TECHNICAL NOTES

Distortion of Bar-Phantom Image by Collimator

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Distortion of the bar-phantom scintiphoto using the medium-energy collimator may lead to the misconception that the resolution of the medium-energy collimator is better than that of the low-energy collimator. The distortion is illustrated by superposition of the transparent films of the bar-phantoms and collimator.

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The medium-energy collimator has thicker septa and larger holes than those of low-energy collimators, and the resolution of the former is usually not as good as that of the latter. We have observed that a bar-phantom scintiphoto using the medium-energy collimator may show much better delineation of the bars than one using the lower-energy collimators. The distortion may lead to the misconception that the medium-energy collimator provides the better resolution. The finding is described and explained here, so that the misconception may be avoided.

A bar phantom* was imaged with a Tc-99m flood source on a gamma camera.* The bar phantom has a bar width and spacing of 4.5, 4, 3.5, and 3 mm in quadrants 1, 2, 3, and 4, respectively (Fig. 1A). A low-energy converging collimator, a low-energy parallel-hole collimator, and a medium-energy parallel-hole collimator were used in the study. The maximum photon energies suggested by the manufacturer for the low- and medium-energy collimators are 140 and 360 keV, respectively. The phantom was placed on the collimator surface and 500,000 counts were acquired for each scintiphoto. The phantom bars were aligned with the collimator septa in the first imaging, then the phantom was rotated successively by 15°, 45°, 75°, and 90° in a counterclockwise direction.

In order to explain the distortion of the bar phantom by the collimator, transparent films of the phantom and collimator were made by placing the bar phantom on a view box and making a photographic (Polaroid) transparent film. A grid pattern was made with the ratio of hole size to septal thickness approximately the same as that of the medium-energy collimator (hole 3.8 mm; septum 1.3 mm) and a transparent Polaroid film of the grid pattern was taken to represent the medium-energy collimator. The minification factor for the collimator transparent film is approximately the same as that for the bar-phantom film. The two transparent films were superimposed on a view box. The bars of the phantom film were first aligned with the septa of the collimator film. Then the phantom film was rotated counterclockwise by 15°, 45°, 75°, and 90°. Polaroid pictures of the superimposed films were taken.

Figure 1 shows the bar phantom (A) and the scintiphotos using the low-energy converging collimator (B), the low-energy parallel-hole collimator (C) and medium-energy collimator (D). Obviously the scintiphoto with the medium-energy collimator shows much better delineation of the bars in all quadrants than do the other collimators.

The transparent Polaroid films of the phantom and the medium-energy collimator are shown in Fig. 2, A and B. Superimposed pictures of the phantom and collimator are shown in Fig. 2, C, D, E, F, and G when the phantom film was rotated counterclockwise by 0°, 15°, 45°, 75°, and 90°, respectively. The corresponding scintiphotos are shown in Fig. 2, Cc, Dd, Ee, Ff, and Gg. Obviously the distortion in the bar-phantom scintiphotos is very similar to that in the superimposed transparent pictures of the phantom and collimator.

Image aberrations produced by collimators are well known. The distortion is manifested as a Moiré pattern showing cyclic discontinuities (1,2). A Moiré pattern is analogous to an effect

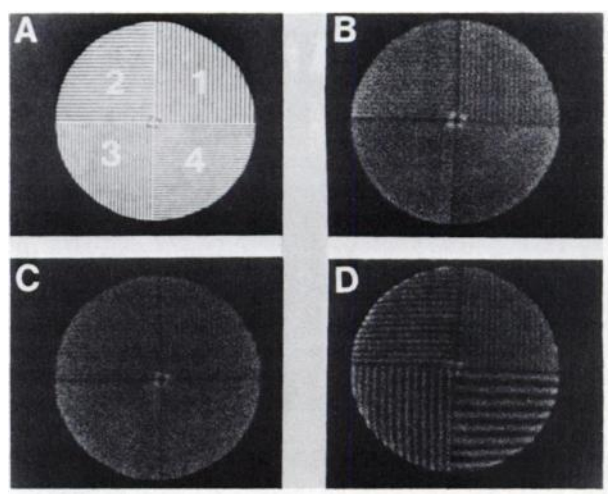

FIG. 1. (A) Bar phantom and its quadrants 1, 2, 3, and 4. (B, C, and D) Scintiphotos of phantom using the converging low-energy collimator, parallel-hole low-energy collimator, and medium-energy collimator, respectively. Note much better delineation in all quadrants using medium-energy collimator (D).

