Comparison of Weekly and Biweekly Generator Systems With Respect to Radiation Safety*

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As a result of the rise in radiation exposure to operators of high-activity generators, we examined an alternative to the traditional single weekly generator. A system consisting of twice weekly delivery of two small generators was evaluated. Technetium-99m yields from this system were comparable to the single weekly system and radiation exposure to operators was lower. We found that the difference in operator exposure level was due primarily to physical construction of the generators rather than to weekly or biweekly delivery.

Nuclear medicine laboratories have traditionally obtained their ^{99m}Tc through the use of a single ^{99}Mo generator delivered weekly *(1)*. Such a generator is usually delivered early Monday and contains sufficient ^{99}Mo to guarantee an adequate supply of ^{99m}Tc throughout the week. The extensive use of ^{99m}Tc as a labeling agent as well as the increased demand for nuclear medicine services has created a need for weekly generators of higher and higher levels of activity *(2)*. Generally, larger generators mean increased radiation exposure to the individuals responsible for elution. For this reason, we decided to look at a system utilizing a biweekly delivery of two less active generators and compare this system with the traditional single weekly delivery approach.

Materials and Methods

We compared a 400-mCi generator delivered on Monday (calibrated for Friday) with a biweekly system consisting of a 300-mCi generator delivered on Monday (calibrated for Thursday) and a 100-mCi generator delivered on Wednesday (calibrated for the following Monday).

Before examining the radiation exposure associated with using the two systems, it was necessary to determine whether the biweekly system could supply adequate ^{99m}Tc to meet department needs throughout the week. Since a single 400-mCi generator had been found through experience to be adequate, a comparison of the two systems was in order. Figure 1 shows the ^{99m}Tc yields of the two systems over a five-day period. The curve representing yield from the 400-mCi generator exhibits the familiar pattern of exponential decay, with high levels of activity early in the week necessary to insure sufficient ^{99m}Tc on Friday. The biweekly curve also exhibits exponential decay, but in two phases. The first phase (Monday–Tuesday) ends with the delivery of the second generator early Wednesday. Because this generator is calibrated at 100 mCi for the following Monday, it contains over 300 mCi of ^{99}Mo when delivered. Consequently, the second phase of the graph is initiated with a substantial boost in available ^{99m}Tc for the rest of the week. Since problems with insufficient yield are usually found late in the week, and the dual system is stronger than the single at that time, it was determined the dual generator system would deliver adequate ^{99m}Tc to meet department needs.

We then proceeded to compare radiation exposure to operators of the two systems. Measurements of radiation exposure were made during situations felt to be typical of those an operator might encounter during the daily elution process. They were made using a "cutie pie" type ionization chamber, calibrated to read in milliroentgens. Because of the one-to-one equivalency of roentgens to rem for gamma rays, ion chamber readings were felt to accurately measure dose rate *(3)*.

Three sets of measurements were taken with the ionization chamber. First, the shipping containers for all generators were monitored before unpacking for initial use. Next, the generator under examination was assembled according to manufacturer's instructions. In all cases generators were placed in the manufacturer-supplied auxiliary shield and skirted by lead bricks as shown in Fig. 2. Each of the two types of auxiliary shields has a removable "door" to allow access to elution ports. With this door open, a second set of ion chamber measurements was taken directly in front of the generator (Fig. 2). This configuration is felt to be typical of where an operator might stand while preparing to elute.

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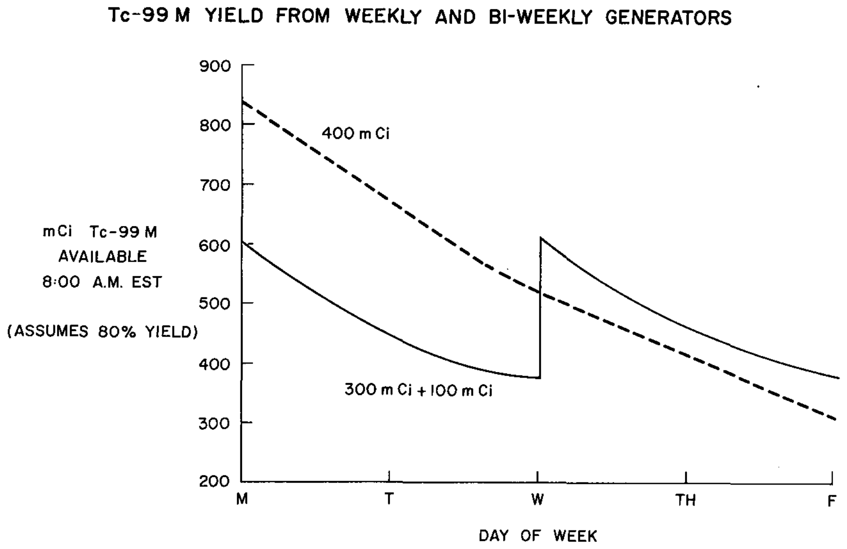

