Camera Uniformity and Resolution with Three Radionuclides: Technetium-99m, Thallium-201, and Gallium-67

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A quality control study was performed by 10 nuclear medicine technology students to evaluate the response of gamma cameras to three radionuclides: technetium-99m, gallium-67, and thallium-201. Uniformity and resolution images were obtained using nine cameras manufactured by five different companies. The uniformity and resolution images were analyzed visually and the results were tabulated. Individual gamma cameras yield varying results when visually comparing uniformity and resolution checks for different radionuclides.

Quality control procedures are used to check the performance reliability of gamma cameras. Because ^{99m}Tc is the most frequently used radionuclide in nuclear medicine, many clinics perform the daily uniformity and weekly resolution checks using this radionuclide. When other commonly used radionuclides, such as ^{201}Tl and ^{67}Ga are used, no standardized quality control is performed. By performing quality control with three different radionuclides, it has been observed that individual cameras respond differently to various radionuclides (*1*). We therefore evaluated several manufacturers' cameras for uniformity and resolution with ^{99m}Tc, ^{201}Tl, and ^{67}Ga.

MATERIALS AND METHODS

Two-hundred-microcurie point sources of ^{99m}Tc, ^{201}Tl, and ^{67}Ga were used for all studies. Nine large field of view cameras*, which are used for studies performed with all three radionuclides, were chosen for this experiment. All cameras were in normal clinical condition and were not serviced for the express purpose of this experiment. A four quadrant bar phantom matching the camera performance was used for resolution studies.

TABLE 1. Comparison of Individual Gamma Camera Performance with Three Radionuclides: ^{201}Tl, ^{99m}Tc, and ^{67}Ga

Camera	Best intrinsic flood field uniformity	Worst intrinsic flood field uniformity	Best intrinsic resolution	Worst intrinsic resolution
1	^{99m}Tc, ^{201}Tl, ^{67}Ga		^{99m}Tc	^{67}Ga
2	^{67}Ga	^{201}Tl	*	*
3	^{99m}Tc, ^{201}Tl	^{67}Ga	^{99m}Tc	^{201}Tl, ^{67}Ga
4	^{67}Ga	^{99m}Tc, ^{201}Tl	^{67}Ga	^{201}Tl
5	^{99m}Tc, ^{201}Tl, ^{67}Ga		^{99m}Tc	^{201}Tl
6	^{99m}Tc, ^{67}Ga	^{201}Tl	^{99m}Tc	^{201}Tl
7		^{99m}Tc, ^{201}Tl, ^{67}Ga		^{99m}Tc, ^{201}Tl, ^{67}Ga
8	^{201}Tl	^{99m}Tc	^{99m}Tc	^{201}Tl
9	^{99m}Tc, ^{201}Tl, ^{67}Ga		^{99m}Tc	^{201}Tl

Note: In cases where more than one radionuclide is listed, the images were comparable; no visual difference between them was seen. Cameras 3, 4, and 7 were the same manufacturer and model. Cameras 2 and 9 were the same manufacturer and model.
*An intrinsic resolution check was not performed on this camera.

