Minimizing Occupational and Patient Radiation Exposure Using an Optimized Injection Technique

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In an attempt to lower whole-body and hand radiation exposure to the technologist and decrease the number of infiltrated doses, our laboratory instituted a "cold start" method for radionuclide injections. We then compared the radiation dosimetry readings for a period before and after instituting the method. The finger ring exposures and whole-body exposures were compared. The exposure to the technologist's hands was reduced by 56% and to the technologist's body by 28%. Detectable extravasation of the dose was reduced from 64% to 9%. We recommend the use of this technique for all nuclear medicine departments.

An important objective in a nuclear medicine department is to maintain occupational and patient radiation exposure as low as reasonably achievable (ALARA) (1). Because radiation exposure carries some risk, all unnecessary exposure should be avoided. Nuclear medicine personnel should be aware of their radiation exposures and constantly strive to reduce exposure not only to themselves, but also to their patients.

Exposure to the technologist occurs during the following three activities: 1) dose preparation and assay; 2) dose administration; and 3) imaging (2). During any of these three activities, good radiation safety practices will minimize exposure. Hand exposure occurs during dose preparation and administration, whereas most whole-body exposure occurs during imaging. When holding the radioactive syringe, the exposure rate to the hand and fingers directly over the portion containing the radionuclide can be as much as 22,000 mR/hr for 20 mCi of technetium-99m (99mTc) (2). Use of a syringe shield can reduce this to 200–300 mR/hr.

Unnecessary exposure to the patient occurs if the dose is partially, or totally, extravasated. We calculated that an infiltrated injection of 5 mCi 99mTc sulfur colloid can deliver approximately 226 rads to the antecubital fossa. An additional reinjected dose causes further exposure to both the patient and the technologist.

In an effort to reduce hand exposure further, we instituted a method of injection called the cold start technique in July, 1981. Our goal was to ascertain significantly reduced hand radiation to the technologist and verify a decrease in dose extravasation in the patient.

MATERIALS AND METHODS

The cold start technique requires the following equipment (Fig. 1): a butterfly infusion set with 12-in. tubing, a three-way disposable stopcock, and a flush syringe containing 3 cc normal saline. The saline syringe is connected to the straight-through port of the stopcock. Using a standard venipuncture technique the butterfly needle is placed in the patient's vein. Blood return in the tubing verifies proper venous access and

FIG. 1. Equipment required for the cold start technique: butterfly infusion set with 12-in. tubing, three-way disposable stopcock, and flush syringe containing 3 cc normal saline.

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a small amount of saline is injected to ascertain that there is no extravasation. Using disposable gloves, the technologist attaches the shielded syringe containing the radiopharmaceutical to the side port of the three-way stopcock and injects the radiopharmaceutical into the patient. The remaining saline is used to flush the radiopharmaceutical syringe and to clear the line. The intravenous line is then removed and the entire assembly is properly disposed of as radioactive waste.

In an effort to evaluate the efficacy of the added expense and time, a study was undertaken to assess the effect of this technique on radiation exposure to the technologist and the patient. The technologist’s finger ring and whole-body badge exposures for the 8-mo period before institution of the cold start technique were compared to those for the same calendar months of the year after the institution of the technique.

The total number of studies per month and the average dose per study were determined using the dose log book and calculating the average doses of 99mTc and gallium-67 (67Ga) for the months of September, October, and November, 1980. Results of these 3 mo were averaged and found to be 15.5 mCi per study, which was used for the pre-cold start technique calculations. Similarly, the months of September, October, and November 1981 were averaged and the average dose per study was 17 mCi for the cold start technique. The total number of milliCuries injected was calculated from these figures. Eleven technologists were surveyed for ring finger and whole-body exposures. The mR/mCi exposure was tallied for each month before and after institution of the cold start technique.

Consecutive whole-body bone scans done in October 1980 and October 1981 were rated by two observers for dose extravasation according to the following scale: 0, no infiltration noted; 1, slight infiltration, < 1 cm; 2, moderate infiltration, 1–5 cm; 3, extensive infiltration, > 5 cm. In October 1980 a total of 40 scans were evaluated, and a total of 69 scans were evaluated for October 1981.

### RESULTS

The dosimetry readings for the pre- and post-cold start technique are shown in Table 1. The whole-body readings and finger ring readings were both reduced after the institution of the cold start technique. The whole-body readings decreased from 0.0430 mR/mCi to 0.0320 mR/mCi, a decrease of 28%, although not statistically significant. The finger ring readings decreased from 0.549 mR/mCi to 0.243 mR/mCi, a 56% reduction, highly significant (P < 0.001). The dose extravasation evaluations in bone scans are shown in Table 2. These dropped from 64% to 9% (P < 0.02).

### DISCUSSION

Although it reduces radiation exposure, the institution of the cold start method does present several problems. The first is the cost of the extra supplies necessary for this technique, which is less than two dollars per injection. This is a small price to pay for the exposure reduction to technologist and patient. Because of the extra volume of trash generated, we instituted a system for separating the 99mTc trash from the other longer half-life trash, similar to a system used by Maguire et al. (3). We hold the short-life trash for decay to background and then it is discarded and burned. The extra time involved has become minimal with practice, and it is actually easier for students to learn the injection technique.

As the use of SPECT equipment becomes more widespread, the prevention of extravasation becomes vital to a properly performed exam.
We have documented a reduction in radiation exposure to the technologist's hands and reduced dose extravasation in patients. Based on our experience we believe that the cold start technique should be as routine as the use of a syringe shield.

REFERENCES

