

# UK RADIOLOGICAL CONGRESS 2005

UKRC was held in Manchester from Monday, 6<sup>th</sup> to Wednesday, 8<sup>th</sup> June, 2005 and attracted over 1,300 delegates. There was also a large technical exhibition.

## **BASIC PRINCIPLES OF CR AND DR**

### **Principles of CR for Implementation**

*(Mrs N Richardson, West Suffolk Hospital, Ipswich)*

West Suffolk have the Agfa system and doses were said to have been set at "2.0". With this system a figure of 2.3 means double the set dose while 1.7 is half the set dose. On the advice of the local Physics department, West Suffolk do not use the system below 60 kV. Plates are cleaned every two weeks and erased every Monday morning. Flat-field tests are done once per month. Quality assurance for the digitizers is done once every two months but the test needs software from the supplier. Rejects are analysed as due to positioning exposure factors and other causes. Plates are not kept on mobiles. Studies have shown that lateral skulls and lateral hip projections can be done without a grid using an airgap technique. West Sussex try to use the bucky in the table or the vertical bucky or a skull unit. If a stationary grid is to be used, then it needs to have more than 70 line pairs per cm. It was said that the equivalent speed for chest X-rays was 400 and for extremities, 200. Mrs Richardson thought that more quality assurance was needed for CR than for conventional radiography.

### **Principles of DR**

*(Ms J Cowell, Addenbrooke's Foundation Trust, Cambridge)*

Ms Cowell said that the initial implementation of a DR system was expensive and required time and investment in staff development. She described some of the artefacts which could be produced. Under-exposed images are subject to quantum mottle. The most common printer artefact was lines which had not been printed. They review their images within the X-ray room rather than at reporting consoles.

### **Debate: DR is Superior to CR**

*For the Motion (Dr Elizabeth Hunt, Addenbrooke's Hospital, Cambridge)*

Dr Hunt said that DR gave improved quality and went on to justify this under a number of headings. As regard the patient, a survey showed that they valued speed with low waiting times and immediate results. It was said that the average time for a CR image was 7.8 minutes whereas for a DR image it was 4 minutes. The times to view the image from the exposure for chest and abdominal images was claimed to be 1 minute and 1 minute 15 sec, respectively, approximately one third of the values for CR. As regards staff, they liked working with modern technology. The manual handling issues of dealing with piles of cassettes are avoided. There is also no need to leave the patient in the room. It was said that staff find CR too slow for modern demands. The higher throughput of patients was said to be less stressful to staff. For image quality, the resolution of DR was said to be greater and doses were reduced. DR was also said to be cost-effective. Six days work with CR was said to be able to be done in less than five days with DR. Alternatively, fewer rooms would provide the same workload. The risk of entering the wrong patient demographics was said to be reduced. Over 10 years, DR was said to be cheaper.

*Against the Motion (Mr Philip Cosson, University of Teeside, Middlesborough)*

The photo-stimulable phosphor plates used in CR were said to have an energy absorption spectra broadly similar to that of film-screen, allowing the same radiographic techniques and exposure conditions to be used. CR was said to require less training and the burden of quality assurance and calibration was lower than that for DR. The CR receptor could be placed in most environments whereas DR would not work at high temperatures. CR gave virtual edge-to-edge coverage and short object to film distances were possible because of the slimness of the units. No cables were necessary. CR had lower purchase costs and allowed 100% utilisation of all existing and future radiographic equipment. There was thus a lower risk of downtime. Mr Cosson said that the argument that DR allowed an increased work-flow was not totally true, particularly if there was a case-mix. Purchase of an IP changer would deal with issues of handling many cassettes. New phosphors were being developed, such as caesium bromide doped with europium, and these gave increased scanning speed and accuracy.

In the ensuing debate it was said that the national programme had chosen CR rather than DR. Others said that this was based on initial costs rather than looking at long-term solutions. For training it was said that there were limitations as to what students could be taught about all technologies. A new ICRP publication talked of three different levels of doses. Mr Cosson was thinking of moving towards these three levels of doses, for example, for chest radiographs.

## **DIGITAL RADIOGRAPHY**

### **Digital CR Mammography**

*(Dr Erica Denton, Norfolk & Norwich University Hospital NHS Trust, Norwich)*

Dr Denton's original system was a Fuji CR 5000 with pixels of 100 microns. This has now been upgraded to a Fuji Profect with pixels of 50 microns. The increased latitude and contrast of mammographic CR was said to more than make up for decreased resolution when compared with conventional film-screen mammography. Her hospital has a GE Pathspeed PACS. The department is filmless except for localisations and referrals to other hospitals. The PACS allows magnification on the screen. Initially it was thought that CR mammography was clinically as good as film and that they may not need the 2A (1728 x 2304) monitors but that the 2B (1200 x 1600 pixel) monitors would be adequate. They wondered if the 1C monitors would be good enough for reviewing by radiographers. Fuji thought that the 100 micron pixels would be adequate. The TOR MAX Test Object showed that resolutions of 16-20 line pairs per mm achievable with film-screen were between 4 and 5 line pairs per mm for CR. However, the number of objects of larger diameter which could be visualised were the same with both systems. Later results, however, showed that the results from test phantoms may be misleading in evaluation. They were not the same as results for clinical films read by radiologists. It was also concluded that there was no need for routine magnification of calcifications and that at least 2A workstations were needed for mammography. This has severe cost implications. Hard copy images were said to be worse than images from the best monitors. Radiographers need at least B-grade workstations to review parameters. It was also said that images with 50 micron pixels could not be distinguished clinically from those with 100 micron pixels.

