These results are significantly better than those obtained by other non-operative techniques of axillary staging. The high level of specificity of colour Doppler for axillary node involvement suggests that this technique merits further investigation.

	Histology	Total	Number with positive scan
Axillary Nodes	Involved	20	15[a]
	Not involved	28	1
	Not known	3	0

[a] Two of five with negative scans had primary tumours which were negative on colour Doppler.

Colour and duplex Doppler in the diagnosis of hepatic venous outflow obstruction

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We have assessed the role of duplex and colour flow Doppler in the diagnosis of hepatic venous outflow obstruction in nine patients with suspected Budd Chiari syndrome and four patients with hepatic vein thrombosis following liver transplantation. All nine patients with suspected Budd Chiari had hepatic venography. Colour flow appearance correlated well with venography in eight. In one patient severe stenosis at the hepatic vein/IVC junction was missed by colour flow although duplex Doppler was grossly abnormal. In another patient there was colour flow in all major hepatic veins but abnormal duplex Doppler. Hepatic venography was normal but the patient deteriorated. Colour flow signals remained normal though the duplex signals deteriorated. At post mortem small vessel veno-occlusive disease was diagnosed. In four children following liver transplantation there was no flow within the hepatic vein (cut down liver). This was confirmed in each case by surgery. In conclusion colour flow correlates well with venographic appearance but the duplex venous waveform and the junction of the hepatic veins with the IVC must be carefully assessed.

Colour Doppler ultrasound in suspected scaphoid fracture — the way forward

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The common clinical problem of the correct management for patients with suspected scaphoid fracture in the presence of normal carpal radiography remains unclear. The radial artery lies in close proximity to the scaphoid bone and its displacement may be the result of soft tissue trauma or haemarthrosis/effusion due to fracture. Both the radial artery and carpal bone contours are visible using ultrasound but conspicuity of the artery is considerably improved with colour Doppler. We have been measuring the scaphoid-radial artery distance in all patients with suspected scaphoid fracture, using the normal wrist as a control. All patients had standard radiography and were followed up to resolution of clinical symptoms. To date 64 patients have been scanned. A large variation in the normal scaphoid-radial artery distance (range 1.0–4.9 mm, mean 2.6 mm) was seen. The results were therefore analysed as a ratio of the symptomatic to asymptomatic sides. 20 of the 64 patients had ratios > 0.33, 11 of these proved to have fractures. Of the 44 with a ratio < 0.33, none proved to have fractures. The use of this method is a very sensitive (100%) predictor of scaphoid fracture. Although the ratio may be increased in soft tissue injuries (specificity = 83%), no false negatives have been seen. The routine use of Doppler ultrasound would significantly reduce the number of patients inappropriately immobilized in plaster casts.

Doppler pressure $\frac{1}{2}$ time estimation of valve area following percutaneous mitral balloon valvotomy

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Since its introduction into Doppler echocardiography the term mitral valve area = 220/pressure $\frac{1}{2}$ time has been widely used to determine the severity of mitral stenosis. We have used Doppler derived pressure $\frac{1}{2}$ time measurements to determine mitral valve areas before and after percutaneous mitral balloon valvotomy in 40 patients. Whilst almost all patients showed significant clinical improvement this improvement did not always correlate well with an increase in valve area measured by the pressure $\frac{1}{2}$ time. The concept basic to the acceptance of the $\frac{1}{2}$ time measurement has been that the flow through the mitral valve depends only on left atrial pressure and valve area. We feel the sudden alteration in the compliance ratios between the left atrium and left ventricle and the decompressive effect of the transatrial septal puncture may also affect transmitral flow. We call into question the accuracy of the pressure $\frac{1}{2}$ time measurement following percutaneous mitral balloon valvotomy.

