Factors Affecting the Diagnostic Reliability of Scintillation Camera Film Images

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Most scintillation camera data obtained in nuclear medicine clinics are displayed on Polaroid and/or 35- or 70 - mm films. This allows little flexibility in data analysis without repeating the imaging procedure with different control settings. This study was designed to demonstrate that the subtle variations in field-uniformity response that appear on film and may easily be dismissed as negligible may indeed be clinically significant. Although a computer was employed in this study, measures can be taken to minimize the effect of field-uniformity variations on diagnosis even in clinics without direct computer support.

Most data from scintillation cameras are recorded on standard Polaroid and/or 35- or 70-mm films. Without some type of data-handling device, it is not possible to obtain maximum information from film data without repeating the imaging procedure. The purpose of this work was to demonstrate several potential weaknesses of film data that are commonly neglected and that may lead to the loss of data of significant diagnostic value. A greater awareness of these factors when analyzing film images will help provide a higher level of reliability in diagnosis. Although these factors are readily discernible and easily controlled through computer handling of the data, measures can be taken to minimize their effect on diagnosis where film is the only data medium used.

Materials and Methods

A Searle Pho/Gamma HP scintillation camera is interfaced to a Nuclear Data MED II computer system so that images may be recorded simultaneously by the computer and on film from the cathode-ray tube on the camera console. Data were obtained using an Alderson head and skull phantom with a volume of 3,500 cc and containing a hollow ovoid-shaped pseudotumor with a volume of 6 cc.

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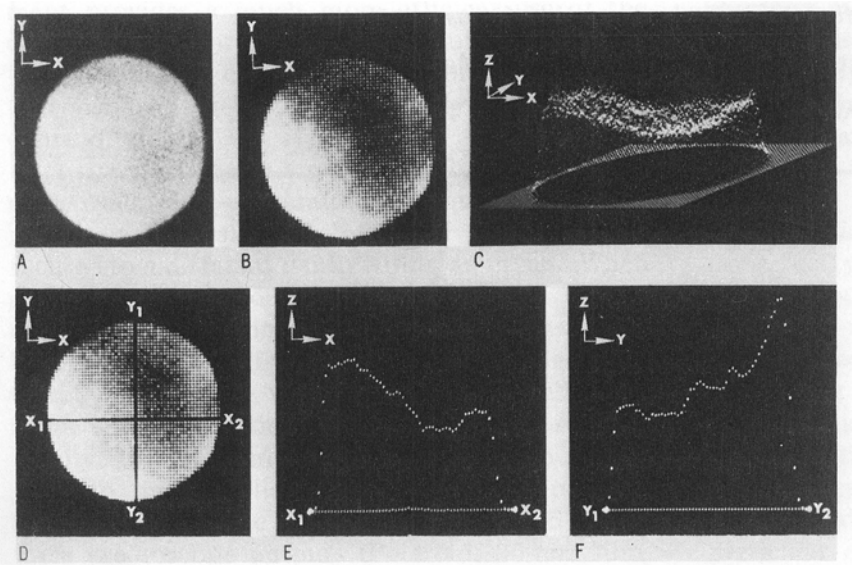

FIG. 1. Field uniformity variations of flood image recorded on 35-mm film (A) are dramatically revealed by planar display (B) and isometric display (C) of same image recorded by computer. Horizontal (X_1, X_2) and vertical (Y_1, Y_2) profiles across computer planar display (D) reveal statistically significant variations (E and F, respectively) after 9-point smoothing operation.

The tumor and head were filled with water and ^{99m}Tc-pertechnetate at such a tumor/tissue volume normalized activity ratio (4:1) to produce a barely discernible image of the tumor on 35-mm film. Images of this phantom were recorded on 35-mm film and by the computer using the high-resolution collimator and Tomocamera. In addition, a flat-field flood phantom was also used to demonstrate the camera uniformity response over the surface of the detector for the pinhole and the high-resolution collimators. Both phantoms contained a total of about 2 mCi of ^{99m}Tc and, except where noted, 500K counts were recorded for each image. All the operations on the computer planar images were accomplished with simple intensity and full-scale control settings.

Results

The 35-mm film image (Fig. 1A) of the field flood phantom using the high-resolution collimator reveals an obvious nonuniform response over the detector surface. These variations are made much more obvious by computer displays (Figs. 1B and C) of the same image. Quantitative visualizations of vertical and horizontal profiles (Figs. 1E and F) taken across the original computer image (Fig. 1D) verify that these variations are clinically and statistically unacceptable. Although the 35-mm film image (Fig. 1A) clearly shows a detuned camera, it would not be very difficult, solely on the basis of the 35-mm film data, in this and other less severe cases to delay tuning the camera because of the effort and time involved.