FIG. 1. ^{99m}Tc activity available Monday through Friday from weekly (broken line) and biweekly (solid line) generator systems.

The final set of ion chamber measurements was taken while starting the elution process itself. Both systems require that the operator be within arm's reach of the generator to initiate elution. Measurements were taken at a representative spot in front and to the side of the generators (Fig. 2).

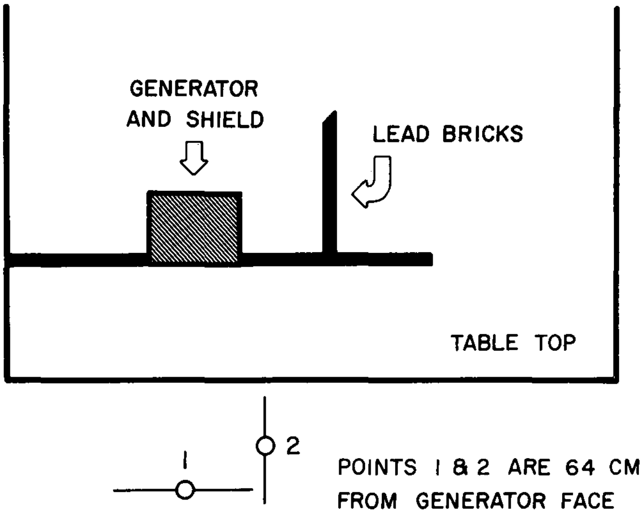

FIG. 2. Placement of generator and shielding during ionization chamber measurements taken at points 1 and 2.

Results and Conclusions

Table 1 summarizes the results found with the ionization chamber. The first set of measurements shows that radiation levels at the surface of the shipping containers are about equivalent if the single generator is compared with the sum of the two generators. The second set of measurements, taken in front of the generator, shows a greater difference early in the week. The third set of measurements, made during the elution process, shows a striking difference in exposure for the person performing the elution. The single 400-mCi generator used in this experiment produced a dose almost 50 times greater than the summation of the 300- and 100-mCi generators.

Paralleling the dose rate measurements of the ion chamber were measurements of integrated radiation dose using body film badges and TLD (thermoluminescent dosimeter) rings. Two sets of badges and rings were used. The first set was worn during a typical week's elution of the single generator system. The second set was

TABLE 1. Measurement of Gamma Emissions from Weekly and Biweekly Generators

	Day 1 (mR)		Day 2 (mR)		Day 3 (mR)			Day 4 (mR)			Day 5 (mR)		
	A*	B†	A*	B†	A*	B†	C‡	A*	B†	C‡	A*	B†	C‡
Box surface before unpacking	20	11					10						
Point 1 (Fig. 2) with shield "door" 14 open	14	1	8	1	4	1	1	2	1	1	2	1	1
Point 2 (Fig. 2) while eluting	50	1	50	1	48	1	2	50	1	1	50	1	1

**400-mCi generator (calibrated for day 5)*
†300-mCi generator (calibrated for day 4)
‡100-mCi generator (calibrated for day 8)

