A Study of the Measurement Uncertainties in Ultraviolet Dosimetry for Phototherapy

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Introduction There are around 200 NHS centres providing various forms of UVA and UVB phototherapy for psoriasis and other skin conditions. The UV dose is a critical quantitative measure that is used, a) in recording cumulative dose to assess lifetime burden, b) when patients transfer between centres to restart therapy, and c) for reporting results in the literature. For these reasons, the accuracy of the in-house dosimetry equipment plays a critical role in a phototherapy centre. During the past three years we have carried out routine, 6 monthly, UV dosimetry at 10 phototherapy centres using accurately calibrated radiometers [1]. This study is based on a retrospective examination of the records of these visits to identify discrepancies between the calibrated survey meters and in-house dosimetry.

Methods In-house dosimetry systems were classified into three categories: a) high quality hand-held meter, b) low quality hand-held meter, and c) in-built dosimetry system. High and low quality meters are distinguished by the degree to which their angular response approximates a cosine. Records of dosimetry performed were supplied to each centre, and a copy retained. The retained records were analysed to assess the ratio of the in-house irradiance to that measured using the survey equipment in whole body phototherapy cabins. Employing, a) broadband UVA, b) broadband UVB, and c) narrowband UVB fluorescent tubes.

Results The results for UVA phototherapy show that 'low quality' hand-held meters and in-built dosimetry systems gave discrepancies ranging from –30% to +45% (mean +15%). 'High quality' hand-held meters gave discrepancies of between -5% to 15% (mean +5%).

Conclusion High quality hand-held meters provide the most robust means of standardising dosimetry across a large number of centres.

Reference

[1] Coleman, AJ. Calibration UKAS Lab. Physics in Medicine and Biology, 2000; 45: 194-201

Revised Risk Estimates for Energy Imparted from Latest A-bomb Survivor Data

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Introduction Energy Imparted has long been used as a denominator for radiation risk. Originally considered as such in tandem with the introduction of Effective Dose Equivalent [1], it continues to receive attention in the literature. Previous Risk Conversion Coefficients for use with Energy Imparted were derived from Tissue Weighting Factors and Risk Estimates employed with Effective Dose Equivalent [2]. Risk Conversion Coefficients for use with Energy Imparted have not been updated to include the increased mortality that has become apparent in the A-bomb survivors since the introduction of Effective Dose Equivalent. This undermines the use of Energy Imparted as a denominator for risk in modern radiation risk estimation.

Methods This paper uses independent methods to derive a risk conversion coefficient for use with Energy Imparted. The A-bomb survivor data is analysed from first principles using Energy Imparted as the risk dependent variable. Excess Relative Risks (ERR) per unit Energy Imparted are calculated from the data. These are used to predict the lifetime mortality in the cohort, for various exposure strata. Simultaneously, the predictions of lifetime mortality from the ICRP analysis *[3]* are replicated and compared with the analysis using Energy Imparted.

Results Reasonable comparability between the predictions of lifetime mortality (within 40%) was found using either the ICRP analysis or the method developed in this paper. A risk conversion coefficient of 2.57×10^{-3} J^{-1} was calculated.

Conclusions In comparison with previous risk estimates, this coefficient is an increase by a large factor *[2,4]*. The impact on future radiation risk estimation, employing this conversion factor, is discussed.

References

[1] ICRP, Recommendations of the International Commission on Radiological Protection, Publication No. 27, 1977.

[2] Pauly H., Stochastic Late Effects After Partial Body Irradiation In Diagnostic Radiology: Evaluation of Approximate Data, Radiation and Environmental Biophysics, 15, pp. 21-33, 1978.

[3] ICRP, Annals of the ICRP, Volume 22, No. 1, 1991; ISSN 0146-6453.

[4] Wall, B.F. and Shrimpton, P.C., Deliberations on a Suitable Quantity for Assessing the Somatic Risk for Diagnostic Radiology, CEC 1981, pp. 413-419, G. Drexler, A.J. Bertinchamps, H Schibilla eds. ISBN 92-825-2860-1

Determining Diagnostic Reference Levels.

