# Differential Syringe Shield Effectiveness: Direct Comparisons Using SPECT and Planar Imaging

**Paul Logan**

*Department of Nuclear Medicine, Meritus Health Systems, Roanoke, Virginia*

***The use of syringe shields in clinical nuclear medicine has been employed to reduce occupational exposure. However, there is little, current, comparative literature available for the diverse number of products available. I performed single-photon emission computed tomography (SPECT) acquisition on four different shields, and the results were quantitated in order to evaluate the percentage of counts relative to an unshielded source and to the other models tested. All models tested were found to significantly reduce available counts, with the thin-wall shield producing the highest number of counts at the viewing port and the tungsten shield being the least effective overall. I concluded that the intrinsic differences between model design and materials utilized determines the overall efficiency, and that this information is important in light of both the as low as reasonably achievable (ALARA) principle and biological model concepts.***

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The formal adoption of the as low as reasonably achievable (ALARA) principle (*1,2*) in clinical nuclear medicine and the advocation of syringe shield use has reduced occupational exposure (*3*) during the many facets of radiopharmaceutical preparation and administration. When use of syringe shields has been widespread, the shields have reduced such exposure (*4,5*). However, consistent usage of these shields has been low, despite the consensus among technologists that they are effective (*6*). A recent literature search by the author concluded that there are few current studies available on syringe shield effectiveness. In addition, there is no detailed information available, which directly compares the new products now being marketed. I have tested four models to determine individual absolute effectiveness and relative effectiveness.

## MATERIALS AND METHODS

The following 3-cc syringe shields were compared for shielding effectiveness: Gamma Vue Model 56-262 (Nuclear Associates, Carle Place, NY), which incorporates a lead barrel and a high density lead-glass viewport; All Vue Model 56-212 (Nuclear Associates), which incorporates a 50% lead barrel and 50% high density lead-glass viewport; Pro-Tec II Model 007-800 (Biodex Medical Systems, Shirley, NY), which incorporates a tungsten alloy barrel and a high density lead-glass viewport; and Thinwall Shield Model 56-272 (Nuclear Associates), which incorporates a lead barrel and a lead-glass viewport.

Four doses of technetium-99m-pertechnetate ($^{99m}TcO_4^-$) were drawn in 3-cc syringes, each containing 20.2 mCi in a total volume of 1.2 cc/dose. Each dose was assayed using a Capintec 15R dose calibrator (Capintec, Ramsey, NJ), which was tested for accuracy and constancy prior to the study and found to be within normal limits. Each needle was removed and all doses reassayed to insure the integrity of the activity attained. The remaining air was expelled up to the needle hub base and individual syringes were secured in one of the four shields so as not to extend any portion of the dose beyond the shield nose. All doses were then arranged on the imaging table in the spatial configuration illustrated in Figure 1.

Images were then acquired using a Summit Nuclear 1024R gamma camera (Summit Nuclear Systems, Twinsburg, OH),

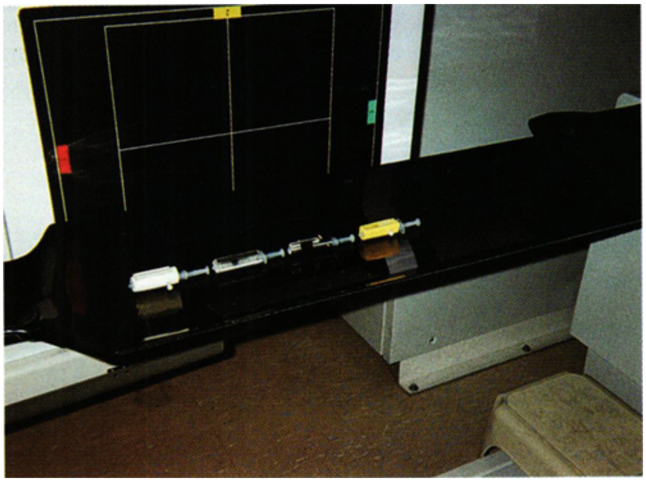

**FIG. 1.** Placement of syringe shields for a trial of SPECT acquisitions.

For reprints contact: Paul Logan, CNMT, Medical Diagnostic Imaging, 3026 Hickory Woods Dr. #88, Roanoke, VA 24012.