Initial problems with the introduction of the system included increased time for radiographers and a long learning curve, particularly for PACS. Analysis of the workflow showed identical number of steps for film and CR but full field digital mammography had a decreased number of steps. Comparing DR with CR showed similar contrast and dynamic range but DR has no cassettes and the post-processing was said to give the potential for improved dose efficiency. The resolution achievable with DR was less than that with film but greater than that from CR. However, DR was much more expensive although this difference is decreasing. A formal physics evaluation of CR has said that the 50 micron and 100 micron pixel systems can meet European standards but do not do so consistently. Contrast-detail performance can be improved with increased dose but the dose may have to rise unacceptably. Artefacts were said to develop on the imaging plates with time. In conclusion, 50 micron systems were said to be superior to 100 micron. Agfa and Kodak were introducing a 50 micron system but the impact was still to be fully assessed. Stringent QA was necessary for soft and hard copy reporting and imaging plates required regular replacement. For the future, it was said that there would be data acquisition at 20 pixels per mm with full resolution on the display monitor so that there would be no need to print to film to obtain the full resolution. Inferior monitors would require zoom x2 to be used.

In the discussion it was asked what frequency was meant by regular change of image plates. The reply was that this was not known but that QA tests were needed to tell us the answer. A delegate said that National Mammography Physics had agreed that the TOR MAX/MAM was insufficient to distinguish monitors. Another delegate asked if the radiologists were given the full image when they said that they could not distinguish images with 50 microns from those with 100 microns. The reply was that they were originally given the full image and they were allowed to manipulate it.

### **DR Mammography**

*(Dr Nick Perry, St. Bartholomew's Hospital, London)*

Dr Perry started by giving an overview of the DR mammography systems available at present. Pixel size has a big effect on the storage requirements. Acceptability of DR mammography was said to be high among radiologists and radiographers. The speaker knew of no centres who had adopted DR and

who later wanted to go back to film-screen. Its logistical use is under evaluation in the NHS Breast Screening Programme and several UK centres are carrying out clinical evaluation. Image manipulation promises potential benefits and there were said to be fewer recalls with DR. The improved image quality leads to better detection rates and there was also said to be a benefit for younger women who have denser breasts. The system lends itself to tele-mammography and the technical platform gives the ability to move into tomo-synthesis and 3D reconstruction. The clinical effectiveness of DR mammography remains under trial in the USA with the ACRIN/DMIST Study still to report but it has been satisfactorily evaluated in the Oslo screening programme. It was thought that full field digital mammography would be the future of mammography. The future would be filmless and paperless. Its introduction would not be cheap and would not be easy but would be exciting.

### **Dental Digital Radiography**

*(Professor Keith Horner, School of Dentistry, Manchester University)*

It is estimated that there are currently 12.5 million dental exposures carried out each year in the UK. The figure is probably a gross underestimate since many exposures are taken by private dentists. The first digital radiography system was the Trophy RVG which came on the market in 1989. It used an intensifying screen which was linked to charge-coupled devices through an optical coupling. Current systems can be divided into two main groups: solid state systems using charge-coupled devices or complementary metal oxide semi-conductors (CMOS) and phosphor plate photo-stimulable systems. For CCD detectors there is now a caesium-iodide scintillator grown on to a carbon base as in the CMOS Schick sensor. Solid-state detectors are bulkier than film and all except one have a cable attached. The exception is the Schick CDR wireless which is an RF device. They are vulnerable and it is not unknown for patient to bite on the cable. Barrier sheaths are needed to prevent cross-infection. Retake rates were said to be consistently higher than with a film, so sensor holding devices should always be used. Early problems from high exposures were saturation of the CCD and blooming effects.

The alternative is photo-stimulable phosphor plates. A full list of what is on the market can be found at [www.odont.au.dk/rad/Digitalx.htm](http://www.odont.au.dk/rad/Digitalx.htm).

Some systems are not DICOM compliant. Typical image sizes for an intra-oral image and an extra-oral image are 250 kB and 10-15 MB respectively. Digital radiography allows the possibility of subtracting images over time to see changes, for example, healing. Interpretation of everyday pathosis was said to be comparable with film with possibly minor problem with the finest details such as endodontic files. There is a distinct advantage over film as processing is not necessary. In selecting systems, care is needed to avoid older designs which may not be DICOM compliant.