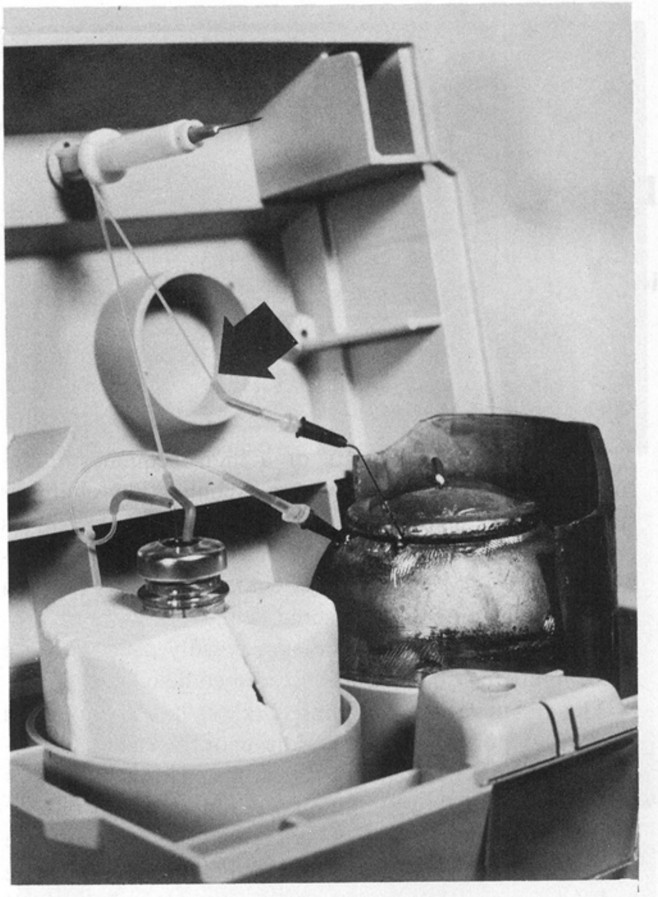

FIG. 3. Single weekly 400-mCi generator opened for inspection. Saline from reservoir washes over ^{99}Mo column and passes through plastic tube (arrow) to exit needle.

used for an entire week's elution of the dual generator system. Both sets were removed and stored after each day's elution so that their exposure was limited to that received from operating the generator systems.

The film badge exposures associated with the operation of both systems were equal to or less than 10 mrem.* The finger TLD rings, on the other hand, showed 30 mrem for the weekly system and 10 mrem for the biweekly system. These TLD readings of integrated dose parallel the ionization chamber measurements and verify the difference in exposure to operators of the two types of systems.

A question now arises as to the reason for the difference in exposure between the two systems. The weekly generator (Fig. 3) employs a well shielded ^{99}Mo column with a plastic tube for carrying ^{99m}Tc from the column to the exit needle. In a fission-type generator even the small volume of ^{99m}Tc flowing in the tube during elution represents significant activity. This activity, presented to the operator as an unshielded source, is responsible for the relatively high radiation levels measured during elution of the single weekly generator. The two generators of the biweekly system (Fig. 4) are identical to each other in physical construction. The column and the exit tube for ^{99m}Tc are held inside a lead sandwich which is an insert into a larger lead unit. This design accounts for the lower radiation doses received by operators of the biweekly system.

*10 mrem is the lower sensititivy level of both the film body badges and the TLD rings used. All references to readings of 10 mrem should be understood as equal to or less than 10 mrem.

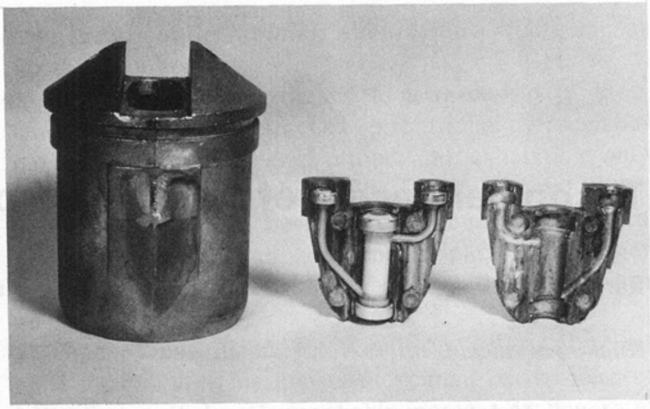

FIG. 4. One of two biweekly generators disassembled. ^{99}Mo column and exit tube sealed in plastic fits into lead sections which, in turn, insert into larger unit.

It would seem that the goal of reduced exposure from high-activity fission-type generators can be accomplished more effectively through proper shielding than by a biweekly system. Another consideration is the comparative cost of the two systems. The single 400-mCi generator can be purchased for about $255 a week (delivered), while the dual generator system sells for approximately $375 a week (delivered). On the other hand, larger laboratories might benefit from the more uniform yields of the dual system. Other possible advantages of a biweekly system, such as reduction of radiolysis and stable ^{99m}Tc from high activity generators, deserve further consideration.

References

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