Effect of Spatial Distortion on Anger Camera Field-Uniformity Correction: Concise Communication

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The field uniformity of a computer-assisted Anger-camera system, and the effect of field correction on quantitative data, have been studied. Our results show that the total counts of a source imaged across the crystal face varies with a s.d. of only 2.0%, but routine flood-field correction degrades the data to a s.d. of 9.4%. On the other hand, the area of a source 1.75 in. in diameter, imaged across the crystal face, varies with a s.d. of 9.7%. We conclude that the major source of field nonuniformity for an Anger camera is spatial distortion and not varying sensitivity across the crystal face.

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It is usual to correct for the nonuniform response of an Anger camera by obtaining a digital flood field matrix, which is then normalized. The data images are field corrected (FC) by dividing by this normalized flood matrix. Thus in computing the corrected images, counts are selectively increased where the digital flood field is cold and decreased where the flood field is hot. This correction method has come under increasing criticism in recent years (*1–5*). The inherent assumption in this FC method is that the camera's nonuniformity is caused by varying sensitivities across the crystal face. We have carried out a few simple experiments to test this assumption.

MATERIALS AND METHODS

The system used in this investigation was a Searle Pho/Gamma HP Anger camera equipped with a low-energy parallel-hole all-purpose collimator on line with a Medical Data System computer. A 25% window centered on the photopeak of Tc-99m was used in all of the experiments. The FC algorithm used works in the following manner. A digital flood is acquired by irradiating the crystal with a uniform extended source of the nuclide of interest. The algorithm first scans the center 16 channels of the 64-by-64 array and calculates the average count per channel (matrix point) for these 16 channels. All the channels that have counts between a factor of 0.2 and 5 of this center average are considered to represent the crystal face. For those channels that represent the crystal face, the average count per channel is calculated. The FC factors for each channel are then calculated by dividing the average count per channel by the counts in the appropriate channel in the flood matrix. This matrix of FC factors is then stored on magnetic disk. The data images are FC by being multiplied by this FC matrix, that is, by being divided by the normalized flood matrix.

Count rate uniformity. A 2-mCi source of Tc-99m

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was collimated down to a diameter of ¼-in. with a ½-in. long-by-¼-in. diameter lead hole. Scattering medium (masonite) of ¼, 1, 2, 4, and 6 in. was inserted between the Tc-99m source and the collimator. For each level of scatter the source was imaged at 25 positions across the collimator face. These images, each containing 13,000–50,000 counts, were acquired in a 64-by-64 matrix and stored on magnetic disk. A 3-million-count flood employing an extended Tc-99m source was also acquired.

The count rate at each of the 25 positions was determined at each level of scatter. These 125 images were FC and the counts in each of these FC images were then determined. The mean, standard deviation, and standard deviation percentage of the total counts were then calculated for the original and the FC images. A normalized range was calculated for each level of scatter.

Image size uniformity. An uncollimated, 300 μCi source of Tc-99m, 1.75 in. in diameter, was imaged on the Anger Camera at 61 positions of a hexagonal array across the collimator face. The images, each containing over 50,000 counts, were acquired in a 128-by-128 matrix and stored on magnetic disk. The area of the source in the individual images was calculated from the number of channels that had counts per channel greater than or equal to 10% of the average counts per channel for the seven center positions on the hexagon. The 10% cut-off was chosen because it was well above background and septal penetration, but included the full image area. The total counts and average counts per channel within each of the 61 areas were also calculated. The mean, standard deviation, and standard deviation percentage were calculated for the counts within these areas, for the average count per channel, and for the size of each area (number of channels).

RESULTS

Table 1 shows the data from the count-rate-uniformity experiment. The non-FC data has a higher precision (2.0% s.d.) than the FC data (9.4% s.d.). The average normalized range of the uncorrected data is 0.97–1.04 (7% spread), but it is .84–1.17 (33% spread) for the corrected data. The introduction of scattering medium has little or no effect on the uniformity measurements.

In the image-size-uniformity experiment (Table 2), the counts within the areas varied with a s.d. of only 2.1%, however, the image size varied with a s.d. of 9.7%.

