FIELD UNIFORMITY DISTORTION WITH THE PINHOLE COLLIMATOR ON THE SCINTILLATION CAMERA

Using a cooperative purchase venture, several hospitals in metropolitan Denver have been able to offer ^{18}F bone scans even though they were not located near a cyclotron. It soon became apparent that the gamma camera imaging device in combination with ^{18}F was not the panacea we had hoped it would be, but was beset by physical problems. Of these the most significant was that of field uniformity distortion when the pinhole collimator was used on the scintillation camera.

The pinhole collimator with special insert (modified by Medi-Physics, Inc.) has been used to perform bone scintiphotography with ^{18}F. This type of collimator was selected to reduce septum penetration by the 0.51-MeV annihilation gamma radiation and to allow increased fields of view. Quinlan and Wagner (*1*) have reported on the use of the pinhole collimator to obtain a field of view large enough to encompass both lungs in the same scintiphotograph. Allthough it was not mentioned in the report, their scintiphotographs show increased "brightness" in the center of each picture. They used a field-of-view diameter versus distance from the end of the collimator ratio of approximately 1.25. We used a similar ratio—23-in.-diam field of view at 18 in. from the end of the collimator with the pinhole-to-crystal distance of 7.5 in. and a crystal reception diameter of 9.25 in.

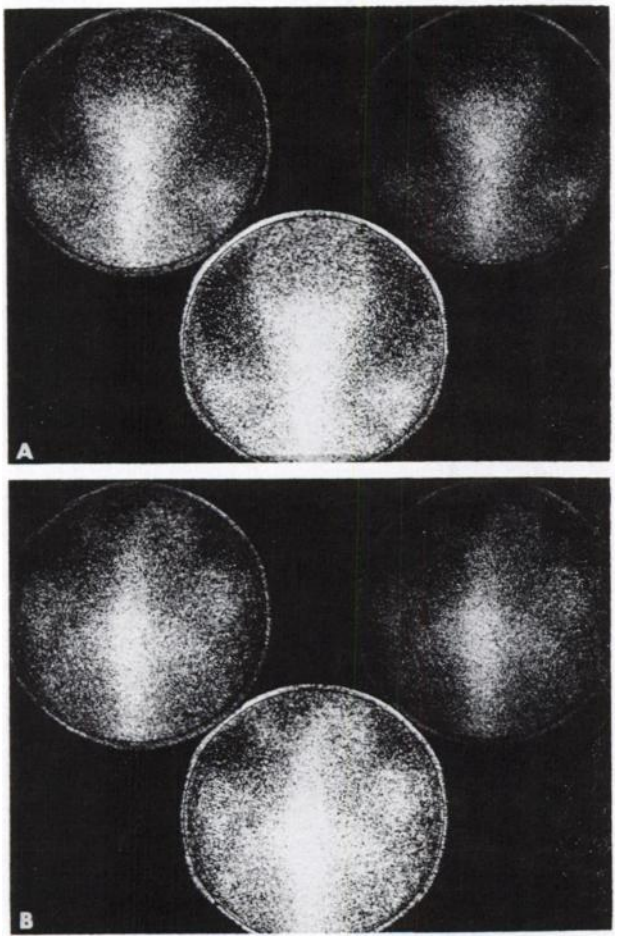

FIG. 1. Scintiphotogram of patient with carcinoma of prostate obtained with Anger camera using ^{18}F as imaging agent. In A notice relatively large amount of radioactivity in upper thoracic and cervical spine with considerable decrease in relative activity near edge of crystal inferiorly. In B camera was centered somewhat lower for evaluation. Compare amount of skull that is included. On scan, notice that most radioactive region is now situated below level of shoulders and that cervical spine and remainder of thoracic spine are relatively "cool" around central "hot" spot.

It was soon noted that scintiphotographs of linear structures such as the spine and limbs in particular and to a lesser degree the pelvis, contained a relatively "hot" spot in the center, suggesting an apparent increase in ^{18}F bone deposition (Fig. 1A) even though this same anatomical area would appear as a relatively "cool" region on a scintiphotograph which was centered over an immediately adjacent anatomic site (Fig. 1B). In simplest terms this aberration is due to the increased count from the center of a uniformly active planar source held perpendicular to the central axis of the collimator because of the inverse square relationship (Fig. 2).

The physical dimensions of our collimator, as described above, give a center-to-edge inverse-square relationship of 1.38–1.00 ($30.5^2/26.0^2$). Paix (*2*) found a similar sensitivity ratio in his study of pinhole-collimator imaging of gamma rays. Regardless of the imaging distance from the end of the collimator, this relationship remains essentially constant. Use of a uniform line source placed perpendicular to the collimator axis at a distance of 18 in. demonstrates the relatively increased central radioactivity as shown in Fig. 3 which is a spatial histogram of the line source. This spatial distribution of a uniformly radioactive line source verifies the inverse-square relationship after the scintillation camera nonuniformity correction has been made.