## **UKRC APPRECIATION OF SIR GODFREY HOUNSFIELD**

### **The History of CT – a Personal View**

*(Professor I Isherwood, University of Manchester)*

Professor Isherwood outlined the development of CT in its early days and described how it was a fundamental advance on diagnostic imaging. Professor Isherwood was involved with the first EMI CT 5000 general purpose scanner which was installed in Manchester in 1975.

### **Multi-Slice CT – New Horizons in Clinical Practice**

*(Professor Adrian Dickson, Addenbrooke's Hospital, Cambridge)*

Professor Dickson said that the majority of sick patients now admitted to hospital would undergo some form of investigation relating to Sir Godfrey Hounsfield's invention. An objective radiological examination was in many cases more reliable than a subjective physical examination. CT can often replace a lengthy sequence of less definitive tests. He said that in 15 years time, chest X-rays would no longer be done. A quick CT might as well be done at the start. For the future he favoured more radiologists and fewer clinicians.

### **CT Technology – A Revolution in Our Time**

*(Mr G Dombrowe, Siemens Medical Solution)*

Mr Dombrowe gave a history of CT describing how the introduction of slip-ring technology in 1987 led to further advances just as it seemed that CT had reached a plateau. Later when it seemed another plateau had been reached, multi-slice CT was introduced. He described soft tissue CT in the Angio Lab, so called Dyna-CT. For the future he said that the number of slices which could be imaged simultaneously was not as important as some people think.

## **CLINICAL INTERVENTION SCIENTIFIC SESSION**

### **Endovascular Treatment of Diseases of the Thoracic Aorta, An Asian Experience**

*(Dr P Uei, National Health Group, Singapore)*

Endovascular repair of diseases of the thoracic aorta was carried out on 18 patients over the period 1998-2004. They were followed up with CT for durations ranging from one month to four years and five months. Technical success was obtained in 17 out of the 18 patients, leading to the conclusion that endovascular repair is a viable option for primary treatment.

### **Look after your Feet: The Value of Radiation Protection Footwear**

*(Miss Jenny Diffey, Christie Hospital, Manchester)*

Surveys of doses to the feet of interventional radiologists in one room have shown doses of approximately 50 mSv per year. The yearly workload in this room is approximately 500 procedures consisting of ERCPs, oesophageal stents and gastrostomies. Attempts were made to try to reduce the dose. There was no mechanism for attaching lead drapes and a mobile screen was thought to get in the way. Protected shin pads were a possibility but the operator often stands with his side to the X-ray tube. A solution was to coat knee-high rubber Wellington boots with 0.125 mm lead equivalent vinyl (supplied by Rothband). It was calculated that this amount of lead would reduce the dose by a factor of 5. Monitoring using TLDs inside and outside the boots for 20 ERCPs and 6 gastro-intestinal procedures over two weeks showed that doses to the foot were reduced by between 80 and 90%. Doses to the left shin were reduced by 97%.

### **DEBATE: Radiological Imaging without Consent is Assault**

#### **For the Motion**

*(Dr Bob Bury, Leeds General Infirmary)*

Last year in the British Medical Journal, Picano, an Italian cardiologist, argued that since radiation was dangerous, detailed consent was required even for an examination with a low dose, such as a chest radiograph. Dr Bury said that, legally speaking, assault included the threat and that the action itself is called battery. He considered that the charge would be trespass to the person which is a civil offence. It was said that there are many different types of consent, written or un-written, actual or implied. All these are valid. An example of implied consent would be where a patient held out an arm for an injection. However, it was said that consent is not valid unless it is informed. In 1988, in Pearce versus the Royal United Bristol Hospital NHS Trust, the judgement was that it was the Trust's duty to inform a reasonable patient. There is no definition of what amounts to reasonable and so one is trying to second guess the patient as to what risks they consider significant. Judges in the past have said that patients have the right to refuse treatment even if it seems unreasonable. It might be argued that in radiology, the risk is less than the benefit and since there is no net risk there is therefore no need to inform the patient. On a population basis, the net benefit exceeds the net risk. However, this does not apply on an individual basis and Dr Bury was certain that at least some patients would want some information. He proposed notices in the waiting room, banding of examinations into low risk, variable risk and negligible risk with the whole being put into perspective with the benefit. Most would be glad of the information and appreciate it.

#### **Against the Motion**

*(Dr Paul Dobbins, Plymouth Hospitals NHS Trust)*

Dr Dobbins said that the motion implied that radiologists favoured sneaking up behind the patient and X-raying them against their will. Informed consent is defined by the courts and all actions in the X-ray room are based upon implied consent. Most departments now produce patient information leaflets

and have web-sites and other means of giving information to the patient. He does not have time to explain to the patient everything which could go wrong and presumably the information would have to be made available in all languages. If he did have the time, then how many patients would be able to understand the risk figures? Informed consent implies that the patient is able to handle the information. He wondered what had happened to the doctor-patient relationship on trust. Informed consent for all eventualities was said to be political correctness gone mad. It was a protective coat for the doctor or radiographer who wants the patient to take the difficult decisions. It is a legal doctrine not to protect the patient but to protect the doctor from other legal doctrines.