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Introduction The requirement for setting Diagnostic Reference Levels (DRL's) was specified in IRMER 1999 [1]. King's Radiation Protection Service holds service contracts with several hospitals and has carried out a patient dose audit in order to set DRL's for each of these hospitals.

Methods Each hospital provided records of exposure parameters used in examinations. It was analysed using custom-built Excel spreadsheets. The results were then compared with the figures given in The National Protocol for Patient Dose Measurements in Diagnostic Radiology [2] and the Doses to Patients from Medical X-ray Examinations in the UK [3]. The 95th percentile value was also calculated for each of the examination types.

Results

- A DRL was set for each examination at each hospital.
- Where the DRL was higher than the National Reference Dose (NRD) advice on dose reduction was given.
- Where standard operating procedures were not being followed recommendations were made.

Conclusion In many of the examinations, doses were too low to warrant using the NRD as the DRL. In these situations using the 95th percentile was deemed more appropriate. In order to audit compliance and ensure doses are as low as reasonably practicable, DRL's should be subject to a review process. Due to the experience gained, improvements to the methods used for data collection have been implemented in order to facilitate this review process.

References

[1] Department of Health, Ionising Radiation (Medical Exposures) Regulations 1999, 1999.
[2] Institute of Physical Sciences in Medicine, NRPB, College of Radiographers. National Protocol for Patient Dose Measurements in Diagnostic Radiology,1990.
[3] Hart, D et al. Doses to Patients from Medical X-ray Examinations in the UK - 1995 Review. NRPB-R289, 1995.

Effective Dose in Paediatric Computed Tomography.

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Abstract There has been some concern as to the radiation dose children have received in computed tomography. Limited published data is available for assessing the radiation dose to children and for making risk assessments. A method for calculating effective dose has been derived from the simply calculated quantity of dose-length-product of which most CT systems now calculate and display. The process involved scanning a series of paediatric anthropomorphic phantoms containing thermoluminscent dosimeters to measure effective dose for scans of four different anatomic regions. Results showed that there was an exponential relationship between the quantity of effective dose / dose-length-product and patient size or height. Simple equations were derived which would enable the effective dose to be calculated for a patient of any size. Measurements were carried out and the technique verified on a second scanner to see if the method could be used for differing patient volumes and scanner types.

Reference

Chapple C-L, Willis S, Frame J. Effective Dose in Paediatric Computed Tomography. Physics in Medicine and Biology 47 (2002) 107-115

Computed tomography doses in children

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Introduction A survey in paediatric radiology is currently being carried out to assess patient dose for common computed tomography (CT) examinations at different hospitals in Belgium. This high dose technique is not always adapted to suit children, which results in much higher doses than are necessary for an adequate image quality.

Methods To compare with reference dose levels the $CTDI_w$ and the dose-length product (DLP) were determined [1]. To estimate the related risk, effective dose (E) was determined from measurements of $CTDI_{air}$ and from paediatric CT organ-dose conversion factors.

Results Values are presented in relation to three patient ages and three types of common procedure. The range of DLP was 117-328 mGy·cm (1 year), 108-503 mGy·cm (5 year), 229-954 mGy·cm (10 year) for brain examination; 14-204 mGy·cm (1 year), 23-309 mGy·cm (5 year), 48-446 mGy·cm (10 year) for chest examination; and 43-576 mGy·cm (1 year), 99-751 mGy·cm (5 year), 181-1063 mGy·cm (10 year) for abdomen examination. Reference dose values [1] were exceeded at two hospitals for some examinations. The ranges of E were 0.4 –2.3 mSv for brain examination, 1.1-6.6 mSv for chest examination, and 2.3-17.1 mSv for abdomen examination.

Conclusion Results obtained up-to-date show clearly large differences between hospitals for same type of examination and age group. The ratios of E by sites varied between 2 and 7. In all centres but one protocols have been adapted according to the patient's age or weight. The largest doses observed did not correspond to the hospital with no-suited children protocols. The survey will be complemented with an audit of image quality and will include more hospitals.