Hayes (*3*) investigated resolution, efficiency, and image distortion with the parallel-hole, pinhole, and diverging collimator on an Anger scintillation camera. His scintiphotographs indicate "bright" centers

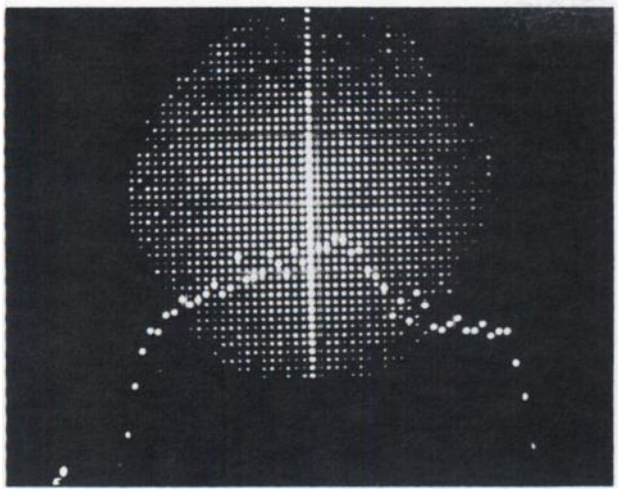

FIG. 2. Histogram taken across crystal face of image created by ^{57}Co flood source through pinhole collimator showing lack of uniformity across crystal.

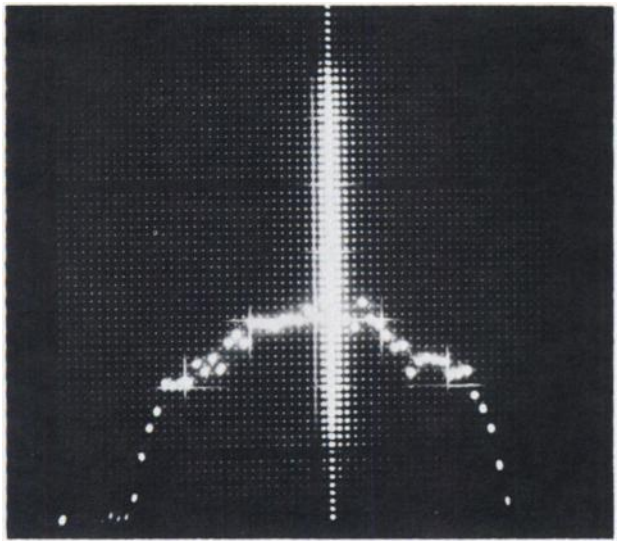

FIG. 3. Image of uniformly linear source as presented on face of 4,096 computer. Linear histogram obtained through center of source across face of crystal is represented by curve which shows dramatically fall-off in activity toward periphery.

when the pinhole collimator was used. He mentions a "brightness reduction" with increasing depth of source in his test phantom. However, he does not mention the problem of increasing center "brightness" for a planar source.

Our studies indicate that the pinhole collimator produces center-of-picture brightness making relative radionuclide "uptake" evaluation in bone imaging difficult. The 38% increase in edge-to-center measured radioactivity correlates with the inverse-square relationship for a collimator as described. This physically generated nonuniformity across the field of view with the pinhole collimator is apparent with all of the radionuclides currently used in nuclear medicine and at all distances from the collimator pinhole front face.

This problem of inverse-square nonuniformity can be overcome by placing the source to be imaged in an arc converging toward the collimator on an equal length radius to the pinhole. This correction is obviously difficult to obtain when imaging the spine in a posterior view. Laboratories with computer capability can correct for this nonuniformity in the final image. We have overcome the nonuniformity problem at our facility by using the rectilinear scanner for bone imaging with ^{18}F.

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^{51}Cr-EDTA BIOLOGICAL HALF-LIFE AS AN INDEX OF RENAL FUNCTION

Since its introduction by Garnett, Parsons, and Veall in 1967 (*1*), ^{51}Cr-EDTA has proved to be a clinically useful radiopharmaceutical for the measurement of glomerular filtration rate particularly when used in the single injection method (*2,3*). The use of glomerular filtration rate as an index of renal function can, however, be considered to suffer from two drawbacks. First, it is dependent on body size or more exactly to extracellular fluid volume, and second at low levels of GFR relatively large percentage changes in renal function show up as small absolute changes in GFR.

Thus a large man can lose a considerable degree of renal function, dropping his GFR from 180 to 90 ml/min, and still remain within commonly accepted normal limits. In addition, a drop in GFR from 40 to 30 ml/min represents a 25% fall for an absolute change of only 10 ml/min.

We have determined the biological half-life of ^{51}Cr-EDTA in 34 patients in whom GFR determinations were carried out by the single-injection technique and correlated these against GFR corrected to a standard surface area of 1.73 m^2 as calculated from a duBois nomogram (*4*). Figure 1 shows the