At the end of the two presentations, 60% of the audience were against the motion. Before the presentations, the percentage of those against the motion had been 42%.

In the discussion which followed, it was said that, for example, bad reactions to contrast were direct effects and could be attributed to the injection of the contrast. Radiation was different in that future ill-effects could not be proven to have been caused by the radiation. Dr Bury thought that this was a “mean view” of consents, protecting the doctor rather than the patient. Another person thought that small doses of radiation were protective. Should patients be told of this? It was said it depended on how much time the person had. It was asked what was the legal position if a patient withdrew consent half-way through a procedure. Dr Dubbins said that this would have to be respected unless the patient was sedated and then it would not be deemed as informed consent. Another person asked about the deterministic effects of radiation. Was that risk informed? Dr Dubbins said that the Royal College of Radiologists had issued advice on this. There was said to be a formal reporting system for radiation injuries such as ulcers.

#### **John Mallard Lecture – Freedom for Imaging**

*(Professor Peter Sharp, Grampian University Hospitals)*

Professor Sharp gave an outline of the career of Professor John Mallard who was involved in a wide range of medical imaging equipment in the early days with rectilinear scanners and gamma cameras. He built one of the first SPECT scanners and carried out PET in Hammersmith in 1960 using arsenic-74 and arsenic-72. Professor Sharp then went on to mention some possible future imaging modalities such as proton-electron double-resonance imaging or PEDRI – a form of electron spin resonance which causes free radicals to light up an image. He also mentioned terahertz imaging, diffractive X-ray imaging and quantitative protein imaging. Many challenges remain. He thought that it must be ensured that people continue to train in research.

### **AUDITING AND OPTIMISING PATIENT DOSE**

#### **Invited Review: Is the Justification Process really Controlling Patient Dose?**

*(Mr S Ebdon-Jackson, Health Protection Agency)*

At first sight Mr Ebdon-Jackson thought that the title for his invited review should have the word *optimisation* rather than *justification*. Studies carried out some years ago showed that about 20% of exams were not justified and so patient dose would be reduced by proper justification. Also, the justification process in EC 97/43/Euratom involves the “prescriber” and the “practitioner” and includes the provision of medical data on which justification is based as well as justification itself. He thought that the concept of collective effective dose had limited usefulness. Low collective effective dose may mean good justification and optimisation but he also thought that it could mean inefficient use of radiological resources or poor access to radiology. Firstly he looked at the number of procedures which were carried out. The total number of radiological examinations in England in 1997 was 26.7 million. This rose to 30.6 million by 2004. For CT the number of procedures in 1997 was 1.05 million which rose to 1.99 million in 2004 whereas for MRI, 0.4 million procedures in 1997 had risen to 0.86 million in 2004. The rate of increase of radiological procedures was less than 3% per year whereas in England for CT there had been an 89% increase in the number of examinations from 1997-2004. The number of CT scanners in England had increased from 200 in 1997 to 364 in 2005 – an 83% increase, almost exactly the same as the increase in the number of procedures. Had he still been at the Department of Health, Mr Ebdon-Jackson would have been expressing concern that all the extra scanners which had been installed had not resulted in greater number of procedures but since he was no longer in the Department of Health he no longer cared. For MRI scans there had been a 120% increase since 1997 while the number of scanners had increased by 135% over the same period. As a

percentage of the number of procedures, CT accounted for 4% in 1997, 4.7% in 2000 and 6.5% in 2004. For MRI the corresponding figures were 1.5%, 2% and 2.8%.

He said there was anecdotal evidence from IRMER inspections that the justification process was being observed, especially for high dose procedures. He thought that justification for CT was well developed and that dose audits were being undertaken. The quality of medical data provided had improved. In conclusion, he said that we did not really know if the justification process was really controlling patient dose but that it was part of the package and was being taken seriously. There had been no explosion in the number of radiological exams in the UK in the last five years and no explosion of dose in the UK over that period. He therefore thought that the justification process must be taking place.

### **UK CT Dose Survey 2003**

*(Dr Paul Shrimpton, Health Protection Agency)*

The 2003 survey of CT doses in the UK has been published as NRPB Report W67 in 2005. It was based on a questionnaire and covered 126 CT scanners, more than a quarter of all the scanners in the UK. Data published by ImpACT were used to estimate the values of  $CTDI_w$  and  $CTDI_{vol}$  for each sequence and the dose-length product was calculated from knowledge of the lengths of the scans. Values of dose-length product were then used to calculate effective doses. Wide variations in practice were still apparent but the third quartile values of the dose indices were in general 10-40% lower than the corresponding data for adults from the 1991 survey or for children from a European survey published in 2000. They were, however, broadly similar to data from a European survey of CT carried out in 2001. National reference values based on the third quartile values have been proposed. They are higher for multi-slice scanners when compared with single slice scanners. The effective doses to 0 – 1 year-old patients were typically higher than the corresponding values for adults. Forms for further data submission may be obtained from [www.ctug.org.uk/ctsurvey.htm](http://www.ctug.org.uk/ctsurvey.htm).