**TABLE 1. Statistical Profile of Total and Mean Counts Detected from a 1024 × 1024 pixel ROI in a 360° SPECT Acquisition**

| | Total Counts/Pixel | | Mean Counts/Pixel | | | | |
|---|---|---|---|---|---|---|---|
| Shield Type | $T_x$ | % Shielded | $S_x$ | % Shielded ($A_x$) | Max. Counts/Pixel | Standard Deviation | Variance |
| Gamma Vue | 48006 | 99.39 | 46 | 99.61 | 1130 | 130 | 16900 |
| All Vue | 112049 | 98.58 | 109 | 99.10 | 1774 | 271 | 73441 |
| Pro-Tec II | 346537 | 95.62 | 338 | 97.11 | 7001 | 972 | 944784 |
| Thinwall | 309008 | 96.10 | 301 | 97.43 | 10448 | 1221 | 1490841 |
| Unshielded | 7905656 | N/A | 11694 | N/A | 152911 | 28507 | 812649049 |

which had been checked for uniformity and linearity and undergone a center of rotation (COR) determination. The camera was outfitted with a low energy general purpose collimator and rotated to −180°. Three clockwise circular orbit SPECT acquisitions were then obtained using a 128 × 128 matrix, a symmetric photopeak centered at 140 keV with a 20% window, and no magnification. Next, 64 frames were acquired at 5 sec/stop with the collimator face 21 cm from the rotational center. These acquisition parameters were repeated and 64 frames were acquired with an unshielded syringe containing 20.2 mCi of pertechnetate in a total volume of 1.2 cc.

Planar images were also acquired using the same syringe and computer parameters. Individual syringes were placed on the low energy general purpose collimator and 5-sec acquisitions were obtained. Each syringe was rotated −180°, hiding the viewport from the detector head, and the acquisition was repeated.

## RESULTS

The absolute effectiveness ($A_x$) is given by the formula:

$$A_x = \frac{U_1}{S_x},$$

where $S_x$ is the shielded mean counts and $U_1$ is the unshielded mean counts detected in a 1024 × 1024-pixel region of interest (ROI). The calculated effectiveness for each syringe is shown in Table 1.

The relative effectiveness ($R_x$) is given by the formula:

$$R_x = \frac{T_{max}}{T_x},$$

where $T_{max}$ is the highest number of counts detected and $T_x$ is the total counts detected in the 1024-pixel ROI. The calculated relative effectiveness for each of the shields is shown in Table 2.

In addition to the quantitative assessments made, qualitative activity curves were generated for Frames 1 through 64. A 1024 × 1024-pixel ROI was drawn for each syringe on a summed image of all 64 frames. These curves are illustrated in Figure 2. At Frame 1, the detector was positioned at −180°; the position exposing no viewport. At Frame 32, the detector was positioned at 0°, facing the viewport of each syringe. Planar acquisitions yielded the number of counts with the collimator facing each viewport (0°) and at −180°. These values are shown in Table 3.

## DISCUSSION

The SPECT data in Table 2 support the conclusion that the Gamma-Vue shield is, overall, the most effective model tested. The All-Vue shield is the second most effective, while the Thinwall shield and the Pro-Tec II are third and fourth, respectively. The planar data in Table 3 validate this conclusion with the noted exception that the Gamma Vue displayed a slightly higher than expected count at −180°.

Much information can be gleaned from the distribution of counts found in the activity curves (Fig. 2). Note the dual peaks detected at Frames 30 and 37 for the Gamma-Vue and at Frames 26 and 40 for the Pro-Tec II. Upon examining both models, I determined that these peaks were due to the lack of shielding that was found when the detector head was facing the angles displayed in Figure 3. In contrast, the Thinwall shield exhibited a single peak of activity. Also note in Figure 2 the more uniform distribution of activity for the All-Vue, which can be attributed to a more uniform shield design. These cross sections are depicted in Figure 4.

