IR(ME)R Frequently Asked Questions

Ebdon-Jackson S, *Department of Health*

Options for Shielding the Hand During Dispensing and Administration of Radiopharmaceuticals

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Introduction Staff manipulating radiopharmaceuticals may receive significant radiation doses to their hands. Different options for shielding both vials and syringes are used to protect the fingers.

Methods A study of finger doses has been carried out in a large radionuclide dispensary and several nuclear medicine departments to evaluate different shielding options. In the radionuclide dispensary vials from which radioactive liquids are dispensed are held in tungsten shields with a small aperture from which liquid can be withdrawn, whereas in nuclear medicine simple lead pots are used from which the lids are removed for manipulations. Syringe shields are employed for parts of the dispensing and for patient injections. Measurements of hand doses for individual manipulations have been recorded with an electronic extremity dose monitor during many routine sessions and dose distributions around shielded vials and syringes have been measured. Tungsten vial shields limit the extent of the radiation field and are useful when patient administrations are dispensed from a vial containing a higher activity.

Results The use of syringe shields during dispensing was found to reduce finger doses by about 80%. The peaks in dose rate were 40% lower and the length of exposure to high dose rates was reduced by a third. Injection of radiopharmaceuticals contributed the higher dose component for nuclear medicine staff with doses from individual injections varying from 1 to 150 μSv.

Conclusions The poorer visibility with syringe shields is a problem when drawing up radiopharmaceutical for injection and their weight makes them cumbersome to use for rapid manipulations. Use of syringe shields is recommended for those procedures for which accurate reading of the syringe scale is not required. This includes higher dose manipulations in the radionuclide dispensary and injections in nuclear medicine.

Precision of Multi-modality Imaging for Region of Interest Definition in Bone SPECT

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We have developed and assessed the precision of a novel method for defining periprosthetic regions of interest (ROIs) on bone SPECT studies after total hip arthroplasty (THA).

Method SPECT studies were performed 1 year after THA. 12 patients had SPECT acquisitions repeated on the same day after repositioning the patient. The SPECT studies were reconstructed and the central 3 coronal slices summed. A digitised plain radiograph was registered to this 'summed' image. Six periprosthetic analysis ROIS were created using the more detailed anatomical information on the radiograph. The precision of this method was compared to that of creating ROIs directly onto the nuclear medicine image.

Results Independent analysis of the consecutive SPECT images (expressed as count ratio to an iliac reference region) when the ROIs were defined on the radiograph had a coefficient of variation (CV%) of between 10.3 and 18.5%. The CV% for ROIs defined directly on the nuclear medicine image was between 12.7% and 17.6%. The precisions of acetabular, lesser trochanter and medial femoral shaft measurements were significantly better when defined on the digitised radiograph compared to those made directly onto the SPECT image ($P<0.05$, all comparisons). No difference between the methods was found for the remaining 3 areas ($P>0.05$).

Conclusion The use of registered digitised radiographs improves precision in ROI definition after THA compared with the nuclear medicine image alone.

Departmental Documents – an Electronic Nuclear Medicine Documentation Resource.

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An electronic nuclear medicine documentation system has been implemented at the Sheffield Teaching Hospitals NHS Trust. The web based system, known as “Departmental Documents” is hosted on a secure citywide intranet. Access is limited to listed personnel with different levels of security applying to restricted areas of the site.

The website, which contains over 3000 documents, is organised into several key groups: Procedures & Protocols, Computers & Equipment, Legislation & Radiation Protection, Quality Assurance, Reports & Literature, Forms, Staff Information and Useful Links. Full cross-referencing is provided with hyperlinks and a search engine offers a full text search of all HTML pages. In addition to web pages, the site contains varying multimedia content, which includes PowerPoint presentations, Excel spreadsheets, training resources and on-line catalogues.

An automatically updated “What’s New” section and weekly emails provide a convenient method of notifying staff of any changes to the site, such as modifications to study protocols or new information sources. A revision control system has been implemented which automatically notifies the author when a particular document needs revising. The previous revisions of each document are securely archived although the history of each document can be reviewed. To minimise risk however, only the current documentation is available.

A Study of Extremity Doses in Nuclear Medicine

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Introduction Staff in nuclear medicine departments have the potential to receive a significant radiation dose to their hands. This dose arises from the dispensing and injection of radiopharmaceuticals prior to a variety of diagnostic procedures. The doses are kept as low as possible using the accepted methods of radiation protection: time, distance and shielding. Manipulations are performed as quickly as possible.

The syringe is held by the plunger and the end of the barrel, to maximise the distance from the radioactive liquid. Both the vial and syringe may be shielded. A study of finger doses has been carried out in nuclear medicine departments in the West of Scotland, adopting a range of differing techniques, protocols and shielding options.