### **Continuing Dose Audit Facility – Quality Control and Diagnostic Radiology**

*(Mr Melvyn Lewis, Integrated Radiological Services Ltd, Liverpool)*

The quality assurance dose data system (QADDS) was networked to five key Trusts to enable staff to enter patient exposure details. Results were linked to a central data management facility. A report analysing radiation doses to patients within each Trust was produced. The QADDS system eliminated paper records allowing comparison of patient dose both internally and against other hospitals. Local DRLs were established and compared with national values. Mr Lewis put forward the idea that there should be separate DRLs for male and female patients.

### **Flat-Plate Cardiac Angiography: Radiation Dose Reduction by Gridless Magnification without Compromising Image Quality**

*(Dr J Partridge, Harefield Hospital, Middlesex)*

One group of patients having uncomplicated diagnostic coronary angiography (n = 154) or single vessel angioplasty (n = 102) were examined on a GE Innova flat-plate system. The mean dose area product was 26.3 Gy cm<sup>2</sup>. A second group made up of 122 diagnostic and 79 PTCA was studied with the grid out and an airgap for control of scatter. Detector magnification was reduced by one step and the air gap adjusted to achieve the same image size as the gridded series. For the diagnostic studies, the mean value of DAP fell from 26.3 Gy cm<sup>2</sup> to 16.13 Gy cm<sup>2</sup>. For PTCA it fell from 48.15 Gy cm<sup>2</sup> to 37.03 Gy cm<sup>2</sup>. A panel of observers said that there was no significant change in image quality for the group examined without the grid when compared with the group who had the grid. There was a significant difference when the whole group was divided into two according to the patient's mass. Image quality was said to suffer more from patient size than the choice of scatter control. The speaker proposed that gridless air-gap images should be the default technique.

### **Dose Comparison between Multi-Slice Non-Contrast CT and Intravenous Urography to Diagnose Renal Colic**

*(Mrs Alison Tuck, Kingston Hospital, Kingston-upon-Thames)*

The study compared the radiation doses from multi-slice non-contrast CT (NCCT) and IVU examinations in the diagnosis of renal colic. Effective doses were calculated for both techniques. The mean dose for CT was 3.3 mSv compared with 2.2 mSv for IVU. The inter-quartile range for CT was smaller than that for IVU because of the consistent nature of the CT exam. The conclusion was that

IVU was the modality of choice for renal colic exams. If there were contra-indications to the IVU exam, then low dose NCCT should be used.

### **Lifetime Fatal Cancer Risk Estimate in Uterine Artery Embolisation**

*(Dr A Craig, Manchester Royal Infirmary)*

It was said that there was a lot of literature on the risks and benefits of uterine fibroid embolisation (UFE) but that little attention had been paid to the risk of radiation-induced cancer. The study calculated effective doses and organ absorbed doses from readings of dose-area products using the software packages NRPB-SR262 and XDOSE. The examination selected was a PA pelvis as this approximated the same actual field sizes and positions used. The risk of inducing fatal cancer was derived from NRPB-R260. For the 28 women, the median value of DAP was 58.5 Gy cm<sup>2</sup> ranging from 2.4 Gy cm<sup>2</sup> to 389 Gy cm<sup>2</sup>. The median risk of fatal cancer was estimated as 0.03% ranging from 0.2 to 0.0014%. It was concluded that the lifetime fatal cancer risk associated with UFE was of the same order of magnitude as the mortality from hysterectomy. The speaker thought that most patients would expect to be informed of a radiation risk of that magnitude and that information on radiation risks should be included in the information leaflet for the patient. Reference was made to the paper by Picano in the British Medical Journal, Volume 329, pp849-851 (2004).

### **Invited Review: The Role of HPA CRCE Radiation Protection Division and Future Inspections for IRMER**

*(Mr S Ebdon-Jackson, Health Protection Agency)*

The speaker said that in the future, the HPA CRCE (Centre for Radiation, Chemical and Environmental Hazards) would advise on IRMER. IRMER policy was a matter for the devolved administrations. Discussions regarding IRMER inspections are ongoing. In England, discussions between the Department of Health and the Healthcare Commission are considering the Healthcare Commission taking on the role of inspections. In England, IRMER incidents are now no longer reportable to Mr Ebdon-Jackson but to Patricia Brown at the Department of Health.