It follows that greater exposure will occur near the viewing port where visibility and shielding are inversely related. However, exposure still occurs around the circumference of the shield, the amount detected being a function of thickness

**TABLE 2. Relative Effectiveness for Each Syringe Using Total Counts**

| Shield Type | Relative Effectiveness |
|---|---|
| Gamma Vue | 7.21 |
| All Vue | 3.09 |
| Pro-Tec II | 1.00 |
| Thinwall | 1.12 |

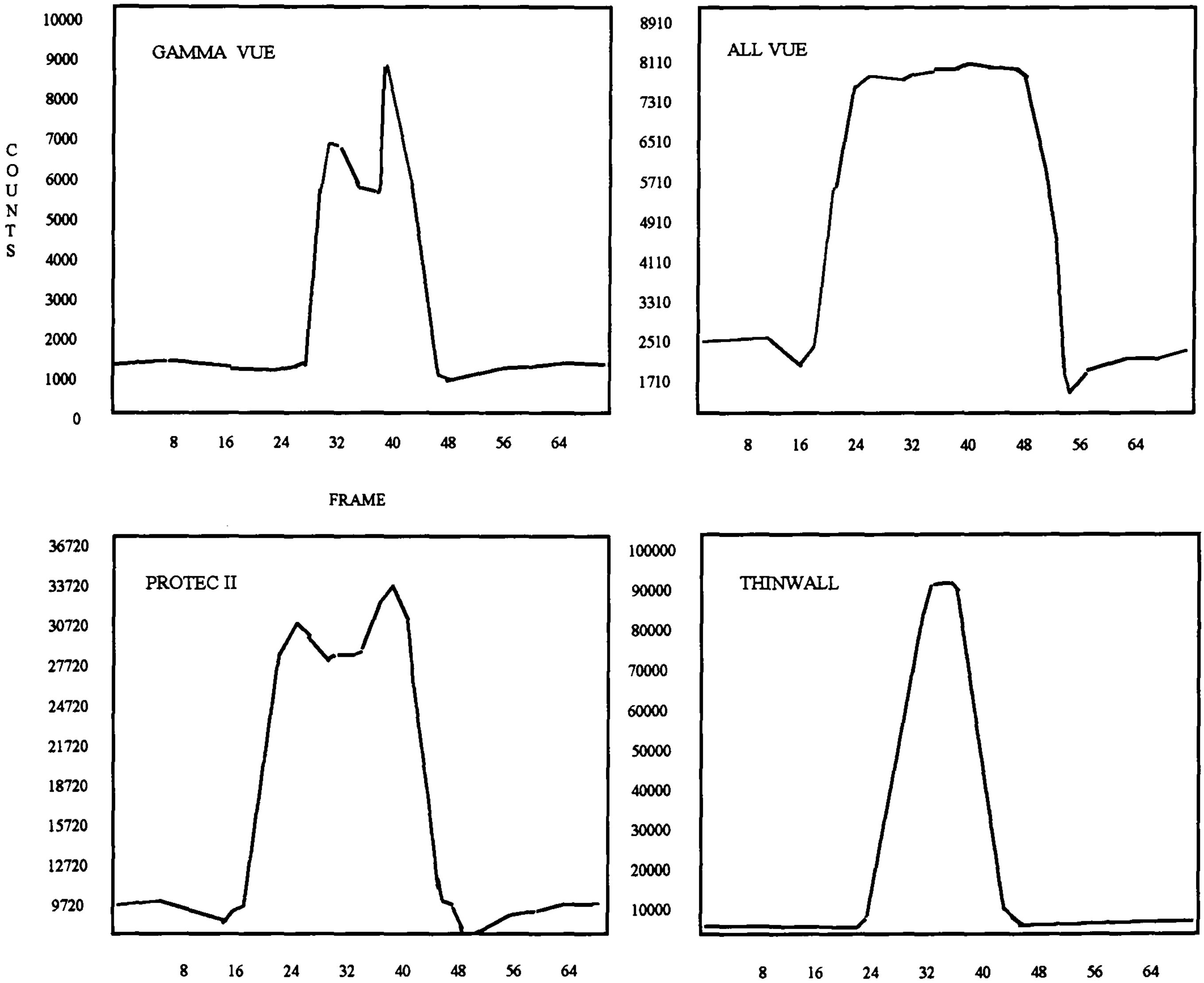


**FIG. 2.** Activity curves illustrating total counts/frame for each shield during a 360° SPECT acquisition.

and choice of materials. A detailed analysis of the activity curves in Figure 2 reveals the differential levels of activity along the circumference of each syringe. Also note the signal attenuation that occurs at roughly Frames 8 through 20 and 46 through 58 for each shield, as a result of the imaging couch being in a direct line between the sources and the detector.

