Using the Gamma Camera for Counting Contamination Survey Wipes

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The gamma camera can be used as a highly sensitive detector for low-level counting. Minimum detectable activities (MDA) of less than 200 dpm for ^{99m}Tc can be achieved using a gamma camera with a collimator. If a nuclear medicine computer is also used, MDAs of less than 100 dpm can be obtained without difficulty.

This work was undertaken to demonstrate that a gamma camera makes a highly sensitive counting device for detecting contamination on routine contamination wipes from ^{99m}Tc sources. While many hospitals have a well counter for wipe counting, those that do not, have a difficult time demonstrating that they can meet the current limits for detecting contamination.

MATERIALS AND METHODS

Technetium-99m sources of ~1.85 MBq (50 μCi) were transferred to small plastic counting vials. These sources were assayed in a radionuclide dose calibrator and allowed to decay until the activity reached ~370 Bq (0.01 μCi). The dose calibrator is checked for accuracy using ^{57}Co, ^{137}Cs and ^{226}Ra sources on a daily basis and is tested for linearity on a quarterly basis.

The sources were then counted on four gamma cameras. The cameras were a two-year-old mobile camera* cardiac field of view (CFOV), an eight-year-old mobile camera† standard field of view (SFOV), an eight-year-old large field of view (LFOV-1) camera‡, and a two-year-old large field of view (LFOV-2) tomographic camera§. Counting times for the calibration sources were two minutes each since the activity of the calibration sources was sufficient to give statistically significant counts in that amount of time. A five-minute background was also obtained on each camera. The choice of five minutes was selected as a reasonable amount of time to count wipes. The mimimal detectable activity (MDA) for each camera depends upon the counting time. The longer the counting time the lower the MDA. All MDAs in this paper are based on a five-minute counting time.

Calibration sources were counted ten times and the counts were corrected for radioactive decay. The apparent half-life for each source at the time it was counted was determined to check for possible contamination with ^{99}Mo.

The sources were counted in two geometries. In the first geometry, the collimator was removed from the camera. The sources were then taped to the aluminum cover over the detector. In the second geometry, the collimator was lowered 5 cm from the camera but not removed. The source was again taped to the detector. Thus the collimator served as a shield to reduce background.

The background and ^{99m}Tc images were acquired on the nuclear medicine computer attached to the gamma camera. A small region of interest (ROI) was drawn around the source on the computer since the ROI reduces the background count rate contribution. This has the effect of reducing the MDA. Counts were recorded from both the background image and the ^{99m}Tc image as counts from the full frame and counts from the ROI. For two of the cameras, the variation in MDA with ROI size was determined. A Chi-square test was done on each data set.

In the case where an ROI was used, the counts in a second ROI whose center was located 10 cm from the center of the first ROI also were determined in order to identify crosstalk between sources.

In each case, the MDA in counts above background, Becquerels (Bq), and disintegrations per minute (dpm) were calculated using the following formulae (*1*):

$$\mathrm{MDA(counts)} = 3\,(C_b)^{1/2}$$

$$\mathrm{MDA(Bq)} = \mathrm{MDA(counts)/Sens}$$

$$\mathrm{MDA(dpm)} = \mathrm{MDA(Bq)} \times 60$$

$$\mathrm{Sens} = C_{Tc\text{-}99m}/A_{Tc\text{-}99m'},$$

where MDA is minimum detectable activity for a fixed counting time, C_b is the background counts, $C_{Tc\text{-}99m}$ is the ^{99m}Tc

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TABLE 1. Minimum Detectable Activity in dpm for a Five-Minute Counting Time