The 35-mm film image (Fig. 2A) taken with a pinhole collimator and a well-tuned camera reveals a slightly brighter central region due to the inverse-square effect of the distance from the source to the crystal. However, the apparent difference between the central light region and the peripheral dark region does not appear to be very significant. The computer display of the same image (Fig. 2B) dramatically reveals the wide count differential between these regions. A plot (Fig. 2D) of the number of counts as a function of distance for a horizontal profile across the image (Fig. 2C) again verifies statistically significant variations. An interesting phenomenon was observed when about 4 million counts were recorded (Fig. 3A) using the same experimental arrangement. Images of most of the photomultiplier tubes are clearly identifiable and correlate with the actual geometric configuration of the photomultiplier tubes (Fig. 3B). This particular example demonstrates the importance of a large number of counts in an image to more clearly discern subtle differences. The existence of such small variations is quickly visualized by recording only one image on the computer without the time-

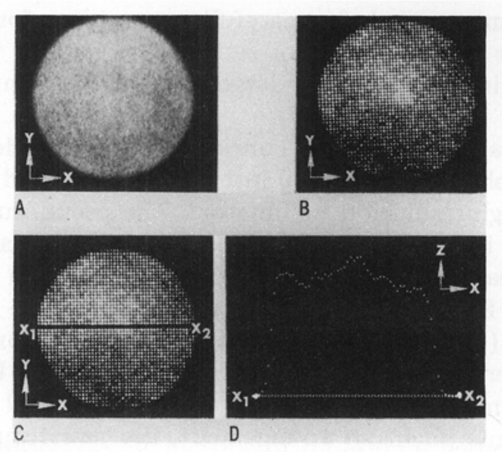

FIG. 2. Field uniformity variations of flood image taken with pinhole collimator and displayed on 35-mm film (A) are more readily observed on computer planar display (B) of same image. Horizontal profile (X_1, X_2) across computer display (C) clearly reveals statistically significant variations (D) after 9-point smoothing operation.

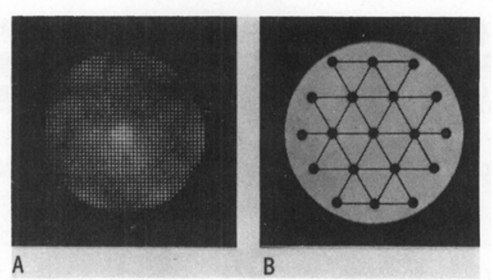

FIG. 3. Photomultiplier tubes easily observed after 4 million counts were recorded for field flood image using pinhole collimator (A). Schematic of actual photomultiplier tube locations (B) shows their correspondence with image locations (A).

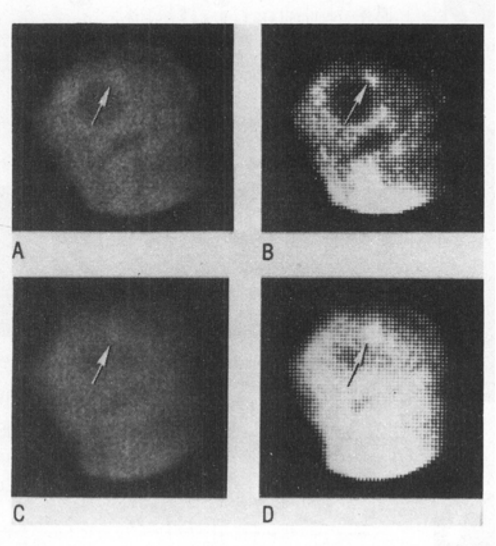

FIG. 4. Image of Alderson head phantom recorded with high-resolution collimator on 35-mm film (A) reveals vaguely discernible pseudotumor (arrow) whereas computer display (B) provides far greater assurance of its presence (arrow). Tomographic image of pseudotumor (arrow) positioned at unfocused plane of interest is barely discernible on 35-mm film image (C) and clearly discernible (arrow) on computer display of same image (D).

consuming need for carefully searching for the proper intensity control settings as required when recording an unusually large number of counts on film.

As a more practical consideration, the Alderson head phantom and pseudotumor were imaged with the high-resolution collimator. The pseudotumor, which is at a depth of 2½ in. beneath the surface of the head, is poorly visualized on 35-mm film (Fig. 4A). However, the computer display of the same image (Fig. 4B) clearly shows the pseudotumor well differentiated from the background activity. Using the tomography attachment to the camera *(1)* and the same phantom arrangement, the pseudotumor, which is not in a plane of focus, is again barely perceptible on the film output (Fig. 4C) and yet clearly visualized on the computer display (Fig. 4D).

Discussion

The examples presented demonstrate the potential limitations on diagnostic value when relying solely on film for displaying scintillation camera data. The advantages offered by a computer for displaying the data are clearly evident. More importantly, it is hoped that these examples serve to stress the importance of maintaining excellent quality control on imaging instrumentation particularly for those facilities that are not equipped with elaborate data-handling systems. In addition the importance of the clinician's awareness of the inherent limitations of the instrumentation, e.g., the pinhole collimator (Fig. 2), cannot be overemphasized. Shadows or other minor variations on field flood images that are not promptly eliminated can lead to loss in diagnostic value especially when a slightly active region of an organ is imaged at a slightly insensitive region of the detector, and vice versa. At the very least it is assured that well-tuned instrumentation will provide the maximum level of diagnostic reliability whereas untuned equipment alone may lead to inaccurate diagnoses.

Reference

1. Sinclair MD, McManaman VL: A table for quickly determining planes of focus for a scintillation tomocamera. *J Nucl Med Tech* 2: 40-41, 1974