Optimisation of Staff Protection

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ABSTRACT It is important to minimise the radiation dose received by staff, but it is particularly important in interventional radiology. Staff doses may be reduced by minimising the fluoroscopic screening time and number of images, compatible with the clinical objective of the procedure. Staff may also move to different positions in the room in an attempt to reduce doses. Finally, staff should wear appropriate protective clothing to reduce their occupational doses. This paper will concentrate on the optimisation of personal shielding in interventional radiology. The effect of changing the lead equivalence of various protective devices on effective dose to staff has been studied by modeling the exposure of staff to realistic scattered radiation. Both overcouch x-ray tube/undercouch image intensifier and overcouch image intensifier/undercouch x-ray tube geometries were simulated. It was deduced from this simulation that increasing the lead apron thickness from 0.35mm lead to 0.5mm lead had only a small reducing effect. By contrast, wearing a lead rubber thyroid shield or face mask is a superior means of reducing the effective dose to staff. Standing back from the couch when the x-ray tube is emitting radiation is another good method of reducing doses, being better than exchanging a 0.35mm lead apron for a 0.5mm apron. In summary, it is always preferable to shield more organs than to increase the thickness of the lead apron.

1.0 Introduction

It is always important to minimise radiation dose levels received by members of staff working in radiology departments. Staff dose minimisation is particularly important in interventional radiology as these procedures generally involve higher radiation doses to both patients and staff than general radiography or fluoroscopy. These higher doses arise, in the main, from the extended fluoroscopy times and greater number of radiographic images acquired during these procedures. Recently, there have been several cases of patients receiving deterministic effects, such as radiation burns and ulcers, reported in the published literature (1,2).

In recent years interventional radiology has become more prevalent, as the improvements in health care associated with these procedures have become widely appreciated. Moreover, developments in interventional radiology continue a pace, with more complicated procedures being investigated at the present time. There is increasing concern about radiation doses to staff. This concern relates to the risk of both deterministic and non deterministic effects. The annual review of radiation doses received by classified radiation workers in the United Kingdom reveals that only one individual received a whole body dose in excess of 15mSv, somewhat less than the annual dose limit (3).

Another group of staff working in radiology departments whose radiation dose is of concern is pregnant staff. The recommendation by the International Commission on Radiological

Protection (4) that the foetus should be protected by a supplementary dose limit of 2mSv to the surface of the abdomen once pregnancy has been declared results in both a monitoring and operational problem. Accurately monitoring dose levels as low as those implied by the limit in diagnostic radiology. There are two principal operational problems. First, in certain circumstances the dose limit could be exceeded even for relatively low interventional radiology workloads. Second, both the film badge and thermoluminescent dosemeters do not give an instantaneous indication of dose received. Thus the wearer of the dosemeter may not realise that the limit has been exceeded until sometime after they have received the dose.

2.0 Reduction of staff doses

In interventional radiology it is necessary for the interventionalist to be able to manipulate catheters and other devices. This requirement means that the interventionalist must stand at the couchside during interventional procedures and have unimpeded access to the patient. It is therefore impractical to attach lead rubber protection from the image intensifier as a means of reducing occupational exposures as would be the norm on equipment designed for barium studies. As a consequence scattered dose rates at the couch side are higher than on fluoroscopy equipment designed for barium studies. Thus not only do interventional procedures involve longer fluoroscopy times, scattered dose rates in the vicinity of the couch are higher for the same technique factors. The combination of long fluoroscopy times and the lack of shielding attached to the fluoroscopy equipment leads to higher occupational doses in interventional radiology.

Moreover patients undergoing interventional radiology procedures tend to require more staff in the room for clinical support. Thus other doctors such as anaesthetists and nursing staff may also be present during a procedure. In the main these staff groups are unaware of radiation protection measures and have to be taught the basic principles of radiation protection.

In view of the high occupational dose levels it is important to ensure that staff are monitored adequately. Interventionalists and others who stand at the couchside should be provided with one or more dosemeters to wear. One dosemeter, generally worn at the waist level under a lead apron, will be issued to monitor whole body or effective dose. In some countries whole body dose is monitored using a dosemeter at collar level worn above the lead apron. Staff may also be issued with additional dosemeters to assess the equivalent dose to critical organs such as the eyes or hands. Hand dose may be monitored using small thermoluminescent dosemeters worn under rubber gloves.

Unfortunately, wearing a single dosemeter does not give a good indication of effective dose(5). A combination of two dosemeter readings, one above the apron and one below will yield an improved estimate of effective dose (6,7).

Local action levels are a useful means of limiting staff doses in interventional radiology. Dosemeter readings in excess of the values given in table 1 would be investigated. The reason for the higher than usual dosemeter reading should be established and action taken to minimize the individual's dose. As may be deduced from table 1, these action levels are set some way below the levels at which the individual would be classified. These action levels serve to identify individuals who may receive higher than normal doses and enable the radiation protection service to implement an action plan to reduce staff doses. This action plan could involve staff training or a review of protective measures. The use of local action levels serves as a constraint on occupational exposures. They are not dose constraints in the true meaning of the definition given by ICRP (4).

Scattered radiation dose-rates at the couchside during fluoroscopy procedures can be quite high (8). However, dose-rates decrease rapidly with increasing distance away from the couch, approximately obeying an inverse square law with the reference point being the centre of the field on the patient. Taking one step back from the couch can have a dramatic effect on the radiation dose to the individual.

Radiation doses to staff working with fluoroscopy equipment have been simulated for both undercouch x-ray tube/ overcouch image intensifier and overcouch x-ray tube/undercouch image intensifier equipment configurations (9). In this study, a patient equivalent phantom was placed on the couch and irradiated using x-ray beams generated at tube potentials of 70, 90 and 110 kV to produce scattered radiation. An anthropomorphic phantom loaded with lithium fluoride thermoluminescent dosemeters was placed adjacent to the couch at the position where the radiologist stands during fluoroscopy. Organ doses in the phantom were measured, from which effective dose was calculated. Transmission data (10) were used to deduce the effect of a lead apron on effective dose. In addition, the effect of a thyroid collar and face mask was simulated.

The impact of wearing a lead apron, a lead apron and thyroid shield and a lead apron and face mask is summarised elsewhere (9). Effective dose decreases with increasing lead apron thickness reaching an asymptote near 0.35mm lead. Wearing extra protection in the form of a face mask or a thyroid shield always reduces the effective dose to an individual wearing a 0.35mm lead apron by a greater amount than exchanging a 0.35mm lead apron for a 0.5mm one.

3.0 Conclusions

Patient and staff doses from interventional procedures can be quite high. It is important that these potentially high radiation doses are minimized. Both patient and staff may be at risk of both deterministic and non-deterministic effects. Staff doses can be reduced by a number of relatively simple methods. It is worth noting that, in general, most of the methods of reducing patient doses will also reduce staff doses. Interventionalists are recommended to consider applying these dose reduction measures in their clinical practice. They will thereby significantly reduce their radiation dose and the dose received by their colleagues.

Table 1 Suggested action levels for staff dosimetry results (10)

Monitor Position	Period worn (weeks)	Action level (mSv)
Body	4	0.5
Eyes	4	5
Extremities	4	15

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