## **RADIATION PROTECTION: LEGISLATION AND GUIDANCE**

### **Radiation Protection and the Interventional Radiologist: A Personal Perspective**

*(Dr H Coons, Interventional Consultants, Escondido, California, USA)*

Dr Coons reviewed some of the harmful effects of radiation and outlined some measures to reduce the radiation exposure of patients and staff. He promoted the use of collimation, undercouch tubes, decreased source to image distance, sparing use of magnification and road-mapping and pulsed rather than continuous fluoroscopy,

### **Invited Review: New ICRP Recommendations**

*(Dr Clare Cousins, Addenbrooke's Hospital, Cambridge)*

Dr Cousins is a member of ICRP Committee 3 (Protection in Medicine). She said that new recommendations were required because there are 30 different numerical values for restriction of individual dose. The new recommendations will taken into account, for the first time, protection of the environment and non-human species. Radiation weighting factors will be specified for protons and neutrons for which a continuous function will be given. Radiation weighted dose will replace the terms dose equivalent and equivalent dose and may be given a new name. Tissue-weighting factors will now be based on incidence rather than on mortality. The tissue-weighting factor for the breast, for example, will now be increased to 0.12. The document will have the same dose limits as ICRP 60 but the limit for the lens of the eye is under review because of new data on cataracts. Maximum values of dose constraints will be given. These will need to be complemented by optimisation so that levels in practice are expected to be well below the maximum. The minimum constraint will be 0.01 mSv. The earliest possible adoption of the recommendations would be in the late summer or autumn of 2006, with the recommendations being published in 2007.

### **Invited Review: Incident Reporting under IRR 99**

*(Mr James Taylor, Health and Safety Executive, Luton)*

Inspections and incident investigations under IRR 99 are carried out by the Field Operations Directorate of the Health and Safety Executive. There are eight specialist inspectors for radiation. Mr

Taylor reminded delegates that Regulation 25(1) of IRR 99 required employers to notify the HSE as soon as practicable when an over-exposure was suspected. This regulation did not apply to medical examination or treatment or to exposure of comforters and carers. Regulation 30 deals with occurrences such as release or spillage of radioactive materials and loss or theft of radioactive materials. Employers are required to make an immediate investigation and forthwith notify the Executive unless the investigation shows that an incident has not occurred. Regulation 32(6) deals with persons undergoing medical exposure who are exposed to radiation to an extent much greater than intended. Again employers are required to notify the Executive forthwith. Mr Taylor said that effective dose is the unit for reporting such incidents. As to what was meant by much greater than intended, there will be new guidelines to replace PM77/HSG226 entitled "Fitness of Equipment used in Connection with Medical Exposure". If the intended dose was greater than 5 mSv, the guideline multiplying factor will be 1.5. For intended doses between 0.5 and 5 mSv, the guideline factor is 10 and for intended doses, less than or equal to 0.5 mSv, the guideline multiplying factor is 20.

A delegate asked how the multiplying factor of 1.5 for interventional radiology would be applied. He said that it was possible to have a range of 10 between easy and difficult cases. Mr Taylor thought that the figure of 1.5 would apply to the average dose. Another delegate asked about failure of equipment half-way through screening for the insertion of a pacemaker. This would require starting the procedure again. The multiplying factor of 1.5 would be exceeded. Mr Taylor confirmed that this would be reportable.

#### **Invited Review: Incident Reporting under IRMER**

*(Mrs Kathyen Slack, Health Protection Agency)*

From 2000 - 2005, 750 incidents were reported in England. 81% of these concerned diagnostic X-rays, 13.5% radiotherapy and 5.5% nuclear medicine. Some sites were said to have a strong reporting culture. Patient identification errors made up 40% of the total and operator errors 49%. In 2004, the Department of Health set up a working party to discuss what was meant by "much greater than intended". It consisted of representatives of the Department of Health, the Royal College of Radiologists, IPEM, the Society and College of Radiographers and other representatives from the medical physics, imaging and oncology communities. An unintended dose of 20 mSv is considered to give an unacceptable risk of 1 in 1,000. The risk-based approach has looked at four groups and is still in draft form.

1. ***Diagnostic X-ray/Nuclear Medicine/Simulation*** – All incidents are to be recorded by the site. Repeated incidents of a particular type may indicate failure of procedures. Report forms would be looked at during IRMER inspections. Incidents were reportable if an adult received more than 10 mSv or more than 20x the intended dose. For children, doses of more than 2 mSv would be reportable or 20x the intended dose. All incidents involving mis-identification were to be reported.
2. ***Therapeutic/Nuclear Medicine*** – All incidents have to be recorded. For adults those incidents where the patient received about half the dose for deterministic effects were to be reported. For children, further advice would be issued.
3. ***Interventional Radiology*** – All incidents have to be recorded by the site. Incidents are reportable if an adult receives half the dose for deterministic effects. For paediatric work, the above may not be appropriate.
4. ***External Beam Radiotherapy/Brachytherapy*** – All incidents have to be recorded by the site. Incidents are reportable if:
  - a) the error cannot be corrected to within 10% in subsequent fractions
  - b) the risk for severe normal tissue complications is doubled
  - c) there is a geographical miss outside the target area

Those incidents involving exposure of persons present but not as part of their own care, diagnosis or treatment, are reportable to the Health and Safety Executive under IRR 99. For the initial reports, the minimum information required will be specified. Incidents in England

are reportable to Ms Patricia Brown, in Scotland to Dr Arthur Johnston and in Wales, to Dr Crawley.