Reference

[1] Shrimpton, PC, Wall, BF. Reference doses for paediatric computed tomography. Radiation Protection Dosimetry, 2000; 90:249-252

Survey of CT Doses in Ireland

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Introduction CT examinations currently result in high patient doses compared to other radiology examinations[1]. It is required by the Medical Exposures Directive 97/43/Euratom that Diagnostic Reference Levels (DRLs) are established for all radiological examinations and CT has been identified as an area of special concern[2]. There are approximately 30 licensed CT scanners in Ireland and to date DRLs for CT have not been established. This study involves measuring doses for a range of common CT examinations conducted on an Irish adult population.

Method The approach used is that developed by the EC for reference dosimetry for the particular conditions of exposure for CT and is based on measurements made within standard PMMA dosimetry head and body phantoms[3]. The combination of $CTDI_{100}$ measurements made at the centre and at 10mm below the surface of each phantom leads to a weighted CTDI ($CTDI_w$) value, representing the average dose to a single slice. An associated dose length product (DLP) for a complete examination may also be derived from these measurements.

Results Initial results of this study from 30% of all Irish scanners have indicated $CTDI_w$ values lower than European DRLs[3]. The complete results of this survey will be presented and will allow comparison of CT doses in Ireland with other surveys.

Conclusion This study may then assist in establishing DRLs in Ireland and play a major role in the implementation of the requirements of the Medical Exposure Directive.

References

[1] Jessen, KA, Geleijns, J, Panzer, W and Tosi, G. Reference doses in computed tomography. Radiation Protection Dosimetry, 1998; 80: 55-59.

[2] European Commission. Council Directive 97/43/Euratom of 30 June 1997 on health protection of individuals against the dangers of ionising radiation in relation to medical exposure. Official Journal of the European Communities, 1997; L180: 22-27.

[3] European Commission. European Guidelines on Quality Criteria for Computed Tomography. EUR 16262, 1999.

Regulation and National Minimum Standards for Class 3b & 4 lasers and intense light sources

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The Nursing Homes and Mental Nursing Homes regulations 1984, which previously dealt with the private (non-NHS) registration of Class 3b & 4 medical lasers, were superseded by The Private and Voluntary Health Care (England) Regulations 2001 [1] on the 1st April 2002. These will be policed by the centralised National Care Standards Commission and should result in consistency of registration. A significant improvement in the regulations has been the statement that the use of lasers and intense light sources in the field of cosmetic surgery will definitely require registration; this was previously open to interpretation. On the other hand, it is not clear how some other issues, such as the requirement for certificated Laser Protection Advisers (LPAs) will be addressed; currently there are insufficient numbers to provide for the estimated number of lasers and intense light sources covered by the regulations.

The IPEM Working Party (set up in April 2001 and consisting of the above members) has reviewed the regulations and considered the possible implications for LPAs. Specific topics such as medical direction (including exclusions), training, intense light sources and excluded premises will be discussed, along with experience gained from registrations under the new regulations.

Reference

[1] The Private and Voluntary Health Care (England) Regulations 2001. SI 2001 No. 3968. ISBN 0 11 039229 9

Application of the R(EPPI)R 2001 to a large London teaching hospital

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Introduction The Radiation (Emergency Preparedness and Public Information) Regulations 2001 came into force in September 2001 and, if initial assessment showed that a site was not exempt, required submission of appropriate assessment reports. These Regulations replace regulation 26 (special hazard assessments) and associated provisions of IRR85 which were 'saved' by IRR99. We have assessed whether R(EPPI)R applies to a large London teaching hospital based on two sites. It is hoped that sharing the methodology of assessment may be of use to other centres.

