Microwave versus Recon-o-Stat™ for Preparation of Technetium-99m-Sestamibi: A Comparison of Hand Exposure, Radiochemical Purity and Image Quality

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Objective: Multiple methods of preparing ^{99m}Tc Cardiolite® are routinely utilized. The most recent method available is the Recon-o-Stat™ which employs heat-pump technology. The Recon-o-Stat was compared to the microwave method with respect to the radiation dose to the preparer, radiochemical purity and the quality of myocardial perfusion images.

Methods: Twenty-five Cardiolite vials were prepared by each method. Thermoluminescent dosimeter ring badges were worn to determine extremity radiation dose during preparation. Radiochemical purity was performed immediately and when possible at 24 hr. Selected images were reviewed for quality in a randomized, blinded fashion by two board certified nuclear medicine physicians.

Results: Use of the Recon-o-Stat resulted in a 60% reduction in radiation dose to the preparer. The immediate Recon-o-Stat radiochemical purity was consistently above 90% but significantly lower than the microwave radiochemical purity. The 24-hr Recon-o-Stat radiochemical purity was occasionally <90% and significantly lower than the 24-hr microwave radiochemical purity. There was no difference in image quality between the highest microwave and the lowest Recon-o-Stat radiochemical purity preparations.

Conclusion: The Recon-o-Stat method can significantly reduce the annual extremity exposure to the preparer of Cardiolite without adversely affecting the image quality.

Key Words: technetium-99m-sestamibi; microwave; Recon-o-Stat™; radiochemical purity; hand exposure; image quality

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Technetium-99m-sestamibi has gained widespread clinical acceptance as a versatile diagnostic radiopharmaceutical. However, in its current primary role as an alternative agent for ^{201}Tl there has been concern over the increased occupational radiation dose associated with its use (*1*). Since ^{201}Tl requires no on-site preparation by the nuclear pharmacy staff, other than transfer to a syringe, the radiation dose associated with ^{99m}Tc-sestamibi preparation can represent a significant increase over levels with the use of ^{201}Tl. Additionally, recent reports of vial breakage that occurred during the preparation of sestamibi (*2*) have prompted the Nuclear Regulatory Commission to issue an informational notice to alert users of the potential problem and of their radiation control responsibilities (*3*).

Currently there are four methods utilized to heat ^{99m}Tc Cardiolite® (Du Pont Pharma, Billerica, MA): boiling water bath, microwave, heating block and, most recently, the Recon-o-Stat™ (Du Pont Pharma, Billerica, MA) (Figure 1). The functional component of the Recon-o-Stat thermal controller is a high-performance Peltier-effect heat pump. When used according to directions with its tungsten vial shield, which is specially designed for the heat pump effect, both heating and cooling of ^{99m}Tc-sestamibi occur in one integrated operation over a 10-min period. Most importantly, the vial remains shielded at all times.

The purpose of this study was to measure the radiation exposure to the hands of the preparer from both the microwave and Recon-o-Stat methods, compare the radiochemical purity (RCP) of the product from both methods and evaluate image quality of best-case microwave RCP and worst-case Recon-o-Stat RCP.

MATERIALS AND METHODS

Preparation of ^{99m}Tc-Sestamibi

General: Fifty kits were prepared by either the microwave or Recon-o-Stat method. The initial elution of the ^{99}Mo/^{99m}Tc generator was avoided with one exception. To expedite data collection for this study and obtain reliable hand exposure measurements, each kit was prepared with substantially more ^{99m}Tc pertechnetate (22.2 GBq (600 mCi)) than is routinely used. A leaded glass syringe shield (Viox Corp., Seattle, WA) was used during kit reconstitution. The volume of pertechnetate used during the heating step was 3 ml. Prior to the heating step, each vial was evacuated twice using a 20-ml syringe. After cooling, the final kit volume was adjusted to 6 ml with 0.9% sodium chloride for injection, U.S.P. All vial transfers were done using a 30.5-cm remote handling tool. Vials and syringes

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FIGURE 1. Recon-o-Stat thermal controller for the preparation of ^{99m}Tc Cardiolite and specially constructed tungsten vial shield shown in its operational position mounted on the base.

were manipulated with the right hand. All kits were prepared by the same individual.

Microwave Method: A standard ^{99m}Tc vial shield fitted with an appropriate sized spacer was used instead of the Cardiolite shield by personal preference. The microwave (Model #JE48A005, 500 watt/0.4 ft^3, General Electric, Louisville, KY) was placed inside a fume hood behind a standard sized (14 in × 14 in base) table-top shield. The top and sides of the microwave and the inside surface of the fume hood were shielded by ⅛ in lead. The microwave was preset for 13 sec on the highest setting.

The reconstituted/evacuated vial was transferred from the vial shield to an open, clear polypropylene container which was 7.6 cm high and 11.4 cm in diameter. A small styrofoam block was placed over the aluminum vial cap using the left hand. The container was carefully placed in the microwave and the door closed with the right hand. After the start button was pushed, the preparer retreated to a distance of approximately 2 m directly in front of the shield.

At the conclusion of the heating cycle the container was removed with the right hand. The styrofoam cap was removed and the vial transferred back to the shield using the remote handling tool. The volume was adjusted to 6 ml after allowing 5 min for cooling.

TABLE 1
Operation of the Recon-o-Stat Thermal Controller

1.	Press on switch (unit initiates self-test).
2.	If self-test fails, record error message and proceed to troubleshooting guide.
3.	If self-test passes, RUN RECON-O-STAT? is displayed.
4.	Vigorously shake Cardiolite vial inside Recon-o-Stat shield using 5–10 quick upward-downward motions.
5.	Place shield on sample block, assuring good contact by pressing downward gently and turning ¼ turn.
6.	Press proceed key. Recon-o-Stat timer is displayed and begins 10-minute cycle.
7.	When thermal control unit beeps, cycle is complete. RECON-O-STAT COMPLETE is displayed.
8.	Remove shield from sample block.
9.	Allow thermal control unit to run for 1 min to cool, then press off switch.