Camera	ROI size (mm)	Full field without collimator	Full field with collimator	ROI without collimator	ROI with collimator
CFOV	100	244	89	122	40
LFOV-1	108	301	82	100	25
LFOV-2	113	356	106	141	38
SFOV	97	483	180	211	71

counts, $A_{Tc\text{-}99m}$ is the ^{99m}Tc activity in Becquerels at the time of counting, and Sens is the sensitivity in counts per Becquerel for the background counting time. These formulae are for counting a source for a fixed period of time (e.g., five minutes in this case). If the background is taken for a time T_b, and the wipe is counted for a time T_w, then the formula for the MDA(counts) becomes:

$$\text{MDA(counts)} = 3\,(C_b\,T_w/T_b)^{1/2}.$$

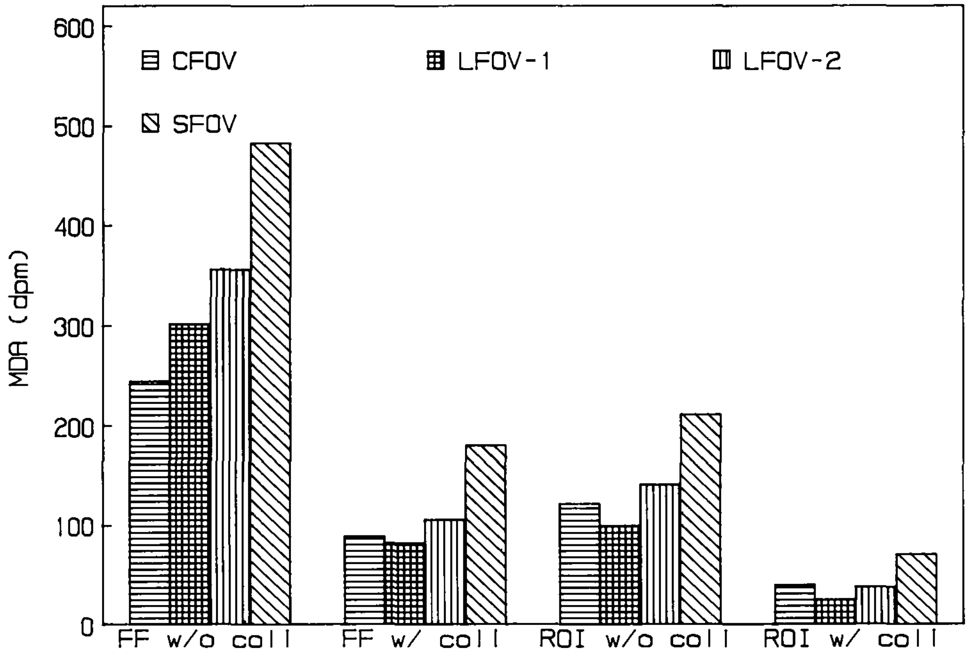

FIG. 1. Minimum detectable activity in dpm for four cameras. MDAs were determined as follows: FF w/o coll—full field without collimator, FF w/ coll—full field with collimator, ROI w/o coll—region of interest without collimator, and ROI w/ coll—region of interest with collimator.