Prediction of vesicoureteric reflux in children using colour Doppler imaging

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This is a prospective study of 25 patients referred for micturating cystourethrography (MCUG) for various urinary tract symptoms. Children with known anatomical deformity were excluded from the study. Colour Doppler imaging was used to visualize the ureteric jets and to locate the ureteric orifice by defining the point of origin of the jets. The distance of the ureteric orifice from the midpoint of the posterior wall (MLOD) and from the lateral angle of the bladder wall on the same side (LWOD) could then be measured. The measurements were compared with the results of MCUG performed on the same day. We found the refluxing ureters had a smaller LWOD than non-refluxing ureters and the difference was statistically significant ($p < 0.001$). Refluxing ureters also had a higher MLOD and the difference was not statistically significant ($p = 0.09$). A distance of < 8 mm included all the refluxers and 36% of non-refluxers. We conclude that the more laterally positioned the ureteric orifice the more likely it is to reflux. The LWOD is a better reading and we discuss the superiority of this over MLOD. This method may be useful for predicting which children with a urinary tract infection would benefit from MCUG.

Ultrasound diagnosis of Peyronie's disease in impotence

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A total of 281 patients (aged 28–74, mean 57 years) with erectile failure (EF) underwent colour Doppler and duplex ultrasound imaging (CDI), following intracorporeal papaverine. After achieving a Grade 2 or 3 erection visual inspection and palpation revealed plaques and/or constriction or deformity of the penis in 55 (20%) cases. 10 (4%) were known to have Peyronie's plaques prior to referral. Of these 55 patients, ultrasound showed focal echogenic plaques in 14 (25%) and diffuse thickening of the tunica albuginea or corpus spongiosum in 41 (75%). CDI diag-

nosed arteriogenic EF in 20 (36%) of these patients, venous leak in 10 (18%), arterial and venous in three (5%), and a normal response in 23 (41%). In 11 (20%) patients (seven with arteriogenic EF and four with venous leak) the plaque was seen to be affecting vessels. *Conclusion:* We believe that the diffuse thickening is a form of Peyronie's disease which is only recognized after pharmacological induction of penile erection. Patients with EF who also have Peyronie's disease commonly have a vasculogenic cause for their EF (59%).

Colour Doppler imaging and prostatic disease

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Objective: To study colour Doppler imaging (CDI) in the normal and diseased prostate. To correlate with conventional sonographic appearances (TRUS) and biopsy proven pathology. *Methods and materials:* 318 patients were examined using prototype CDI software with a transverse axial transrectal probe for the Acuson 128. Focal and generalized increases in CDI intensity were graded on a scale of 0–3. 100 biopsies were taken. *Results:* 132 had normal TRUS and CDI. 71 out of 91 cases of BPH had normal and 3 out of 91 significantly increased CDI. 36 out of 40 cases of prostatitis had increased CDI, 12 confined to the central zone (CZ), nine to the peripheral zone (PZ) and 19 out of 40 had a diffuse distribution. 42 out of 55 biopsy-proven carcinomas had increased CDI of grade 2 or more. 11 cancers had normal CDI; five had had radiotherapy, two were microfoci from reference biopsy sites. Increased CDI was confined to the PZ in all but two where it was diffuse. One case of cancer was diagnosed by CDI alone. *Conclusion:* There is generally no increase in CDI in BPH. Increased CDI in prostatitis was generally less than that seen in cancer and had a CZ or diffuse distribution. Increased CDI in cancer is seen in the PZ. CDI helps discriminate benign from malignant nodules and improves the specificity of conventional TRUS appearances.

Colour Doppler imaging in the investigation of impotence

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Colour Doppler and duplex ultrasound (CDI) was performed following intracorporeal papaverine on 220 patients (mean age 66 years) with erectile failure (EF). 154 (70%) patients were found to have an organic cause for their EF on CDI. Arteriogenic EF was diagnosed in 85 (39%) patients when the maximum systolic velocity, $V_{max} <$ 35 cm/s. Five patients had a $V_{max} > 35$ cm/s without a full erection, and seven patients with a $V_{max} < 35$ cm/s achieved a full erection, giving this criterion a sensitivity of 94% and specificity of 85%. All patients with a systolic rise time (delta T) > 0.1 s had arteriogenic EF, making this a very useful parameter indicating proximal stenosis. Venous leak was diagnosed in 69 (31%) patients, when the end diastolic velocity, $V_{min} > 7$ cm/s for at least 5 min and $V_{max} >$ 30 cm/s. Using cavernosometry and cavernosography as a gold standard in 48 patients, CDI had a sensitivity of 94% and specificity of 69%. Frequent measurements from both cavernosal arteries are required as the peak V_{max} occurred between 1 and 18 min (mean 7 min), and marked asymmetry of flow altered the diagnosis in 20 (9%) patients. *Conclusion:* Papaverine stimulated CDI is simple and provides helpful diagnostic information in the majority of patients with EF.