Another way to look at these data is by the generation of computer images where the intensity at each point is proportional to either the count rate or the image size of that point. Figure 1a shows this type of image. The 61 data points from the count-rate-uniformity experiment were interpolated to provide a smooth image representing the counting efficiency at every point on the crystal face. The uniformity is clearly superior to that in Figure 1b, which is a routine flood-field image. Figure 2a is a display of the data from the image-size-uniformity

TABLE 1. COUNT-RATE-UNIFORMITY EXPERIMENT

	Scatter (in.)	Mean	s.d.	%s.d.	Normalized range
Not field-corrected					
	¼	49941	1379	2.76	0.95–1.04
	1	36074	569	1.58	0.98–1.04
	2	23693	517	2.18	0.95–1.04
	4	16821	259	1.54	0.97–1.03
	6	13241	234	1.77	0.97–1.04
		Avg.		1.97	0.97–1.04
Field-corrected					
	¼	48515	4122	8.50	0.85–1.14
	1	36090	3446	9.55	0.82–1.16
	2	23809	2518	10.57	0.83–1.20
	4	16882	1547	9.16	0.86–1.18
	6	13264	1194	9.00	0.86–1.16
		Avg.		9.36	0.84–1.17

TABLE 2. IMAGE-SIZE-UNIFORMITY EXPERIMENT

Parameter	Mean	s.d.	%s.d.	Normalized range
Counts	61798	1305	2.11	0.94–1.04
Area (no. of channels)	682	66.4	9.74	0.81–1.17

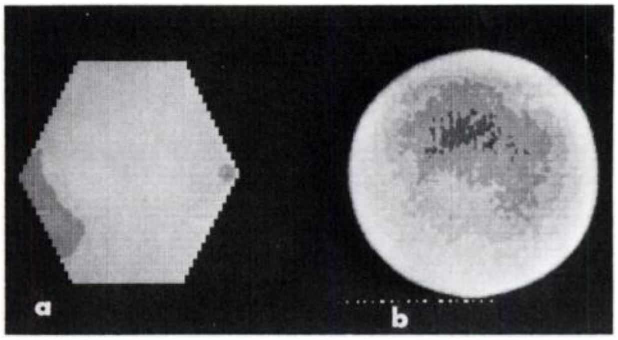

FIG. 1. Comparison of count-rate-uniformity image (a) with usual flood-field image (b) shows that counting efficiency is far more uniform than flood-field image indicates.

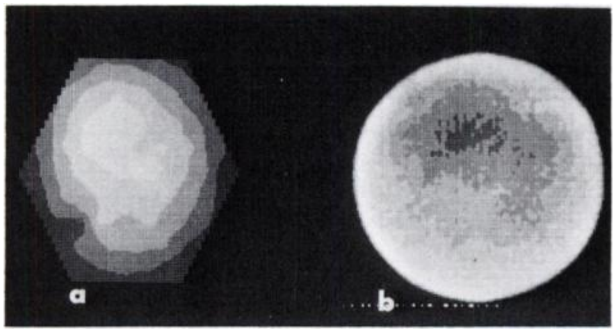

FIG. 2. Comparison of image-size-uniformity image (a) with usual flood field (b) shows that regions where image size is abnormally large correspond to "cold" areas on the flood field.

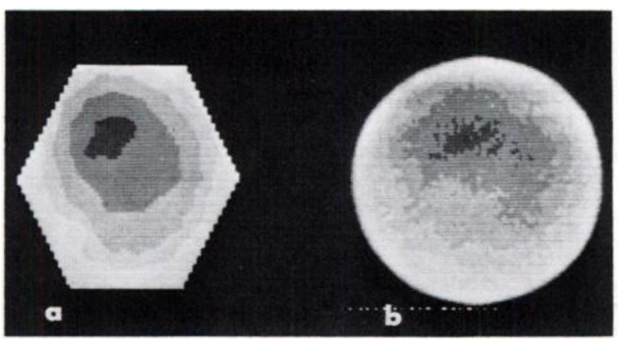

FIG. 3. Image on left (a) has intensity inversely proportional to image size. Comparison with flood field (b) shows that almost all of the nonuniformity in the flood field is due to image-size variation.

experiment, in which the intensity at every point is proportional to the image size at that point. Comparison of this image with the flood field in figure 2b shows that the regions where the image size is abnormally large correspond to "cold" regions on the flood field. Figure 3a shows an image generated from the inverse of the image-size data shown in Figure 2a. In Figure 3a the intensity is inversely proportional to the image size measured at that point. Comparison with the flood field in Figure 3b shows that almost all of the apparent nonuniformity in flood fields can be attributed to variations of image size, rather than of count rate across the crystal face.

CONCLUSION

These results clearly show that the major cause of field nonuniformity for an Anger camera is spatial distortion rather than changes in sensitivity. Whereas translation of one distortion into the other, as is done with the usual field-correction techniques, may improve visual image quality, this is done at the risk of degrading quantitative data. Comparison of region-of-interest counts with other areas in an image, or with standards imaged at the same time, should be done on uncorrected images only. Proper field correction should be done with position shift corrections (*3*) rather than efficiency corrections.

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