Methods Detailed calculations were performed to calculate the Quantity Ratio for each site. The quantity ratio is the ratio of the activity held on site to the activity stated in Schedule 2 of the regulations and must be summed for all radioisotopes held. The regulations state that if the site Quantity Ratio is greater than 1 then a hazard and risk assessment has to be performed to determine whether a radiation emergency is 'reasonably foreseeable'. If this is the case, then the operator has to draw up emergency plans.

Results The results of the calculations will be given and details of the considerations and assumptions made. For example, some large activity sources can be classed as 'non-dispersible' which makes them exempt from the Regulations.

Conclusions Even though HSE were hopeful that hospitals were exempt from these Regulations, it can be shown that a large teaching hospital should not assume that they are exempt. Sites with large radiopharmacies, cell irradiators, PET activities (with or without cyclotrons on site) as well as certain radiotherapy situations increase the possibility of detailed assessments being required.

To classify or not to classify? Evaluating finger doses to Radiographers working in PET at Mount Vernon Cancer Centre.

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The PET Department at The Paul Strickland Scanner Centre, Mount Vernon Hospital, has been in clinical operation since May 1997. Records for the last 3 years have been reviewed, including patient numbers, workload and radiation doses to staff.

This retrospective study has shown a steady increase in patient numbers, resulting in the increase of dose to the fingertips of staff. Exposure to radiation occurs both during the preparation of the dose for the patient and during the injection procedure.

Concern has grown regarding the annual dose limits to the skin, 500mSv averaged over an area of 1cm^2. A worker must be classified if he/she receives greater than 3/10 of the annual dose limit, in this case 150 mSv. If current trends of dose received by staff continue, some radiographers will approach this limit soon. To determine whether classification can be avoided, a study has been undertaken to identify the areas of greater risk and to take appropriate measures to minimise exposure to the hands of staff.

This poster will describe how these risk areas have been identified and the new measures taken in order to decrease the dose to the radiographers' hands.

Do old hospital buildings use Uranium ceramic wall tiles?

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Introduction In April 2001, the NHS Estates Scientific Advisory Group concluded that while the use of depleted uranium, in shutters and beam collimators of linear accelerators was tightly controlled and therefore represented a minimal radiation hazard, the extent to which uranium salts had been included within the glaze of ceramic decorative wall tiles used in hospital buildings erected or modified between the late 1930's and around 1966, remained unknown. We wished to carry out a radiation survey to identify the extent of their use, to estimate the activities involved and estimate the risks posed.

Method We used a NE/Bicron PCM 5/1 contamination monitor with a type DP2R/4 probe to survey a range of interior decoration within a number of hospital buildings that had been constructed within the range of dates specified. The instrument had been calibrated for of natural uranium (NAT-U) contamination.

Results In most cases no response above background could be detected. However in three separate areas of the hospital uranium glaze was positively identified. Count rates of around 80-200 counts per second above background were obtained. We estimated activity at around 7.7Bq cm^{-2}, extending over a total area of up to $50m^2$. Being contained within the ceramic glaze itself, this contamination was fixed.

Conclusions It was concluded that the hazard presented by tiles in-situ was small but that special precautions would be required were they to be removed.

Reference Doses and Operator Performance in A Cardiothoracic Tertiary Referral Centre – A Work in Progress

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Introduction Fluoroscopically guided cardiac procedures give rise to relatively high radiation doses to the patient [1,2]. It is important, therefore, that dose levels are monitored, and operator performance assessed to ensure that high values are restricted as far as reasonably practicable. In the Cardiothoracic centre in our hospital Cardiac procedures are performed by in-house cardiologists as well as specialist registrars and visiting cardiologists. The study aims to establish reference doses in accordance with the statutory requirement[3].

Methods Data for cardiac procedures was obtained from the Radiology Information System (McKesson, Warwick, UK). Information routinely recorded includes total Dose Area Product (DAP) and Screening Time. Additional information detailing the operator is also available for some procedures. Analysis of the data yielded a total of over 250 individual combinations of procedure. These were categorised according to type to obtain a range of categories for diagnostic and therapeutic procedures. A program was written in Microsoft Excel (Microsoft Corporation, Seattle, US) to extract the data from the Radiology Information System format. The data was sorted according to the predetermined categories of procedure type. Reference values of DAP for each category were obtained using the median value, as the sample populations exhibit a large degree of skewness at the high end. Where it was possible to identify the operator, individual operator DAP values were calculated and used to compare operator performance.