4.15 – 4.45

Body CT — Clinical and Technical Advances

Hall 10a

Spiral *versus* conventional dynamic CT: a randomized trial

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Spiral volumetric computed tomography (SVCT) has been predicted to improve vascular and organ enhancement with little effect on image quality. To investigate this, we studied 100 patients referred for CT where we would normally have performed dynamic incremental computed tomography (DICT). Patients were randomly allocated to undergo either DICT or SVCT. The resulting images were analysed for overall diagnostic quality, degree of enhancement and extent of artefacts associated with the technique. No statistically significant difference in overall image quality between SVCT and DICT was found, except for hepatic studies where the quality was significantly worse on SVCT ($p < 0.05$) due to the low milliamperes permissible. Enhancement was better with SVCT, although only in the thorax ($p < 0.01$) and for the group as a whole ($p < 0.01$) did this improvement reach significance. There was no significant difference in the extent of artefacts observed. All examination acquisition times were shorter using SVCT. The benefits of SVCT include the absolute contiguity of the reconstructed images and the ability to obtain many images at peak contrast enhancement. We have confirmed the latter effect. We are now also satisfied that there is no appreciable loss of image quality except where large volumes of solid tissue are examined.

Congenital abnormalities of the interior vena cava: diagnosis by computed tomography

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Congenital abnormalities of the inferior vena cava (IVC) and its tributaries are not uncommon. They may have important clinical consequences, complicating surgery and the interventional treatment of venous thrombo-embolic disease. These abnormalities may be simply diagnosed by computed tomography (CT) scanning of the abdomen, however, if their true nature is not appreciated they may provide a diagnostic pitfall by simulating para-aortic lymphadenopathy or other retroperitoneal disease. The commest abnormalities are double IVC, left-sided IVC, retrocaval ureter and retroaortic left renal vein. We demonstrate how these and other congenital abnormalities of the IVC may be diagnosed by CT scanning and illustrate how they may simulate pathology.

Computed tomography of the abdominal wall

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Computed tomography (CT) demonstrates the abdominal wall very well. Examples are shown of neoplastic, inflammatory, infective, vascular haemorrhagic and traumatic conditions of the abdominal wall imaged with CT. Its role in patients with abdominal wall hernia and ileostomy is illustrated. Pitfalls in interpreting abdominal wall CT, *e.g.* post-operative changes, are dealt with. Its limitation as well as its advantages are also addressed.

Optimum dose of non-ionic contrast media in abdominal and pelvic CT

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In order to determine the optimal amount of non-ionic contrast media (NICM) in intravenously enhanced computed tomography (CECT) in adult and paediatric liver, para-aorta and pelvis, extent of enhancement was assessed and analysed in relation to amount of NICM (iohexol or iopamidol) administered and conditions of CECT including the amount of iodine contained in NICM administered per body weight (I-dose/BW). Numbers of CECTs analysed were from 48 to 56 in adults and 16 to 33

in paediatrics. Contrast between the landmarking vessels and adjacent tissues including tumours or swollen lymph nodes was evaluated and categorized as "good", "fair" and "poor". Discriminant analysis was applied to the results of the assessment, in which the criterion variable was the categorized contrast evaluation; the explanatory variables were age (8 months–80 years), body weight (2.9–75 kg), I-dose/BW (0.1–2.3 gI/kg) and time-lapse from the administration of NICM to the scanning of the examination site. A standard of the minimum I-dose/BW for 50% of cases or more to achieve "good" contrast by each site of examination ranging from 0.6 to 1.9 kgI/kg according to the body weight was established, of which detailed figures will be discussed.