As indicated in Figure 2 and the planar data in Table 3, the Thinwall shield exhibited the highest number of viewport counts at Frame 32. This was due to the relatively thin glass used during construction as well as the larger viewing surface (see Fig. 4). The Tungsten Pro-Tec II displayed less

**TABLE 3. Counts Detected from Planar Acquisition of Each Syringe Shield at 0° and 180°**

| | Total Counts | | Max./Pixel | |
|---|---|---|---|---|
| Shield Type | −180° | 0° | −180° | 0° |
| Gamma Vue | 123123 | 15152 | 2513 | 2612 |
| All Vue | 9004 | 17367 | 2251 | 2730 |
| Pro-Tec II | 15704 | 34543 | 2293 | 2414 |
| Thinwall | 11697 | 99469 | 2941 | 9279 |

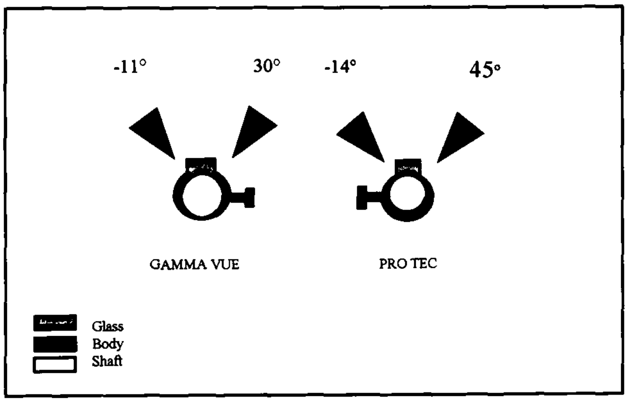


**FIG. 3.** Gamma Vue and Pro-Tec II shield cross sections revealing areas of thin shielding (indicated by the arrows) and their corresponding detector angles, which detected higher counts.

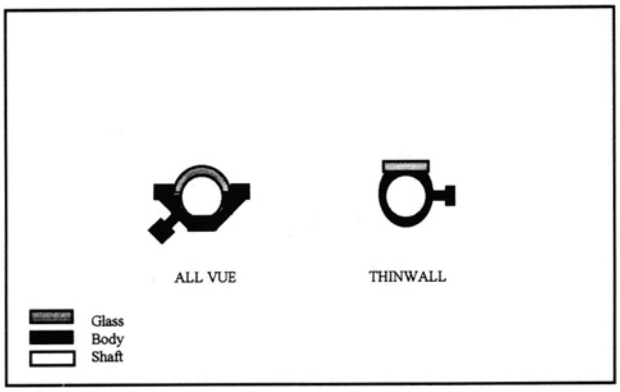


**FIG. 4.** All Vue and Thinwall shield cross sections denoting uniform shielding design.

viewport activity than the Thinwall shield; however, it had the highest number of counts detected along the remaining circumference.

## CONCLUSION

Since this study was a pilot study, the conclusions drawn are only pertinent to the models tested and I acknowledge the need for further experimentation encompassing other models (e.g., Viox model 320, 3-cc, 360°, lead glass, cylindrical body, Viox Corporation, Seattle, WA). In addition, other variables such as differential activities, isotopes, and volumes need assessment.

While a survey by Burr (*5*) indicated that the tungsten and thinwall designs are the most frequently used, my study has determined that these designs are the least effective. The Burr study cited bulk, fragility, and cost as determinants in shield selection. Certainly other factors such as injection facilitation and durability are important when evaluating an optimum shield; these variables were not assessed and remain beyond the scope of this study. Clearly, they are important and deserve further study and attention.

In keeping with the ALARA principle, a responsible program fosters syringe shield use regardless of the additional burden to the technologist; and these burdens are minor in comparison to the alternative.

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