UF UNIVERSITY of FLORIDA

College of Medicine
Department of Radiology
Radiology Practice Committee

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Dose Reduction Techniques

Intermittent Fluoroscopy

Most radiologists are trained to control the fluoroscope intermittently, that is, keeping the x rays on only a few seconds at a time, long enough to view the current catheter position. Judicious use of the method can reduce total fluoroscopic times considerably. This simple technique is particularly effective when combined with last image hold features

Removal of Grid

The presence of grids in x-ray systems primarily increases the contrast and hence the image quality; however, they increase the dose to the patient and staff by a factor of two or more. Studies have shown that, especially in pediatric cases, removal of the grid has resulted in dose reduction of up to one-third to one-half with little or no degradations in contrast and image quality. Grids should be used with discretion when fluoroscopic examinations are performed on children, and the systems for such examinations should have the capability for easy removal and reintroduction of the grid.

Last Image Hold and Electronic Collimation

A useful feature on many modern fluoroscopy systems is last image hold, whereby the last image is digitally “frozen” on the monitor after x-ray exposure is terminated. Last image hold is a dose saving feature, since it allows physicians to contemplate the last image and plan the next move without additional radiation exposure in an interventional procedure. In addition, some modern systems have electronic collimation, which overlays a collimator blade on the last image hold so that one can adjust field dimensions without exposing the patient.

Dose Spreading

In most interventional fluoroscopic procedures, the bulk of the fluoroscopic time is spent at a particular anatomic region during the procedure. For example, in radio-frequency ablation procedures, the fluoroscope is used to guide the catheter from the femoral artery to the heart but thereafter remains over the heart region. Some reduction of maximum skin dose can be achieved by periodically rotating the fluoroscope about a center within the anatomy of interest. This method tends to spread the maximum dose over a broader area of the patient’s skin so that no single region receives the entire dose.

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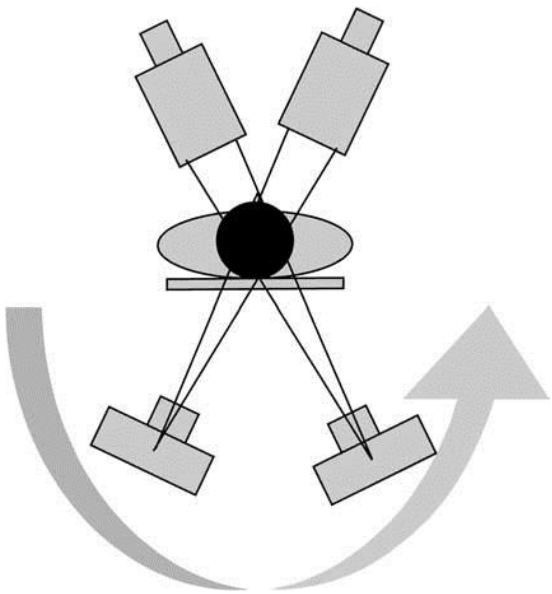

Effect of dose spreading by varying the beam incidence angle. The maximum dose thus tends to be spread over a broader area of the patient's skin.

Adjustment of Beam Quality

Beam energy primarily depends on the peak kilovoltage selected and the amount of filtration in the beam. Selection of higher kilovolt peaks increases the average beam energy of the x rays (beam hardening) and therefore the fraction of the entrance beam that passes through to the image receptor. For a fixed receptor entrance exposure, the skin entrance dose varies inversely with the kilovolt peak, more precisely as (kVp)3. The worst case is with a thick patient and a low kilovolt peak. The drawback of using a high-energy beam is some loss of image contrast. It has been shown that the loss in image contrast resulting from increasing the kilovolt peak from 60 to 70 is not significant, whereas the corresponding decrease in skin entrance dose is substantial (eg, about 30%). Maintaining the highest peak kilovoltage that will provide acceptable image contrast leads to lower skin dose.

