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 (^{99m}Tc) (*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 ^{99m}Tc 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

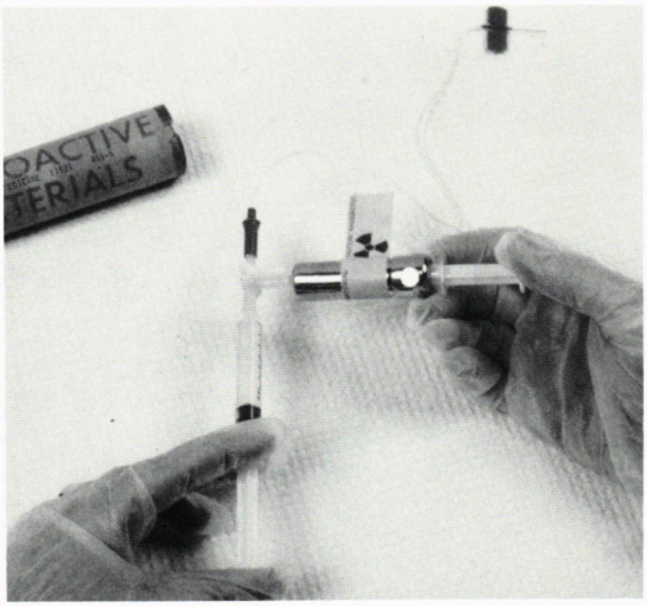

FIG. 1. Equipment required for the cold start technique: butterfly infusion set with 12-in. tubing, three-way disposable stopcock, and flush syringe containing 3 cc normal saline.

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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 ^{99m}Tc and gallium-67 (^{67}Ga) 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.

TABLE 1. Dosimetry Readings Before and After Use of the Cold Start Technique

	Total studies	Total mCi	Whole-body readings mR	Whole-body readings mR/mCi	Ring readings mR	Ring readings mR/mCi
Pre-cold start						
Sept 80	322	5152	220	0.0427	3150	0.611
Oct 80	379	6064	85	0.0140	3720	0.613
Nov 80	267	4272	150	0.0351	5500	1.29
Dec 80	299	4635	400	0.0863	1240	0.267
Jan 81	296	4588	275	0.0599	2220	0.484
Feb 81	315	4883	145	0.0297	1520	0.311
March 81	265	4108	135	0.0328	1510	0.367
April 81	278	4309	245	0.0569	1950	0.452
Average	303	4751	207	0.0430	2601	0.549
Post-cold start						
Sept 81	281	4777	270	0.0565	1220	0.255
Oct 81	289	4913	120	0.0244	1220	0.248
Nov 81	277	4709	130	0.0276	1450	0.308
Dec 81	301	5117	60	0.0117	1030	0.201
Jan 82	236	4012	320	0.0797	1030	0.257
Feb 82	219	3723	60	0.0161	740	0.199
March 82	282	4794	125	0.0261	1250	0.261
April 82	243	4131	60	0.0145	930	0.225
Average	266	4522	143	0.0320	1109	0.243
Change (%)				28		56
P (unpaired t-test)				NS*		< 0.02

*Not significant.

TABLE 2. Infiltration of Bone Scan Injections*

Pre-cold start (Cases: 40) Rating	No. of scans	Percent	Post-cold start (Cases: 69) Rating	No. of scans	Percent
None	15	37	None	63	91
Slight	9	23	Slight	6	9
Moderate	9	23	Moderate	0	0
Extensive	7	18	Extensive	0	0
Percent of infiltrated doses		64			9

*$P < 0.001$ (Chi-square test).

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 ^{99m}Tc 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

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