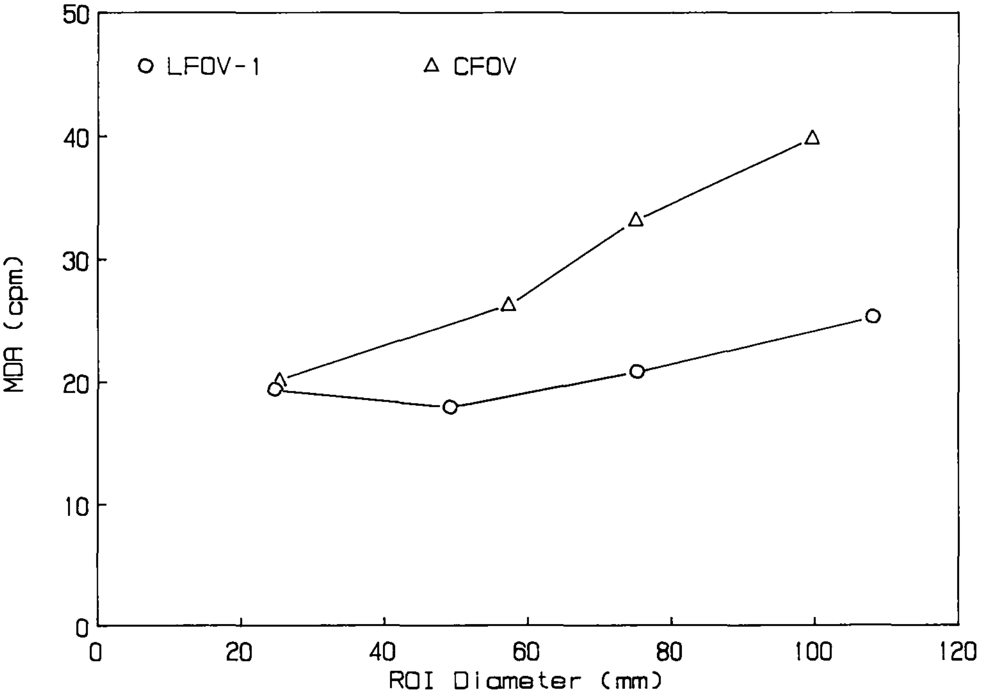

FIG. 2. Variation in minimum detectable activity as the diameter of the ROI is varied.

The formulae for MDA(Bq), MDA(dpm) and Sens would remain unchanged.

The factor of three (3) in the MDA equation represents the number of standard deviations (s.d.) above the background that are considered significant. A higher number would produce a higher MDA; a lower number a smaller MDA but with a higher chance of a statistical "false alarm."

RESULTS

The MDA results are presented in both Table 1 and Figure 1. Figure 2 shows the variation of MDA with changing ROI size. All data sets passed the chi-square test at a sensitivity of 0.05 to 0.95 except those for the LFOV-1 camera. This camera had a Chi-square value of 22 for nine degrees of freedom. The measured half-life for the sources at the time of decay had a mean of 6.01 and a s.d. of 0.3 hr. The crosstalk was always <0.0012. The camera field size, crosstalk values, and sensitivity values for a 100-mm ROI are presented in Table 2.

DISCUSSION

The Nuclear Regulatory Commission (NRC) requires that licensees be able to detect 2,000 dpm on wipes (*2*). The state of South Carolina has proposed that this value be reduced to 200 dpm for its licensees (*3*). Since many smaller nuclear medicine departments do not have well scintillation counters they have difficulty achieving these low MDAs. Data in this paper show that a gamma camera can be used as a very sensitive counter for these wipes.

In practice, the wipes would be placed in sealed plastic bags to insure that the gamma camera does not become contaminated by the wipes. A large group of wipes may be counted at one time by spreading them out on the crystal. If the group as a whole does not show any contamination, the test may be halted. If contamination is found, the sources can be counted separately if the whole-crystal method is used. If computer analysis is used, individual ROIs can be placed around each source.

TABLE 2. Camera Field Size, Sensitivity, and Crosstalk Values

Camera	Field size (mm)	Sensitivity cts/dpm	Crosstalk
CFOV	21	0.21	0.0008
LFOV-1	43	0.21	0.0012
LFOV-2	40	0.20	<0.0005
SFOV	26	0.23	<0.0005

CONCLUSION

Data presented in this paper represent the results from four particular cameras for a specific total count time. The formulae used are equivalent to those in Blue et al. (*4*), unless the background is very small. When this technique is applied to other cameras, the MDA for each camera should be determined separately.

NOTES

[*] Elscint 209, Elscint Inc., Boston, MA
[†] Picker Dyna-Mo, Picker, Inc., Cleveland, OH
[‡] Picker 4-15, Picker Inc., Cleveland, OH
[§] Elscint 409, Elscint Inc., Boston, MA

REFERENCES

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2. CFR 35.70(f).
3. Draft Regulations SC RH 4.8.11.6.
4. Blue PW, Brown PH, Manier SM, Ghaed N. Calculation of minimal detectable activity for scintillation detection systems. *J Nucl Med Technol* 1987;15:5–7.