Radiation Attenuation and Barrier Protection

Fluoroscopic procedures have increased with the advancement of minimal invasive procedures and improvements in technology. The tremendous growth of fluoroscopy in the emergency room and in orthopaedic, coronary or vascular procedures, have increased the occupational risk of radiation exposure to the surgeon and other personnel in the proximity of the procedure.[1, 2] The surgeon or x-ray operator can be exposed to radiation in two ways: exposure to direct radiation coming out of the radiation beam or exposure to scattered radiation.

Scattered radiation is the radiation that changes direction during its passage through a substance. When x-rays interact in a patient, many are scattered in random directions from the exposed volume of the patient. In general, thick, heavy parts of the body, such as the thigh, the hip or the abdomen will produce higher levels of scattered radiation than thin parts such as the hand or the arm.[3] During fluoroscopic procedures, the patient is the primary scattering object and this type of radiation is the principal source of exposure to personnel. Ionizing radiation, especially fluoroscopy, is potentially harmful with the risk of long term effects due to the cumulative effect of low dose exposure over many years. The biological effects of radiation can be separated into two categories: deterministic effects; and, stochastic effects.

Deterministic effects are those for which a minimum number of cells must be affected above a threshold before a biological response is seen. Cataracts or radiation-induced erythema and necrosis are examples. As the dose increases above the threshold, the likelihood of seeing the effect and the severity of the effect increases. If the dose is sufficient, there is a high chance an effect will be induced.[4]

Stochastic effects are those that occur by chance and consist primarily of cancer and genetic effects. Stochastic effects have no known threshold dose and often show up years after exposure. As the dose to an individual increases, the probability that cancer or a genetic effect will occur also increases.[5, 6]

There is a perceived increase in the incidence of malignant disease among surgeons who have used ionizing radiation over a substantial period in their surgical practice, with anecdotal evidence suggesting that orthopaedic surgeons are in a high-risk category for malignancies. A likely contributor to this is exposure to ionizing radiation during surgical procedures, which may be attributable in part to the low use of protective equipment.[3, 5] As the exposure to the surgeon is usually due to the cumulative exposure from scattered radiation, protection and care is imperative at all times.[1, 3]

There are three fundamental principles of radiation protection:

1. **Minimal time of exposure**
   Minimizing the duration of exposure directly reduces radiation dose. Simply put, if the amount of time spent near a radiation source is reduced, the amount of radiation exposure received and the resultant health risks will also decrease.

2. **Maximum distance from the radiation beam**
   When the working distance from a radiation source is increased by a factor of two, the dose received from that source will be reduced by a factor of four. Therefore, a person four feet from a radiation source will receive a quarter of the exposure than that of a person two feet from the source.

3. Use of all possible shielding

Shielding is the use of any material to reduce the intensity of the radiation by absorption or reflection. Increasing the shielding around a radiation source decreases the exposure.

At times, it is impossible for the surgeon to distance him/herself from the radiation beam because the surgeon needs close access to the patient such as during intramedullary nailing and fixation of upper femoral fractures amongst other procedures. In these cases, Radiation Attenuation Gloves should be used.[1, 7] However, gloves will not protect hands if placed fully into the fluoroscopy beam. When placed fully in the x-ray field, gloves add to the attenuation of the beam, reducing image brightness and producing a large amount of scattered radiation irradiating the hand. Therefore, medical personnel should not rely upon gloves as their principal means of protection during fluoroscopy. Hands should always be pulled back from the imaged area.

Double gloving with conventional latex surgical gloves provides only 1 per cent attenuation.[8] Specialized radiation protection gloves shield hands from the harmful exposure to scattered radiation and can reduce scattered radiation to the hands by as much as 58 per cent at 60 kVp. Today's radiation protection gloves are less bulky and can be used effectively in combination with surgical gloves for interventional procedures, diagnostic heart catheterizations, coronary angioplasties, orthopaedic surgery, urology, or in other situations where there may be exposure to scattered radiation. Some manufacturers offer lead-free bismuth oxide attenuating specialty gloves. Per unit weight, bismuth oxide provides approximately the same radiation protection as lead, but it has the clear advantage of much lower toxicity.*

Chronic irradiation of the hands is a principal radiation safety concern for any physician involved in high-dose fluoroscopically guided interventional procedures[1] and radiation exposure to hands is often the most significant factor in terms of overall radiation risk.[1,5]

** Always check with the manufacturer for attenuating capabilities and specific performance characteristics*

References

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