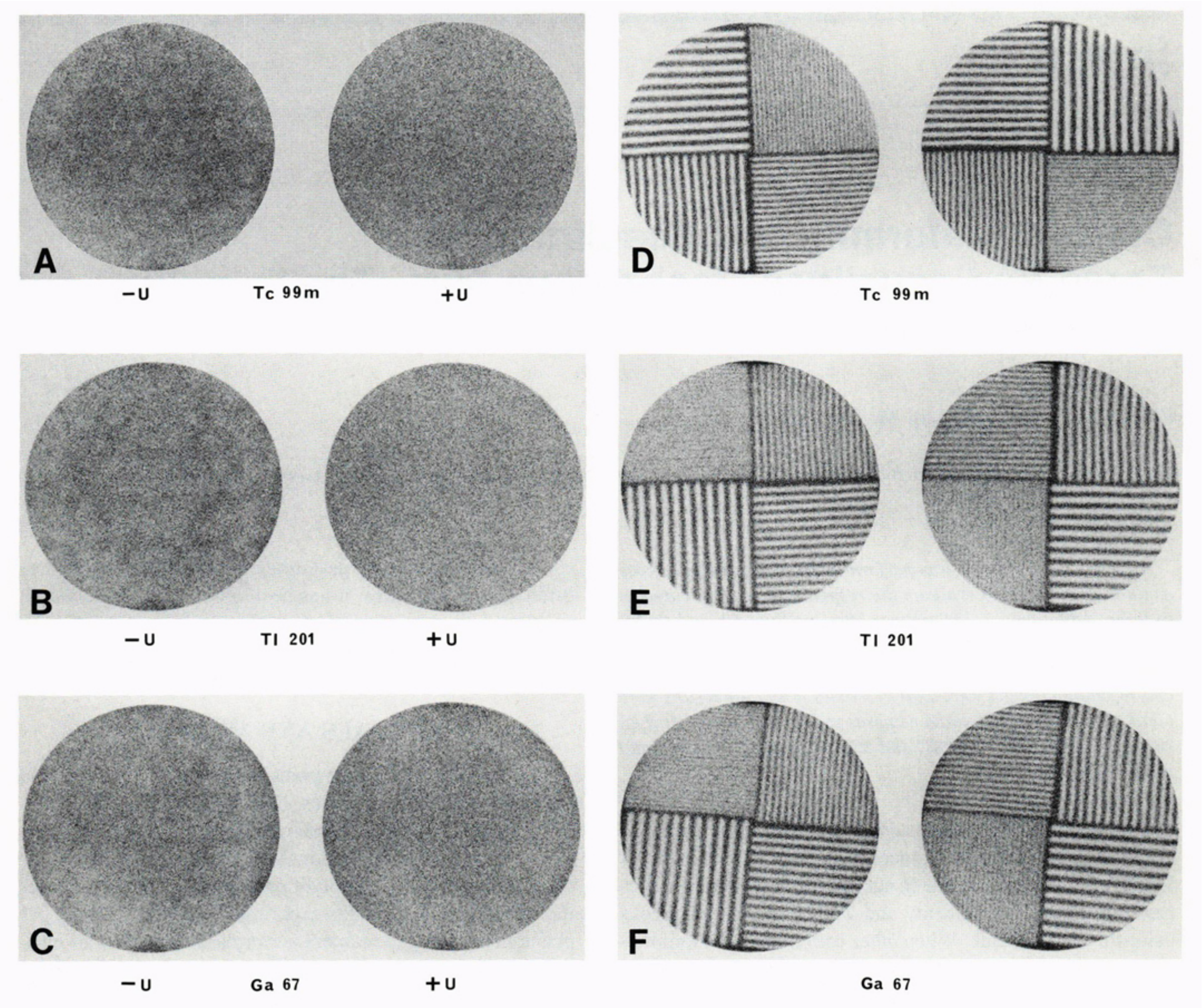

FIG. 1. This figure shows the set of flood and bar phantom images obtained from camera 3. Two flood images (A–C) were taken with each radionuclide. One flood image was taken with the camera uniformity correction device off (−U) and another with it on (+U). Two bar phantom resolution images (D–F) with each radionuclide were taken. Similar data were obtained from each gamma camera used in the study.

Three sets of intrinsic flood images and bar phantom images were obtained from each camera using a 200 μCi point source of ^{99m}Tc, ^{201}Tl, and ^{67}Ga. Radionuclide photopeak settings were carefully adjusted using the photopeak setting method routinely used in the clinic where the experiment was done. A 20% energy window width for each of the radionuclides was used. Only the two lower energy photopeaks of ^{67}Ga were imaged. The point sources were placed at a minimal distance of five field of view diameters from the crystal. Two floods were taken for those cameras with a uniformity correction device, one with the correction device on and one with it off. Resolution images using the bar phantom were performed with the correction device on. Four quandrant bar phantoms were used and two floods were taken, rotating one 90°. One million counts were collected and the detector orientation remained the same for all uniformity and resolution checks.

RESULTS

A group of 10 observers compared the flood images of each individual camera. No intercamera comparisons were made. The best resolution images for each camera were again determined by the ability of the group to distinguish the bars of the quadrant phantom (example floods and bar phantom images shown in figure 1).

The quality of instrinsic flood field uniformity in response to ^{99m}Tc, ^{201}Tl, and ^{67}Ga varied with each camera. Four of the nine cameras produced comparable floods with all three radionuclides. (Three of the four had good uniformity with all three radionuclides. One of the four had comparably poor uniformity with all three radionuclides.) Three of the remaining cameras gave comparable uniform floods with two of the radionuclides. In each case from this set of three cameras,