Results Data was obtained from in excess of 8000 procedures performed in the two catheter laboratories from 1997 to 2001. Reference doses for ten diagnostic and seven therapeutic procedure types was obtained representing 99 % of the workload of the centre. Individual operator performance in terms of total DAP and Screening time for four diagnostic and four therapeutic procedure types will be compared between operator groups, and to the reference dose.

References

[1] Betsou, S, Efsthathopoulos, EP, Katritsis, S, Faulkner, K, Panayiotakis G. Patient radiation doses during cardiac catheter procedures. British Journal of Radiology 71 : 634-639.

[2] Wild, P, Pitcher, EM, Slack, K. Radiation hazards for the patient in cardiological procedures. Heart 2001 85: 127-130.

[3] The Ionising Radiation (Medical Exposure) Regulations 2000. London. HMSO 2000

Distribution and Magnitude of Primary and Secondary Radiation in Dental Radiography

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Introduction Assessment of the distribution and magnitude of primary and secondary radiation produced by dental radiography is important as often the only radiation protection available to the operator is distance. Determination of the spatial distribution of radiation will enable the operator to minimise their dose from the dental radiography.

Methods An *Alderson Rando* anthropomorphic phantom was positioned for intra-oral and occlusal radiography. Measurements were made around the phantom at 1.5m from the centre in 20 degree increments for the full circumference using a 1800 cm^3 ionisation chamber. Exposures were made using a *Siemens Heliodent HD* intra-oral dental x-ray unit operating at 70kVp with exposures times appropriate to E speed film.

Results The results show that the magnitude of transmitted primary radiation (< 0.05 μGy) is low in comparison with secondary radiation (upto 0.5 μGy) with the highest recorded doses on the x-ray tube side of the anthropomorphic phantom.

Conclusions Although the dose received by the operator at 1.5m from a patient is low it can be made upto a factor of ten lower by standing on the side of the patient opposite that of the x-ray tube rather than on the same side as the x-ray tube [1].

Reference

[1] Tabakov SD, Nixon PP, Smith NJD. Instantaneous dose rate of scatter radiation in dental radiography. Physica Medica, 2000; XVI:35-38

Use of an Electronic Finger Dosimeter in Optimisation of Finger Doses

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Introduction This study reports dose optimisation using an Advanced Extremity Gamma Instrumentation System (AEGIS) (CIL (Barrow in Furness, UK), which has a small probe that can be attached to a finger. AEGIS records data on the instantaneous dose rate, which can be downloaded onto a PC for analysis. This allows doses received from individual actions to be quantified and patterns of radiation exposure determined.

Methods Data were recorded in a radionuclide dispensary, in several nuclear medicine departments and in a brachytherapy theatre. Staff were filmed while they were being monitored and the video reviewed to link the doses recorded to the manipulations performed. These techniques enable the actions which make the most significant contributions to doses to be identified.

Results Optimisation has been achieved through changes in the order in which procedures are carried out, use of different shielding devices and evaluation of alternative manipulation techniques. AEGIS has also been used to determine relationships between doses to the most exposed part of the hand and those at the monitoring positions. For radionuclide dispensary staff, the tip of the index finger on the dominant hand receives the highest dose with a mean value of 1.5 mGy per session. There is a factor of two between the dose to the tip and that to the position on the index finger where a ring dosimeter might be worn. However, if the fingertip is closer to the activity, as is the case during nuclear medicine procedures, the distribution is different and an alternative monitoring strategy is required.

Conclusion

Results from studies undertaken in nuclear medicine departments from drawing up and injection of radiopharmaceuticals, and in brachytherapy theatres from insertion of source pins will be reported.

Chapter 9. Radiation Protection