At the question and discussion session, Mr Taylor of the Health and Safety Executive, said that the current legal advice to HSE is that the public dose limit applies to cases of mis-identification. This has not yet been published as discussions are still continuing with the Department of Health.

A delegate asked if lost films were reportable. Mrs Slack said that the inspectorate would consider the urgency of the case, for example, in theatre. Also was a report available and sufficient. At the moment, these incidents are being reported.

Another delegate asked if cases of a processor damaging films were reportable. Mrs Slack said that this was not a procedural fault unless the person was not processing the film properly. Mr Taylor said that he would have to check if this type of equipment fault was reportable.

It was asked why the factor of 1.5 was chosen. Mr Taylor said that the HSE felt that they were not getting reports of equipment failures with the current guidelines.

## **UNDERSTANDING MULTISLICE CT**

### **Invited Review: Spiral/Multi-slice CT: Physics and Dosimetry** *(Mr N Keat, ImPACT, London)*

This talk discussed some of the changes brought about by the introduction of multi-slice CT. These scanners can scan faster than single-slice systems. CT contributes more than 40% to the collective effective dose. Mr Keat thought that the true figure was somewhere between 50 and 60%. For the future, it was thought that volume scanners would allow full coverage of an organ in one rotation. This would have applications in cardiac and perfusion scanning. Flat-panel detectors such as used by Siemens and Philips are currently too slow by a factor of about 10.

### **DEBATE: Multi-slice CT: More Slices the Better!**

Before the debate, 78% of those attending were in favour of the motion.

#### **For the Motion – Dr S Halpin, University Hospital of Wales**

Dr Halpin said that multi-slice CT enabled greater speed and almost isotropic resolution. The ability to acquire thin slices reduced many artefacts, for example, in the posterior fossa. Excellent reconstructions could be done and better coverage was enabled, for example, with a chest, abdomen and pelvis able to be scanned in 10 seconds and a child's brain in 2 seconds. The aortic arch to the toes could be scanned in 15 seconds. Those who particularly benefited were trauma patients, children and the neurologically impaired. The greater throughput had benefits in private practice. It was conceded that the increased amount of data was a disadvantage.

#### **Against the Motion – Dr C L Kay, Bradford Royal Infirmary**

Dr Kay said that increasing the number of slices did not increase the image quality. He said that other factors affected resolution, such as the design of the gantry and the size of the focal spot. Multi-slice CT could not reduce helical artefacts and cone beam artefacts. He thought that 16-slice scanners were superb pieces of equipment and asked if there was a need to increase the number of slices from this. He said that MS CT had implications for data flow, management and storage. Radiologists could have 1,000 images to look through and did not want to see 1 mm thick images. It was true that data would need to be looked at in a new way but he asked for evidence that changing the way we look at data benefits the patient. If a 128-slice scanner was installed, the number of patients would fall. Some patients wait for six weeks for their scan and then it is over in a matter of a few seconds. As to the radiation dose, some have claimed that 5 500 deaths per year in the USA are due to radiation dose from CT scanners. As to whole body scanning, he said that \$151 000 was the cost of each year of life gained according to the Massachusetts Institute. Image acquisition is not the challenge but rather how the data are managed.

In the discussion it was asked if radiologists were innovating themselves out of business. It was thought that clinicians would still need interpretation of images. Another delegate thought that he could see things better with discrete images rather than with videos but it was said registrars now like to look at 3D re-formats rather than individual slices. At the end of the debate, those disagreeing with the motion had risen from 20% to 60% of those attending.

## **OPTIMISING X-RAY EQUIPMENT PERFORMANCE**

### **Invited Review: What is the Role of a Medical Physics Expert in Diagnostic Radiology?**

*(Mr A Workman, Forster Green Hospital, Belfast)*

The term “medical physics expert” is defined in Euratom 97/43, IRMER and in the Medical and Dental Guidance Notes. Mr Workman said that the medical physics expert needed to have sufficient authority and status to raise items at an appropriate level and should be in a position to give specific advice. In the Northern Ireland Regional Medical Physics Agency, there are areas of expertise for each individual. The lead MPE for a specific Trust works closely with the lead RPA and co-ordinates activities and advice from Medical Physics. The remit concerns optimisation, quality, patient dosimetry and new techniques. For equipment, a “conception to grave” approach is taken. The entire equipment QA programme is overseen and audited regardless of who does it. For equipment procurement, it was said to be essential that the MPE was involved. For general radiographic equipment, the involvement would be in the specification whereas for others, for example, computed tomography, the involvement would be in specification and evaluation. The MPE would also be involved with the review, setting and ensuring adherence to diagnostic reference levels. Optimisation was said not just to be about dose reduction but about obtaining an effective result. The focus is on image science not just dosimetry. It was asked if the role in optimisation extended to image display. Certification of the medical physics expert is recognition by a competent authority. This was said to have been in the European Directive but was not translated into IRMER.