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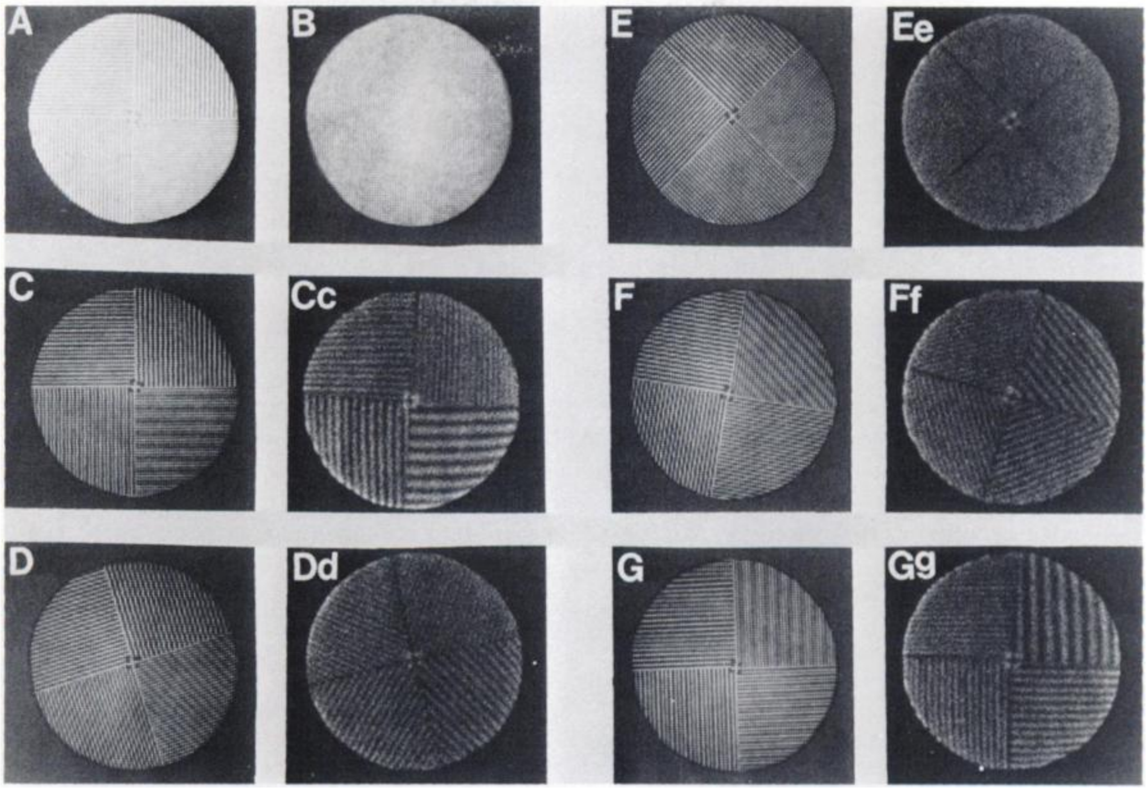

FIG. 2. (A, B) Phantom and medium-energy collimator. (C) Superimposed pictures of A and B. (Cc) Scintiphoto of phantom positioned as in (C). With collimator rotated counterclockwise by 15°, 45°, 75° and 90°, superimposed pictures and scintiphotos are shown in D, Dd; E. Ee; F, Ff; and G, Gg, respectively. Note distortion in phantom images.

seen in fiber optics. The images of objects viewed through a fiber-optic bundle tend to become fragmented into Moiré patterns owing to the discontinuities produced by the insulation between the individual light-conducting fibers. The holes in a collimator might be likened to the fibers in a fiber-optic bundle and the septa between the holes to the insulation between the fibers. The image artifact caused by the collimator shown by Bonte et al. (*1*) is apparent even at first glance. In our case, when Fig. 1D was presented, very few observers would immediately suspect any distortion by the collimator—in fact, Fig. 1D convincingly represents much better resolution than Fig. 1, B and C.

When Fig. 1D is closely examined, however, the distortion of the phantom image becomes obvious. There are fewer bars than the bar phantom actually has. In the scintiphoto, the bar sizes increase successively in quadrants 1, 2, 3, and 4, whereas the phantom's bar sizes actually *decrease* in that order. The bar images may not be exactly perpendicular to each other in adjoining quadrants, such as those in quadrants 3 and 4, Fig. Cc. These subtle findings make one think that something is wrong with the scintiphoto performed with medium-energy collimator. When the phantom is rotated, obvious distortion appears in the scintiphoto, proving that the distortion is due to the collimator.

The superimposed pictures of the bar phantom and collimator show patterns like those of the scintiphotos at similar rotations. Obviously the distortions shown on the scintiphotos are the same as the optical distortion shown on the superimposed pictures because of relative positioning of the collimator septa and phantom bars. As Bonte et al. (*1*) have pointed out, the better the scintillation camera's resolution, the clearer the septal effect will be. Even though the collimator septum is thinned, if the intrinsic resolution of the camera is improved, the septal effect may still be shown. Our study was done on the medium-energy collimator with a Tc-99m flood source, consequently the resolution is not the true representation. A medium-energy flood source should be used. Perhaps the resolution shown on the scintiphoto when the collimator was rotated by 45° (Fig. Ee) is a better representation of the resolution for the medium-energy collimator.

FOOTNOTE

* Searle LFOV.

REFERENCES

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