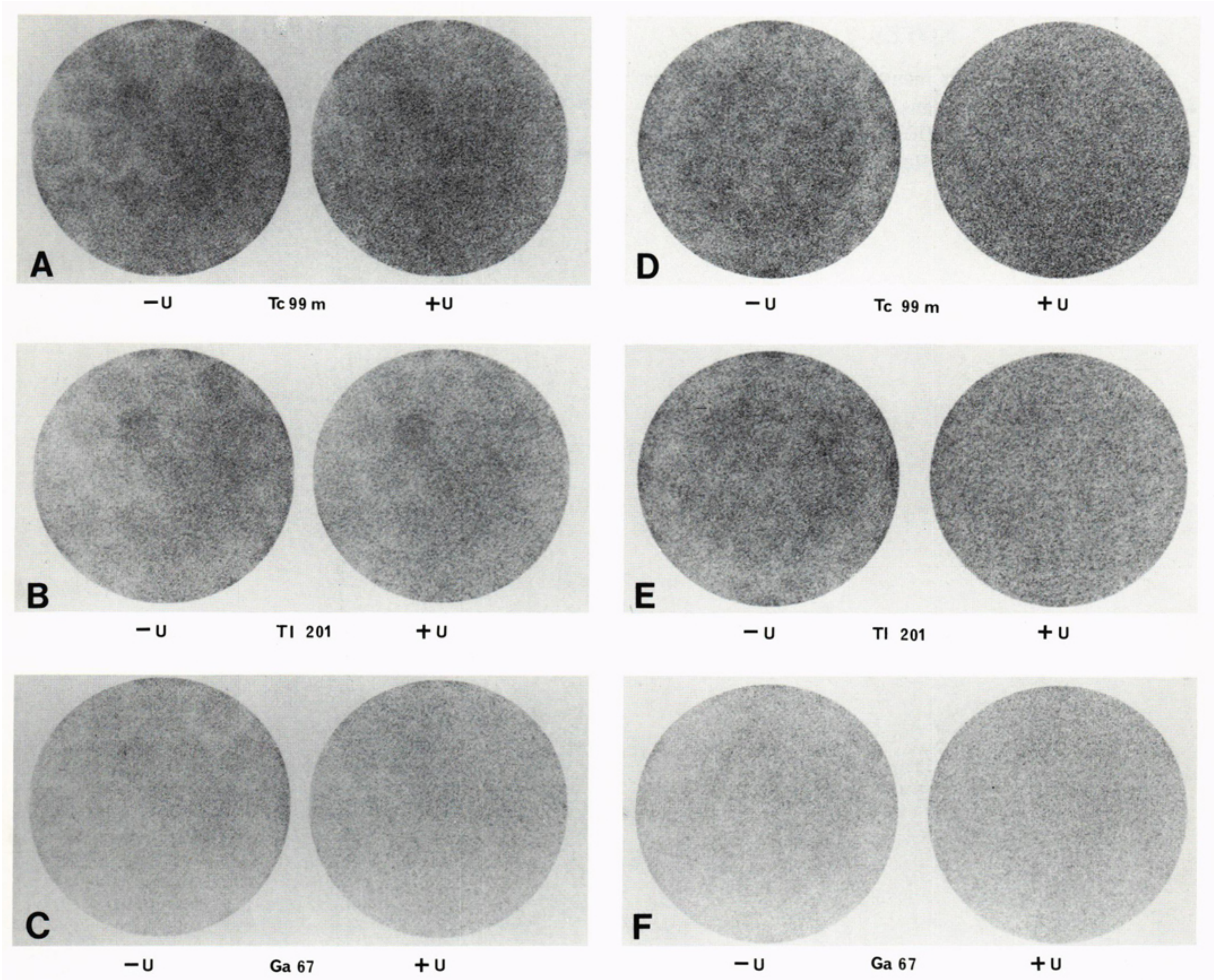

FIG. 2. The images before service (A–C) shown here were obtained as part of the class study and correspond to the results listed in Table 1, camera 4. The camera was consequently serviced to improve uniformity. The flood images (D–F) were obtained after service.

a different radionuclide produced a flood that was nonuniform in comparison. The two remaining cameras produced differences in uniformity with all three radionuclides.

In six of the eight cameras, ^{99m}Tc gave better resolution images than ^{67}Ga or ^{201}Tl. Thallium was cited the most frequently as providing the least distinction among the bars of the resolution phantom. This was an expected finding as ^{201}Tl has the lowest energy photon of the three radionuclides (*2*).

CONCLUSION

The experiment demonstrated that camera performance may vary with different radionuclides. After the experiment, several cameras were serviced to improve the uniformity with selected radionuclides (Fig. 2). The differences in uniformity were attributed to differences in photomultiplier tube gain and coupling grease. Even the same model cameras gave different results in uniformity and resolution. Also, there was no correlation between a camera's resolution and uniformity for a particular radionuclide.

The experiment may provide information to help improve the quality of clinical images. Some hospitals that performed this experiment a year ago found differences in individual camera response to the three radionuclides over a year's time. This experiment is thus not only worthwhile, but should be periodically performed.

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NOTES

*Gamma camera models included Siemens Medical Systems, Inc. (Siemens 75, Siemens ZLC), Des Plaines, IL; General Electric Co. (MAXI 400T, MAXI II), Milwaukee, WI; Raytheon Medical Systems, Rosemont, IL; and Technicare, Inc. (S438), Solon, OH.

REFERENCES

1. Kasulis PW, Hill TC, Lee RG, et al. How does your camera respond to Ga-67, In-111, and Tl-201? (abstr) *J Nucl Med Technol* 1984;12:93–94.

2. Sorenson J, Phelps M. Physics in nuclear medicine; Orlando, FL: Grune & Stratton, 1980:287–288.