### **Development of a Computer Simulation for Radiographic Speed Optimisation of Digital X-ray Imaging Systems**

*(Dr G Johnston, Forster Green Hospital, Belfast)*

The signal transfer function, noise per spectrum and modulation transfer function of a computed radiography system were measured. These measurements were used to construct a linear systems model of the imaging system and the model used to generate simulated CR images. It allowed the simulation of images at lower exposures from the existing images acquired at higher exposures by processing and modulating generated noise templates. The simulated images of test objects showed similar contrast-detail to actual acquired images. Modification of the acquired images to simulate higher radiographic speeds also showed similar contrast-detail performance. It was said that the application of the technique to clinical images should provide a way of addressing the optimisation of radiographic speed for X-ray examinations.

### **Automated and Visual Scoring of Contrast-Detail Images – A Comparative Study**

*(Ms A Pascoal, King's College, London)*

Contrast-detail images were scored using a software package (CDRAD Analyser Version 1.0) and the results compared with those from three experienced observers. Contrast-detail curves show that for large details, the automated scoring gave a lower threshold contrast (i.e. better image quality) than visual observation for both CR and DDR images. For small diameter details, the threshold contrast was higher with automated scoring than for visual observation for CR, but the two techniques were nearly identical for DDR. Image quality factors obtained for automated scoring were higher than for the average observer for CR but identical for DDR. Relative comparisons of image quality while varying factors such as kVp and exposure, showed identical trends for both scoring methods. A conclusion was that the software did not mimic the absolute performance of the human observer and was not appropriate to evaluate absolute image quality. However, agreement between the two methods was observed in relative comparisons. The software was said to cost approximately £600.

## MEASUREMENT OF PATIENT DOSE

### *Film Dosimetry in the Cardiac Catheterisation Laboratory*

*(Ms R Morrell, Nottingham City Hospital)*

Skin dose distributions were recorded during coronary angiography and angioplasty by using a film positioned on the X-ray couch underneath the patient's back. The maximum skin dose for each patient was obtained from the optical density on the processed film. For coronary angiography, the maximum skin doses ranged from 82 mGy to 520 mGy. For coronary angioplasty, the doses ranged from 189 mGy to at least 1 000 mGy, which is the approximate saturation point for the film. The film used was Kodak EDR2 film. Saturated areas were seen on 23% of the films for coronary angioplasty. For the unsaturated films, there was a poor correlation between the maximum skin dose and the dose-area product and dose-area product was not an adequate indicator of patient skin dose. The ICRP in their report number 85 recommends that skin doses above 1 Gy be recorded. In order to comply with this, a more accurate method for routine assessment of skin doses was needed.

### *Skin Dose Modelling in the Cardiac Catheterisation Laboratory*

*(Ms R Morrell, Nottingham City Hospital)*

A mathematical model was developed to estimate the maximum dose to the patient's skin. Detailed information on projections and imaging parameters was extracted from the DICOM headers and used, with details of the imaging geometry to calculate the dose distribution in the plane of the couch-top. Calculated maximum skin doses were compared with film dosimetry measurements. Below the saturation point of the film, the correlation between calculated and measured doses was  $R^2 = 0.68$ . One examination had a calculated maximum dose of only 330 mGy but showed film saturation. The discrepancy was corrected when contributions from fluoroscopy were added. A correction factor based on fluoroscopy time gave the best correlation between calculated and measured maximum doses. In order to take the contribution from fluoroscopy into account, the software would need to be able to interface with the dose recording system.

### *Validation Testing of a Computer-based Model designed for the Calculation of Mean Glandular Breast Dose*

*(Mr P Connolly, IRS Ltd, Liverpool)*

A mathematical model based on the anatomical structure of a human breast has been developed to describe the interaction of X-rays with breast tissue. European protocols use conversion factors relating incident air kerma to mean glandular dose. Conversion factors currently use a model with 50% adipose and 50% glandular tissues by mass. Relative factors have been determined to take into account varying glandularity and a range of X-ray spectra corresponding to a range of potentials from 24 kV to 34 kV. Target/filter combinations of Mo/Mo, Mo/Rh, Rh/Rh and W/Rh are included in the model. The model was validated by comparing computer-generated data with calculations done by hand. There was agreement to better than 1%. When uncertainties associated with measurement of data are accounted for the error is expected to be better than 10%.

John Robertson, Glasgow  
June 2005