Methods Radiopharmaceuticals for administration to individual patients are delivered to the nuclear medicine departments from an external radionuclide dispensary in vials contained within lead pots. The radiopharmaceutical is dispensed from this vial into a syringe, which is then placed within a 'well' type pot to await injection. Common practice is to shield the syringe only when ready to give the injection. The doses to the hands were measured using an electronic extremity dose monitor (AEGIS). Doses were measured over many sessions of both dispensing and injecting radiopharmaceuticals for different staff members. Dose distributions around shielded vials and syringes have also been measured and used in the interpretation of monitoring results.

Results Results show that finger doses when dispensing radiopharmaceuticals ranged from 4 μGy to 555 μGy per manipulation. This was compared with doses of 1 μGy to 150 μGy received from individual injections.

Conclusions This wide range of doses reflects the different techniques and shielding options employed by staff. The patterns of exposure that occur will be discussed in relation to the techniques and shielding used. Guidance on methodology for dose monitoring will also be discussed.

Radioactive Substances Management and BPM

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Environment Agency ("the Agency") enforces the Radioactive Substances Act in England and Wales. The Agency regulates the keeping and use of radioactive materials in some 900 premises, and approximately 6000 premises are authorised under the Act, for the accumulation and disposal of radioactive waste.

In accordance with a recent Direction from Government, new authorisations will in future include the following condition:
"The user shall use the best practicable means to:

1. minimise the activity in all disposals of radioactive waste;
2. where authorised, minimise the volume of radioactive waste disposed of by transfer to other premises;
3. dispose of radioactive waste at times, in a form, and in a manner so as to minimise the radiological effects on the environment and members of the public."

The paper will illuminate the meaning of BPM and how it will be treated by the Agency. In particular, the paper will consider BPM as applied to the discharge of waste radioactive iodines from hospitals. The implications for new build will be discussed.

Liquid Iodine-131 Radioactive Waste - Monitoring and Modelling

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Introduction Due to an increasing demand for in-patient treatment of thyroid cancer using gigabequerel levels of iodine-131, an application was made to the Environment Agency (EA) for an increased authorisation to dispose of aqueous iodine-131 radioactive waste under the Radioactive Substances Act (1993). The EA requested that a 'Best Practicable Means' report be produced to assess the environmental impact of these discharges and to consider possible methods of reducing levels of liquid iodine-131 radioactive waste. A study was therefore undertaken to look at the liquid discharges of iodine-131 from the Royal Surrey County Hospital with the aim of modelling the time activity curve of the discharges.

Methods A programme of monitoring was undertaken that included monitoring of the discharges to the drains from the dedicated treatment rooms and an assessment of iodine-131 concentrations in the outflow from the sewage works in Guildford prior to discharge to the River Wey.

Results An attempt was made to correlate the input to the hospital drains with the discharges from the sewage works.

Discussion An evaluation of the assumptions made in modelling aqueous radioactive waste disposal and radiation dose estimates of critical groups for the impact assessment will be made. Suggested methods to reduce discharges of liquid iodine-131 will also be discussed.

The Fate of Radioactive Waste in Sewers and the Impact on the Environment

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Introduction This paper describes the journey of aqueous radioactive waste from disposal to discharge from sewage treatment works and identifies critical groups of exposed individuals. A method of standardising risk assessments for these groups is proposed.

Methods The risk assessments use a dosimetry model published by the Environment Agency [1] adapted for typical hospital discharges. With the aid of a spreadsheet macro it is possible to tailor the assessment to individual requirements.

Results The risk assessment results for a "typical" large teaching hospital give a maximum annual dose to a local plumber of 80μSv and less than 0.04μSv to the sewer worker.

Conclusion The risk assessment model has been used as part of an application to the Environment Agency for authorisation to dispose of radioactive waste. It could be applied to other hospitals and academic institutions in the UK.

Reference

[1] Titley, JG, Carey, AD, Crockett, GM, Ham, GJ, Harvey, MP, Mobbs, SF, Tournette, C, Penfold, JSS and Wilkins, BT. Investigation of the Sources and Fate of Radioactive Discharges to Public Sewers. Environment Agency Technical Report P288, 2000.

Use of Accumulation Tanks for Decay Storing Radioactive Aqueous I-131 Waste

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Introduction With heavy patient workloads and high activity radionuclide therapy treatments the discharge of radioactive aqueous waste from Guy's Hospital is increasing. This is compounded by the proposed building of a new cancer centre with the potential for more iodine therapy beds resulting in increased radioactive discharges. The significant number of hospitals in South London performing such therapies discharging to a limited number of sewerage treatment works has made the consideration of installing delay tanks in new facilities almost inevitable. This situation is not unique to London – other cities throughout the UK and Europe have similar situations.

With the 'Best Practicable Means' policy included on new Environment Agency Authorisations, site releases will now have to be further justified. Is disposal *direct* to the drain still justified for such large I-131 disposals? Conversely does the dose saving obtained justify the cost of installing of a delay tank system?

Methods A detailed questionnaire has been sent to hospitals throughout Britain and Europe who have committed to use accumulation tanks to decay store radioactive aqueous waste.

Results The replies from this survey will be analysed to determine the range of practices and the most effective method of delay tank used. The effect on the reduction of radioactive discharges will also be discussed together with the resource / cost implications.