Image Magnification

The ability to create magnified images can be clinically very useful but in almost all cases results in a higher patient dose. There are two basic ways to magnify the image in fluoroscopy: geometric and electronic. Geometric magnification takes advantage of the diverging x-ray beam to project a smaller region in the patient to a larger area on the image intensifier. When source-to–image receptor distance is fixed, both image magnification and skin dose increase as the patient is moved closer to the x-ray source. Many interventional system fluoroscopes do not fix the sourceto– image receptor distance, and the positions of the tube and the receptor can both be

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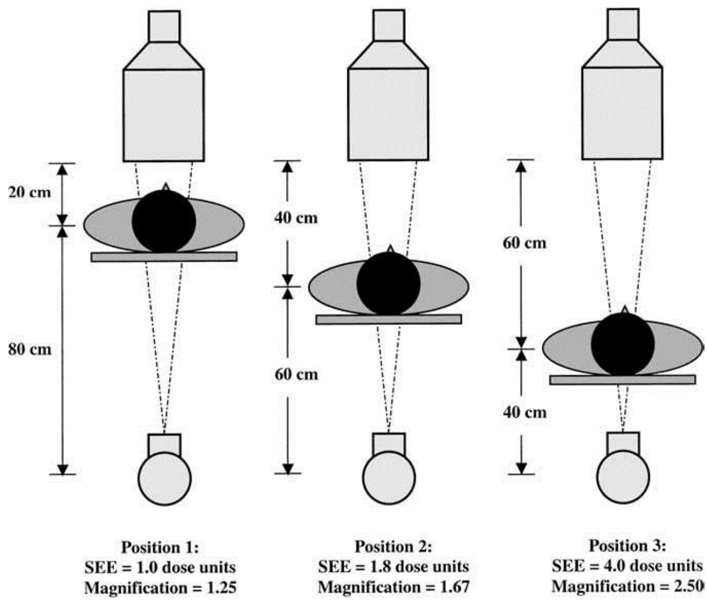
changed independently. Thus, moving the source closer to the patient or the receptor further away can magnify the image. Also, there is increased penumbra (focal spot blur) with higher magnification, and unless a very small focal spot is used (eg, 0.3 mm), the spatial resolution is degraded. It is generally best to minimize geometric magnification in prolonged procedures by keeping the image receptor close to the patient and the source away. Most modern fluoroscopes can also magnify the image electronically within the image intensifier. Systems typically have at least three and sometimes as many as five electronic magnification modes, each with a unique dose level. Usually, dose increases with greater electronic magnification. **One rule of thumb is that the radiation dose to the patient increases by the square of the ratio of the image intensifier diameters**. For example, if the entrance skin exposure is 100 units for a 23-cm field of view, the radiation entrance dose increases to 235 units when the field of view is reduced to 15 cm (23/15)2 and to 440 units for a field of view of 11 cm (23/11)2.



Effect of geometric magnification on entrance skin dose. With fixed source-to–image receptor distance, both magnification and skin entrance exposure (SEE) increase as the patient is moved closer to the x-ray source.

Pulsed Fluoroscopy

Some modern fluoroscopes have the capability of pulsed fluoroscopy, whereby the x-ray beam is emitted as a series of short pulses rather than continuously. At reduced frame rates, pulsed fluoroscopy can provide substantial dose savings. Images may be acquired at 15 frames per second rather than the usual 30 frames per second. Each image is displayed multiple times in sequence to provide a 30 frames per second display. Pulsed fluoroscopy can also be performed at even lower frame

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rates (eg, 7.5 or 3 frames per second) at the expense of a “choppy” display when imaging rapidly moving regions like the heart. Because simply reducing the number of pulses would result in an increase in image noise, manufacturers may increase the milliamperage setting to achieve a similar visual appearance. For example, one would expect a 50% dose reduction when going from 30 to 15 frames per second, but, because of increased milliamperage, the actual dose savings are 25%–28%. With equivalent perceptibility levels, Aufrichtig et al (34) showed average dose savings of 22%, 38%, and 49% at 15, 10, and 7.5 frames per second, respectively.

When operating at lower frame rates and higher magnification (decreased field of view), some systems open the television camera aperture instead of increasing the exposure to maintain similar image brightness. Pulsed fluoroscopy has a great advantage as long as the radiation exposure is lower at lower frame rates. If the tube current is set too high to achieve better-quality images, the entire advantage of pulsed operation is defeated and there may be no actual dose savings.