Notes

4.45 – 5.30

The Breast — Clinical and Technical Advances

Hall 10a

Mammography in the assessment of response to treatment in patients with large primary breast cancer

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Recently, treatment of large primary breast cancer has altered, with a trend toward initial management by chemotherapy or hormone therapy rather than immediate mastectomy. This allows tumour response to an individual therapy to be evaluated and if unsatisfactory, changed. Clinical examination to assess such response is essential, but the role of mammography in providing a more objective parameter for monitoring change is unclear. In order to determine the value of mammography in this group of patients, the sequential mammograms of 47 patients (age range 24–84 years) undergoing primary medical treatment for locally advanced breast cancer at this institution were reviewed and compared with the findings at clinical assessment. 26 patients underwent endocrine therapy and 21 chemotherapy. All had more than two mammograms which were reviewed blindly by two independent radiologists. Response to treatment was recorded using WHO definitions (NC, PR, CR, PD) by both evaluation modalities. Overall comparison of clinical examination with mammography showed agreement in 38 cases (81%) and disagreement in nine (19%). Agreement in type of response but not its degree was found in 21 cases (45%). The results suggest that whilst in the majority of cases mammography is a useful adjunct to clinical examination in monitoring response to treatment for locally advanced breast cancer, it does not provide a "gold standard" and the search for alternative modalities of assessment should continue.

Interval cancers in the breast screening programme

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In the prevalent round of breast screening in the North-west Thames Region, some 60 000 women have been screened and 340 women with breast cancer diagnosed. These have included 12 women whose initial screening mammograms were passed as normal and who presented within 12 months of this negative screen with carcinoma of the breast. The clinical data of these women and their mammograms have been reviewed and the findings analysed. An attempt is made to assess which cancers were missed rather than true interval cancers and which might have been diagnosed had clinical examination been part of the original screening process. Two of the 12 mammograms were thought to be abnormal on review and three of the 12 malignancies might have been diagnosed had clinical examination been carried out at the time of the initial screen. The value of double reading the mammograms is discussed and quality assurance guidelines presented to ensure as many interval cancers as possible are reported back to the screening centres.

The indeterminate breast mass. Does gadolinium-enhanced MRI have a role?

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Difficulty in mammographic and clinical differentiation of scar tissue from carcinoma is an increasing problem, owing to more conservative breast surgery. We used magnetic resonance imaging (MRI) to examine 22 women who presented with a mass which was indeterminate on clinical and/or mammographic examination. MRI was performed prior to biopsy. Surface coil axial T_1- and sagittal T_2-weighted images were obtained initially. Dynamic enhancement following intravenous gadolinium DTPA (Magnevist) injection was then assessed at 20 s intervals for 8 min using a T_1-weighted gradient echo sequence. A post-contrast T_1-weighted sequence was performed. Fat suppression images were obtained in two patients and were more sensitive in lesion detection. The dynamic gradient echo sequence was the most useful sequence in predicting tissue character. All carcinomas enhanced significantly, defined as $> 100\%$ of the original mean signal intensity. Areas of scar showed either no enhancement or enhancement $< 32\%$. These initial results suggest that contrast-enhanced MRI has a

role in the assessment of the indeterminate breast mass. Further assessment of fat suppression sequences is required.

Digital mammography: evaluation of digitizers

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At the present time the resolution achievable using computed radiography systems is insufficient, and to study the potential of the computer interpretation of digital mammograms, it is necessary to use digitized conventional films. In this paper we present a method to evaluate the technical performance of three film digitizers. These are being assessed as possible methods for obtaining digital mammograms for a national data-base. The digitizers investigated are a scanning microdensitometer, a laser scanning digitizer and a CCD camera. Each has a high resolution sampling pixel size (50 microns or less) and is capable of digitizing to a grey level of at least 8 bits over the complete range of diffuse optical densities (0–3) typically found in a mammogram. The digitizers have been compared by measuring the modulation transfer function, noise and linearity of each system. The results demonstrate the importance of considering all these aspects of performance when choosing a digitizer.

Computer detection of soft tissue masses in digital mammograms: automatic region segmentation

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The automatic location of suspicious areas in digital mammograms is difficult for a number of reasons. There is sometimes very little contrast between a tumour area and its background in the image. Tumours can have fuzzy edges, can be very small and are sometimes obscured by normal anatomical structure. A radiologist uses the anatomical symmetry of a pair of normal breasts as one of his many tests for locating suspicious areas in mammograms. In this paper we describe a method for unsupervised segmentation of equivalent regions in a pair of breasts. These regions can then be used to check for asymmetry between breasts. The first stage in the regional segmentation process is the development of a clustering procedure based on textural and spatial features sampled from a training set of pairs of mammograms. The resulting clusters are used by a weighted minimum distance classifier to partition any given pair of mammograms into regions with similar properties. Results for a test set of 50 patients are presented and it is shown that the algorithm is successful in separating the images into regions of axillary tail, regions radiographically very dense with structure and regions corresponding to adipose tissue. This is the initial step in the development of a system which will locate and classify soft tissue masses by comparing left and right breast images.

