Collimator Selection for Ga-67 Imaging with the Anger Camera

Michael L. Caprio, Jr.

Bionucleonics, Inc., Kenilworth, New Jersey

Gallium-67 images have generally suffered from poor quality because of difficulty in properly collimating the multiple photopeaks released by the radionuclide. A comparison of the spatial resolution and septal penetration characteristics of two collimators we currently use for Ga-67 imaging—with a scintillation camera system equipped with single photopeak analyzers— is presented. Results show that the camera performs best when a medium energy collimator is used with the system's photopeak analyzer centered around the 93-keV photopeak of Ga-67.

The widespread popularity of Ga-67 citrate as a clinical agent for both soft tissue tumor localization (*1*) and occult abscess detection (*2, 3*) has created the need for efficient gamma camera imaging. Historically, the Anger camera has not been used extensively for Ga-67 scintigraphy. This is due to poor image quality, probably caused by the improper choice of collimation, as well as the multipeak characteristics of the Ga-67 spectrum.

Improper collimation of multipeak radionuclides results in image degradation, which, in turn, is due to septal penetration by high energy gamma photons when using a collimator with an energy rating that is too low, or unnecessary loss of sensitivity and spatial resolution when a low energy gamma photon interacts with a collimator with an energy rating that is too high. Gallium-67 presents a unique problem in scintigraphy because of its prominent photopeaks—corresponding to photon energies of 93 keV, 184 keV, 296 keV, and 388 keV with relative abundances of 40%, 24%, 22%, and 7%, respectively. Thus, low counting rates and subsequent long imaging times are generally required to use Ga-67 citrate.

Although the recent introduction of scintillation cameras with dual and triple photopeak analyzers has increased the sensitivity of Ga-67 imaging devices, many nuclear medicine departments still rely on scintillation cameras with single photopeak analyzers. For these institutions, the choice of proper photopeak selection is critical. Regardless of the photopeak analyzing capabilities of an Anger camera, the proper choice of collimator is equally important. We evaluated the use of the Anger camera equipped with a single photopeak analyzer for Ga-67 citrate imaging in terms of optimal photopeak and collimator selection.

For reprints contact: Michael L. Caprio, Jr., Health Physicist, Bionucleonics, Inc., 753 Boulevard, Kenilworth, NJ 07033.

Table 1. FWHM* Measurements for Both Low Energy and Medium Energy Collimators

Collimator type	Photopeak	Scattering	No Scattering
Medium energy	93keV	33.4	25.1
	184 keV	34.6	29.1
Low energy	93 keV	> 50	> 50
	184 keV	> 50	>50

*expressed as percent of the photopeak

Materials and Methods

We studied a Picker Dyna Camera 4/12 equipped with a standard single photopeak analyzer. The collimators we selected were the Picker 10,000 parallel hole general purpose low energy collimator, and the Picker 1,700 parallel hole medium energy collimator. These collimators have energy ratings of 44–140 keV and 44–400 keV, respectively.

Gallium-67 spectra were obtained using both collimators; two spectra were recorded for each collimator. One showed the Ga-67 spectrum measured with no scattering medium; the other showed the scattering spectrum for Ga-67 obtained during patient imaging. All spectra were measured using a 15% window and a counting time equal to 1 min.

The indices of resolution used were full width at half maximum (FWHM) to measure the collimator's spatial resolution, and the full width at tenth maximum (FWTM) as an index of septal penetration and Compton scattering within the collimator (*4*). Both the FWHM and the FWTM are expressed as a percentage of photopeak energy.

Results

The FWHM and FWTM measurements are presented respectively in Tables 1 and 2. Table 1 shows that optimal spatial resolution of the system is achieved by using the medium energy collimator, with the photopeak analyzer centered upon the 93-keV photopeak of Ga-67. This table also shows that the use of the low energy collimator with Ga-67 resulted in the most degraded spatial resolution, regardless of photopeak analyzer setting.

Table 2. FWTM *Measurements for Both Low Energy and Medium Energy Collimators

Collimator type	Photopeak	Scattering medium	No Scattering medium
Medium energy	93 keV	8.9	8.9
	184 keV	8.9	13.3
Low energy	93 keV	26.0	11.9
	184 keV	27.9	14.9

*expressed as percent of the photopeak

Table 2 documents that the amount of septal penetration and Compton scatter degradation using the medium energy collimator is equivalent under all clinical situations, no matter what photopeak analyzer settings were used. Table 2 also shows that there is approximately a 200% increase in the amount of septal penetration and Compton scattering produced by using a low energy collimtor for Ga-67 imaging compared to that of a medium energy collimator.

Discussion

It can easily be seen that the collimator of choice for Anger cameras with single photopeak analyzers when imaging Ga-67 is the medium energy collimator. This decision is based upon both the superior spatial resolution achieved, and the resulting septal penetration decrease from the high energy components of the Ga-67 spectrum. These results agree quite closely with those obtained by Garcia et al. (*4*) using the Searle Pho Gamma IV camera. Tables 1 and 2 also show the unacceptability of the low energy collimator for imaging multipeak radionuclides with energies above 140 keV. The septal penetration through the low energy collimator from high energy components of Ga-67 tends to degrade the detector's spatial resolution to a clinically unacceptable level. In our study, a high energy collimator was not included since the energy rating of the medium energy collimator (44–400 keV) can adequately attenuate the high energy photons of Ga-67. The use of a high energy collimator in Ga-67 imaging would result in a loss of sensitivity and spatial resolution (5), as well as increase patient inconvenience.

Data presented in Table 1 show the optimal spatial resolution achieved with the medium energy collimator occurs when the photopeak analyzer is centered over the 93-keV photopeak. Although spatial resolution is decreased by only 1.2% when centered around the 184-keV photopeak, we recommend imaging Ga-67 with the single peak analyzer calibrated around the 93-keV peak. We advise this because the high relative abundance of the 93-keV gamma peak (40%) and the high absorption efficiency of this photopeak (~ 100%) within the camera's crystal (*6*) combine to produce a relative counting rate frequency that is superior to that obtained using the other Ga-67 photopeaks.

These results demonstrate the superiority of the medium energy collimator—used in conjunction with the 93-keV gamma photopeak—when imaging Ga-67 compounds with Anger cameras equipped with only single photopeak analyzers.

Acknowledgment

The author is indebted to John Marquis, MD, and the staff of the nuclear medicine department at East Orange General Hospital for use of the equipment and radiopharmaceuticals needed to acquire data.

References

1. Edwards CL, Hayes RL: Scanning malignant neoplasms with gallium-67. *JAMA* 212: 1182–1190, 1970

2. Blair DC, Carroll M, Carr EA: ^{67}Ga-citrate for scanning experimental staphylococcal abscesses. *J Nucl Med* 14: 99–102, 1973

3. Harvey WC, Podoloff DA, Kopp DT: ^{67}Gallium in 68 consecutive infection searches. *J Nucl Med* 16: 2–4, 1975

4. Garcia EV, Kilanowski E, Miale A: Gallium-67 imaging performance for scintillation camera systems. *Appl Radiology* 7: 125–128, 1978

5. Rollo FD: Quality assurance in nuclear medicine. In *Nuclear Medicine Physics, Instrumentation, and Agents*, Rollo FD, ed, St. Louis, C.V. Mosby Co., 1977, pp 322–360

6. Hoffer PB, Schor R, Ashby D, et al: Comparison of Ga-67 citrate images obtained with rectilinear scanner and large-field anger camera. *J Nucl Med* 18: 538–541, 1977