Rotational Variation in Gamma Camera Sensitivity and Uniformity Due to a Defective Collimator

It is generally recognized that good quality single photon emission computed tomography (SPECT) requires system stability with respect to rotation of the scintillation camera for both uniformity and sensitivity (*1*). Two of the many causes of variation in image sensitivity and uniformity are the effects of the earth's magnetic field and gravity on the gamma camera as a function of gantry angle. Although the effects of gravity cannot be eliminated, modern gamma cameras contain Mu shields around the photomultiplier tubes to reduce the effects of magnetic fields on apparent photon energy and counting rate.

A simple way to determine the effects of rotation on camera sensitivity and uniformity is to tape a cobalt-57 flood field source to the camera face. Then, perform a 16-image tomographic acquisition through 360°, acquiring 1–10 million counts per image. View the 16 images as a dynamic study to assess uniformity variation and examine the total counts within the images to determine the effects of rotation on sensitivity. Any large rotational effects that are present are usually assumed to be due to inadequate shielding of the photomultiplier tubes, or possibly slippage of the crystal and photomultiplier tube assembly within the camera head.

We recently observed an unusual angular variation in camera sensitivity and uniformity due to a defective collimator. A low-energy all-purpose collimator was replaced on a camera system due to damage to the septa. A new collimator, of similar specifications, was checked on arrival, considered satisfactory, and installed on the gamma camera. Subsequent to its installation, the angular variation of flood field uniformity and sensitivity was measured (Fig. 1). This showed a variation of up to 4% in image sensitivity during a 360° clockwise tomographic acquisition. When the image was divided along the axis of rotation, region of interest analysis showed a 7% variation in sensitivity for the left side (Fig. 1, lower left) and a 3% variation for the right side (Fig. 1, lower right). Rotating the camera counterclockwise did not yield mirror image results. In the

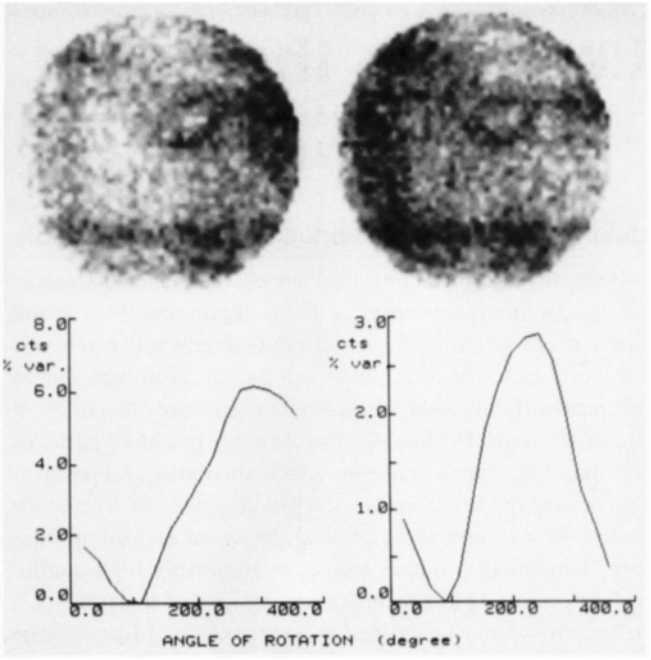

FIG. 1. Variation in image uniformity between the first image (upper left) and last image (upper right) of 16-image tomographic acquisition. The contrast levels have been set from 80%–100%. The curves show the percentage variation of image counts with angle of rotation for the left side (lower left) and right side (lower right) of the images shown.

uncorrected images, integral nonuniformity varied from 5.0% for the 0° image (Fig. 1, upper left) to 6.5% for the 360° image (Fig. 1, upper right), thereby making uniformity correction for tomographic acquisitions impossible.

When removing the collimator from the gamma camera, it was found that the collimator core had come loose within its surrounding lead ring. By shifting slightly within this lead ring, it was effectively altering its position with the angle of rotation. This should have caused a variation in the collimator hole angle relative to the crystal face and hence should have been detected during the weekly center of rotation calibration. However, the calculated center of rotation deviated by less than 0.15 pixels (64 × 64 matrix) over the full range of gantry angles, which is within normal limits. Replacement of the collimator reduced the variations in imaging sensitivity to less than 0.7% and eliminated the angular variations in image uniformity.

Although collimator failure is an unusual occurrence in gamma camera systems, the performance of routine quality control on the camera not only detected this problem but prevented the ultimate and expensive consequence of this fault—the collapse of the collimator core onto the crystal face.

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REFERENCE

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