Ultrasound demonstration of small cancers detected by mammographic screening

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Previous studies have found ultrasound unreliable in the demonstration of small breast cancers (lesions measuring 10 mm or less). As a result, ultrasound has not gained wide acceptance as a method for assessing small, screen-detected lesions. In this centre, ultrasound is considered to be a useful modality for imaging small cancers found at screening. The visualization of these lesions has often been aided by combined mammography and ultrasound — a recently described technique developed in our unit. The mammographic and ultrasound appearances of 80 small cancers have been retrospectively analysed. Ultrasound demonstrated the vast majority of small cancers which presented as a mass on mammography. Cases showing only microcalcification on the mammogram were much less frequently demonstrated. Detailed results are discussed. We believe that ultrasound has an important role in the assessment of small breast cancers.

Colour flow characteristics of benign and malignant breast lesions

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Malignant tumours stimulate the growth of new vessels by a process known as neovascularization. The vessels have abnormal flow patterns and high velocity signals. These abnormal vessels are detectable using colour flow Doppler ultrasound. Early reports have indicated that malignant lesions of the breast may be distinguished from benign lesions by visualization of abnormal vessels in and around the lesions. Spectral pattern analysis of the vessels identified on colour ultrasound may show typical features in malignant lesions. We have studied 150 women of all ages with a

variety of breast lesions, using colour flow Doppler. We have correlated the histological analysis of the breast lesions with the vascularity and flow characteristics seen on colour ultrasound. We have found that certain malignant lesions have typical "malignant" circulation. However, some carcinomas show no abnormal vessels, and large benign lesions may also show abnormal flow. Colour ultrasound is very useful in the analysis of certain breast lumps, but a normal study must be interpreted in the clinical context.

Notes

4.15 – 5.30

Physics IV — Radiation Protection and Risks

Hall 11b

CT dosimetry: the joule in the crown of medical imaging

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Computed tomography (CT) is the crowning triumph of medical imaging technology in the excellence of the images and the speed of their acquisition, but it still delivers radiation energy to patients in doses that are large in comparison to those from conventional X-ray examinations. The undoubted benefits of improved diagnostic capability are achieved at the cost of increased radiation risks. Not all referring clinicians or radiologists are aware of this or of the fact that CT examinations now contribute as much as 20% of the collective dose to the population from all medical and dental X-rays. To make sensible dose comparisons, CT exposures should be expressed in a form that can be related to the potential radiation risks for the patient. Dosimetry methods have been developed at NRPB which allow the derivation of doses to radiosensitive organs from a simple dose measurement on the axis of rotation of the CT scanner. These methods, based on computer simulation of CT examinations on a geometric anthropomorphic phantom, are outlined. Results of a national survey showing the magnitudes of, and variations in, effective doses delivered by different CT facilities are presented. The variations are appreciable, and with effective doses for routine body scans exceeding 20 mSv (0.02 J/kg) at some facilities, the need for regular dose monitoring and control is evident.

The radiation burden of patients undergoing percutaneous transluminal coronary angioplasty

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The first large-scale estimate of radiation dose and associated stochastic risks surrounding the use of percutaneous transluminal coronary angioplasty (PTCA) was undertaken. Retrospectively, 2063 PTCA cases from 1987–1989 at the Ottawa Heart Institute were analysed. Skin entrance dose, individual and collective effective dose equivalent (EDE) were calculated. A subgroup of 311 patients who had multiple (3, 4 or 5) PTCAs was selected for a worst case analysis. Estimated skin doses are higher than in any other report and make PTCA the producer of the largest X-ray dose of any procedure in diagnostic or interventional radiology. Some skin doses are of an order considered to be near the skin erythema dose. We conclude that for the average patient this study justifies the current practice of PTCA. However, cumulative radiation burden should be monitored in patients under age 40 especially in young women where the risk of radiation-induced detriment to the breast or lung may be significant. We propose that a longitudinal epidemiological study be carried out on the cohort of women in this study.