Recon-o-Stat method: The tungsten vial shield which is supplied with the Recon-o-Stat device was used. The standard procedure which was followed is outlined in Table 1.

The volume was adjusted to 6 ml approximately 1 min after removing the Recon-o-Stat shield from the thermal control unit.

Extremity Monitoring

A separate pair of thermoluminescent dosimeters (TLDs) was worn on the palmar portion of each index finger. The TLDs were worn from the time the vial was placed into the vial shield until the final volume adjustment of the kit. The same pair was worn 25 times for each method. When not in use, the TLDs were stored with a control in a lead shield in an office outside the nuclear medicine department.

Quality Control

Quality control was performed immediately postpreparation and 24 hr later when possible. A Sep-Pak® Light Alumina-N cartridge (#23561, Millipore Corp., Bedford, MA) was conditioned with 5 ml of absolute ethanol. A small sample of ^{99m}Tc-sestamibi between 7.4–18.5 MBq (200–500 μCi) was loaded at the head of the cartridge. Ten ml of absolute ethanol was slowly passed through the cartridge, and collected in a 15-ml test tube. The cartridge (C) which retains unbound pertechnetate and tube (T) which contains ^{99m}Tc-sestamibi were measured in a dose calibrator. RCP was calculated as RCP% = T × 100/(C + T).

Clinical Evaluation

Fifteen patient studies from the lowest Recon-o-Stat RCPs recorded and 16 from the highest microwave RCPs were randomly selected. Two board certified nuclear medicine physicians, experienced in nuclear cardiology image interpretation, independently reviewed the images without knowledge of the preparation method. Image quality with emphasis on target-to-background contrast was graded as 1, 2 or 3, representing inadequate, adequate or excellent image quality, respectively.

TABLE 2
Comparison of Radiochemical Purity (%) of ^{99m}Tc-Sestamibi Kits Prepared by Recon-o-Stat or Microwave Methods

Recon-o-Stat		Microwave	
Immediate (n = 25)	24 hr (n = 16)	Immediate (n = 25)	24 hr (n = 10)
96.1		97.9	
93.8		97.4	
82.5#		99.3	
95.5	93.2	98.7	
94.7	92.8	95.6	
98.6		98.5	
94.4	93.4	98.5	
93.9	94.0	96.4	
90.6*		96.5	
95.2	93.2	97.2	
94.7		98.6	96.9
95.1	95.0	97.8	96.7
94.2	95.2	98.6	
92.3		98.3	
91.6	86.9	95.0	
94.5	94.6	98.9	97.0
93.3		97.6	98.5
91.7	87.8	96.2	98.1
93.5	94.9	94.3	94.6
90.6*	89.9	98.6	97.7
96.5	95.6	93.2	
96.1	92.4	99.5*	
96.3	93.3	98.2	97.3
96.2		98.8*	98.1
93.7	90.0	98.5	98.1
Mean 94.3†	92.6§	97.5†	97.3§
s.d. 1.96	2.64	1.62	1.13

#Monday generator first elution product discarded and RCP value not included in statistical analysis.

*Preparations used for image evaluation.

†p = 0.0001 by Student's t-test.

§p = 0.0001 by Welch's t-test.

All demographic data was available so that patient-specific variables which may affect image quality were taken into consideration.

RESULTS

Both the immediate and the 24-hour Recon-o-Stat RCP results were significantly different from the corresponding values obtained with the microwave method (Table 2). One Recon-o-Stat kit was prepared by necessity with the initial elution of a 83.3 GBq (2250 mCi) generator. The resultant 82.5% RCP supports the generally accepted practice of avoiding the use of initial eluates. This kit was discarded and the RCP value was not included in the statistical analysis.

TABLE 3
Comparison of TLD Finger Exposure by Recon-o-Stat and Microwave Methods*

Finger	Microwave mSv (mrem)	Recon-o-Stat mSv (mrem)	Reduction
Left	4.5 (450)	1.9 (190)	57.8%
Right	3.9 (390)	1.5 (150)	61.5%

*25 kits and 555 GBq (15.0 Ci) total activity for each method.

TABLE 4
Comparison of Image Quality Assessment for Recon-o-Stat and Microwave Methods

	Recon-o-Stat	Microwave
Number of patient studies	15	16
Excellent by both evaluators	3	0
Excellent by one evaluator	6	9
Average patient age (yr)	60.5	59.8
Patient age range (yr)	42–82	42–85
Number of males	6	10
Number of females	9	6
Number of obese males	2	1
Number of obese females	2	1
Average image quality score*	2.4	2.3

*Scoring: 1 = Inadequate; 2 = Adequate; 3 = Excellent.

The TLD finger exposure results are shown in Table 3. A significant reduction of approximately 60% was realized with the Recon-o-Stat method.

Table 4 depicts the results of the image quality assessment. None of the 31 image sets (16 microwave and 15 Recon-o-Stat) evaluated were judged inadequate. Overall image quality scores were virtually identical at 2.4 and 2.3 for Recon-o-Stat and microwave, respectively.

CONCLUSIONS

The Recon-o-Stat method significantly reduced the occupational radiation dose when preparing ^{99m}Tc-sestamibi. Although RCP is consistently lower with the Recon-o-Stat, >90% RCP is routinely achieved and image quality is not compromised. An additional benefit may be a reduced potential for vial breakage during preparation resulting from a less intense physical abuse of the vial when compared with the microwave.

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