Reference

[1] Laing, P M K and Nikolic M. Disposal of Therapeutic ^{131}I waste using a multiple holding tank system. Health Physics, 1998; 75

MUGA LVEF Calculation on Three Nuclear Medicine Processing Stations- Inter-system, Intra Operator and Reproducibility.

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The objective of this study is to perform an inter-comparison of the three systems using a single operator, investigate the reproducibility of each system both intra operator and inter operator and the robustness of each processing algorithms and highlight weaknesses. The processing systems are

Adac Pegasys : Planar cardiac ver. 3.40
GE Millennium MPR : EF analysis ver. 2.65
SMV Vision: GBP_BNL ver. 5.2.0

The data used in this study was transferred to individual processing stations using dicom transfer. The data was grouped into the following ranges: LVEF <40%, 40%-60% and > 60%.

Preliminary Results SMV vision: Inter operator reproducibility was measured. Two experienced operators and a trainee processed MUGA studies. There was good correlation between all operators in the <40% range. In 40%-60%, a correlation coefficient of 0.84 was obtained between the two-experienced operator and 0.58 was achieved for the trainee and other operator. There was a significant decrease in the correlation for the higher range, >60%.

ADAC Pegasys: Intra operator reproducibility was difficult. The edge detection is not consistent.

GE Millennium: Intra operator reproducibility was performed. The edge detection algorithm is efficient.

GE Millennium vs. Adac Pegasys:

8 studies were processed on each of these systems. Correlation coefficient of 0.75 was obtained.

SMV vision vs. GE Millennium:

10 studies were processed and a correlation coefficient of 0.78 was obtained. The LVEF measured on SMV vision was slightly higher.

A full quantitative evaluation will be presented highlighting algorithm problems associated with Adac Pegasys and limitations associated with all the systems.

A study of Nuclear Medicine Waiting Times

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A study was undertaken of workloads and waiting times in five Nuclear Medicine departments within London, with a view to comparing the services provided by each centre. Referral data for each centre was compiled in order that the demand on each service could be assessed. Referral procedures were also examined to reveal the communication channels currently in place. Workloads are presented, and available waiting time data are cross-referenced to these. The workloads show different specialities across different centres, and reveal the demand for exams to be driven both by the referrer's requests and by the radiologist's particular interest. Waiting times are shown to vary widely between centres. This led to a study of the staffing levels and staffing requirements in order to determine the approach to reducing waiting times. Particular scans, for example myocardial perfusion scans, highlighted the problems facing departments of providing timely diagnosis.

Electrical Interference- Can It Really Disrupt Your PET Service?

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A PET service relies on a stringent program of quality assurance to ensure optimal image quality. However, external factors which may affect image quality are often neglected. This study highlights the effects of electrical interference.

Several clinical PET scans exhibited an artefact which was intermittent and affected a single bed position. The artefact was often undetected when viewing the emission image without checking the corresponding transmission image although it resulted in a large error in lesion visualisation and quantitation. In the worst case, a lesion within the affected area had a SUV value increased by more than 100% (2.4 to 5.0). Examination of the transmission scan header showed that data was corrupted with erroneous values for scan start time and duration at affected bed positions. The effect only appeared subsequent to room layout modifications where equipment associated with the scanner (workstation, media converter and printer) was repositioned bringing cables closer together. The hypothesis of electrical interference causing data corruption was tested by performing phantom studies where (a) equipment was positioned so that cables ran adjacent to each other, (b) equipment was moved further apart to distance cables and (c) unshielded cables were replaced with shielded cables.

In test (a) the effect was observed in 6/14 scans, reducing to 2/16 scans in test (b). The effect was removed completely by unshielded cable replacement indicating that electrical interference was the likely cause of the problem.
In conclusion, electrical interference can cause artefacts in images which, if undetected, can seriously affect diagnosis. Quality assurance of equipment should include consideration of electrical interference and unshielded cables should be replaced by shielded ones to remove adverse effects.

Eye Doses to Staff in a Nuclear Medicine Department

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Occupational radiation doses to staff of the Nuclear Medicine Department at Mount Vernon Hospital are routinely measured using optically stimulated luminescence dosemeters for whole body effective dose and ring TLD's for finger doses.
Using LiF:Mg,Cu,P chinese TLD's, this study aims to measure the dose to the lens of the eye received by staff during working procedures, concentrating in particular on the dose received from procedures involving I-131.

Separate pairs of TLD's are being worn by staff on their forehead between their eyes whilst dispensing and releasing in the radiopharmacy, injecting and when administering I-131 capsules to patients for the treatment of thyrotoxicosis and carcinoma of the thyroid.

The dose received from each isotope (I-131 and Tc-99m) will be calculated using calibration data from identical TLD's irradiated with a superficial X-ray set and the Ir-192 source of a Gammamed HDR treatment unit.

As well as ensuring the dose to the eye received is below the annual dose limit of 50mSV, through analysis of the results and techniques of the staff performing each procedure, we aim to determine whether the dose received could be reduced by altering working practices.

Chapter 13. Nuclear Medicine