CTDI: confusion and clarification

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The Department of Health Computerized Tomography Assessment group (ImPACT) perform dose measurements for type tests which are an adapted form of the computerized tomography dose index (CTDI). The CTDI is the most widely used dose parameter for X-ray CT specification, having its origins in early CT dosimetry papers. Since then, the definition has evolved in various forms, leading to confusion over its application. One particular adaptation of the CTDI has been adopted for use by the Food and Drugs Administration (FDA) in the USA, and as a consequence many CT manufacturers quote it in their technical literature. This paper describes the differences between the various definitions of the CTDI and examines different approaches to its measurement. Comparisons between the FDA and ImPACT versions of the CTDI are illustrated by means of data from a number of scanners. The practical application of CTDI measurements to acceptance testing and quality assurance is also discussed.

The use of lithium fluoride and lithium borate in CT dosimetry

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Lithium fluoride (LiF) and lithium borate ($Li_2B_4O_7$) are two thermoluminescent (TL) materials suitable for use in patient dosimetry. Until recently lithium fluoride was the material of choice as it was more readily available in a reliable form. Lithium borate however has an energy response which more closely corresponds to that of soft tissue and is therefore now sometimes favoured, particularly at diagnostic X-ray energy levels. In the energy range 30–100 keV there is a variation of 30% in the ratio of mass energy absorption coefficients of lithium fluoride to soft tissue, whereas for lithium borate this ratio remains close to unity. Because the effective X-ray energy of a CT scanner in the patient/phantom is usually not known, the use of lithium fluoride can lead to significant errors in absolute dose estimates. The disadvantage of lithium borate is that with most TL dosimetry readers it demonstrates a lower sensitivity than lithium fluoride. This paper presents measurements of the effective X-ray energies encountered in CT examinations and discusses the errors that can be introduced by the use of lithium fluoride. Comparisons are made with results obtained using lithium borate, indicating the optimum choice of dosimeter for this application.

Increased accuracy of CT dose profile measurement by the use of film

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In order to ensure the accuracy of the slice collimation of a CT scanner, it is important to be able to make accurate measurements of the dose distribution in the direction perpendicular to the scan plane. Thermoluminescent dosimetry (TLD) is currently used to measure dose profiles, but with many scanners now able to achieve slice widths down to 1 mm, this method is severely limited in terms of accuracy and spatial resolution. These problems can be considerably reduced by replacing the TLD with a sheet of envelope-wrapped film. An optical density profile is obtained using a scanning densitometer. Because of the non-linearity of the film's dose response, the width of the density profile differs slightly from the width of the corresponding dose profile. However, measurements carried out on a number of different scanners using a range of exposures and slice widths have shown that the full-width half-maximum (FWHM) of the dose profile may be derived directly from the FWHM of the density profile by the application of a simple numerical factor. Dose profiles accurate to within 0.2 mm may be achieved by this means, whereas TLD measurements are limited by the 0.9 mm thickness of each chip. Improvements in speed and convenience are also obtained.

Assessment of entrance doses received by patients undergoing lateral lumbar spine examinations

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Entrance surface doses to male patients were evaluated for lateral lumbar spine examinations in a sample of 11 hospitals within the West Midlands Region. Doses were evaluated using lithium borate thermoluminescent dosemeters placed on the patients' skin. The mean dose was 29.0 mGy (range 3.4–77.0 mGy, SD = 18 mGy, n = 43) for a mean patient weight of 70 kg (range 48–110 kg). This compares with the NRPB 1985 national survey: mean dose = 25.2 mGy (range 2.4–73.8 mGy, SD = 13.0 mGy, n = 185) for a mean patient weight of 73 kg (range 46–114 kg). For patient weights up to 30 kg, three hospitals gave doses exceeding the CEC guideline level of 30 mGy. Reasons for this included low film screen speed, filtration, kVp and small focus skin distance. Following the pilot study the procedure has been incorporated into the RRPPS routine survey of 67 hospitals and extended to cover thoracic spine, skull, pelvis and abdomen examinations. In addition to thermoluminescent dosimetry measurements, doses are calculated based on the exposure factors supplied by radiographic staff and technical data obtained during radiation surveys of the X-ray equipment.

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