Evaluation of a Molybdenum Assay Canister

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The performance characteristics of a commercial molybdenum assay canister were evaluated. The geometrical variation of the technetium-99m (^{99m}Tc) activity reading was studied as a function of the elution volume for the standard vials. It was found that the ^{99m}Tc canister activity reading was ~ 5% lower than that of the standard method. This is due to attenuation by the canister wall. However, the effect of the geometric variation on the clinical dose preparation was found to be insignificant. The molybdenum-99 (^{99}Mo) contamination level was compared by two methods: (1) the commerical canister and (2) the standard assay kit. The ^{99}Mo contamination measurements with the canister indicated consistently lower readings than those with the standard ^{99}Mo assay kit. We conclude that the canister may be used in the clinical settings. However, the user must be aware of the problems and the limitations associated with this canister.

A commercial molybdenum assay retractable canister* was designed to eliminate radiation exposure from an unshielded vial while assaying ^{99}Mo contamination level and ^{99m}Tc activity. In this report, data are presented indicating the problems and the limitations associated with the clinical use of the retractable canister. We have found a strong geometric variation on the activity reading as a function of the elution volume. We also observed that the commerical canister yielded lower ^{99}Mo contamination readings than the standard molybdenum assay kit. We will discuss these problems in terms of their clinical applications.

MATERIALS AND METHODS

Two dose calibrators†‡ were used side by side for the study. They were originally factory-calibrated, and thereafter the regular quality assurance programs, such as a quarterly linearity test, an annual accuracy test, and a daily constancy test, were implemented at our institution. The standard assay kit consists of a lead canister and an insertion holder. The characteristics (*1*) of the canister are such that the ^{99m}Tc reading is reduced to $< 10^{-6}$ of the unshielded reading whereas the ^{99}Mo reading is reduced by ~ 65%. The background corrected (Bkgd) ^{99}Mo contamination is calculated by the following equation:

$$^{99}\text{Mo contamination} = \frac{^{99}\text{Mo activity } (\mu\text{Ci}) - \text{Bkgd}}{^{99m}\text{Tc activity (mCi)} - \text{Bkgd}}.$$

The physical parameters of the retractable canister (*2*) are such that the attenuation factor for the ^{99m}Tc is 10^{-7} and the wall has a thickness of 7.6 mm lead. The geometrical variation on the activity reading as a function of the elution volume was determined for a 10-cc and a 20-cc vial, respectively. The activity ratio, R = Ds/Dr, was used as a parameter for the volume effect, in which Ds represents the ^{99m}Tc activity by the standard assay method (an unshielded vial in the dose calibrator), and Dr represents the ^{99m}Tc activity by the retractable canister. The ^{99}Mo contamination level was measured by two methods, one with the standard kit and the other with the commerical canister*.

RESULTS

The results presented here are for one dose calibrator† only since we have obtained almost identical results for the other dose calibrator‡. Figure 1 shows the results of the volume effect on the ^{99m}Tc assay readings for a 10-cc and a 20-cc vial, respectively. The *Y*-axis represents the activity ratio (R) defined in the previous section. The *X*-axis represents the elution volume in the vial in cubic centimeters. In Figure 1, the data points were fitted to the following linear equation:

$$Y = A + B \times X,$$

where Y = activity ratio, X = assay volume (cc) in the vial. The fitted parameters for the 10-cc vial are A = 0.9678, B = 8.747×10^{-3} cc^{-1}, and the coefficient of correlation = 0.988. The fitted parameters for the 20-cc vial are A = 0.981, B = 4.490×10^{-3} cc^{-1}, and the coefficient of correlation = 0.981. Figure 2 shows the activity ratio (R) as a function of the ^{99m}Tc activity (Ds) measured by the standard method. Figure 3 shows the ^{99}Mo contamination level obtained by two methods, the standard technique and the commercial canister, respectively. The *Y*-axis represents the ^{99}Mo contamination and the *X*-axis represents the ^{99m}Tc activity (Ds).

DISCUSSION

Figure 1 illustrates that the activity ratio (R) increases as the elution volume increases. This means that the ^{99m}Tc assay with the commercial canister yields lower values than those with the standard assay method. This is because the greater percentage of photons is absorbed by the commerical canister wall (Figure 4). Figure 1B shows that the ratio (R) becomes < 1 as the elution volume decreases. This indicates that the commercial assay canister yields greater values than the standard method. The reason for this is not clear; however, the scattered photon contributions at the canister base may be the cause. Figure 2 shows that the activity ratio (R) is indepen-

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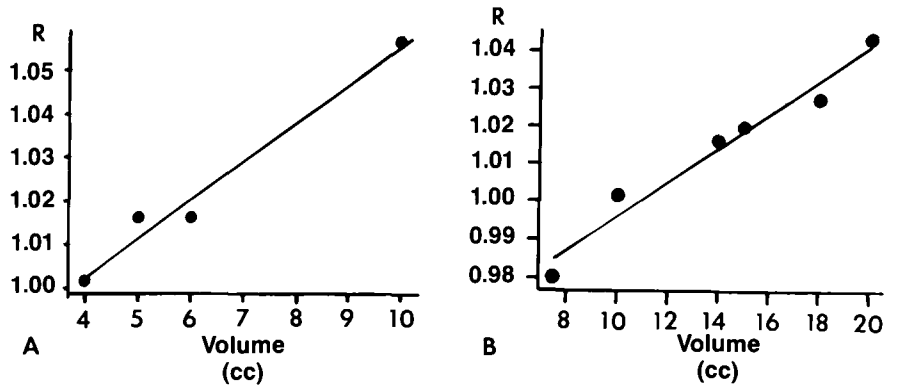

FIG. 1. Geometrical variation of the ^{99m}Tc assay between the retractable canister and the standard method. Activity ratio (R) as a function of elution volume (cc). (A)10-cc vial and (B)20-cc vial.

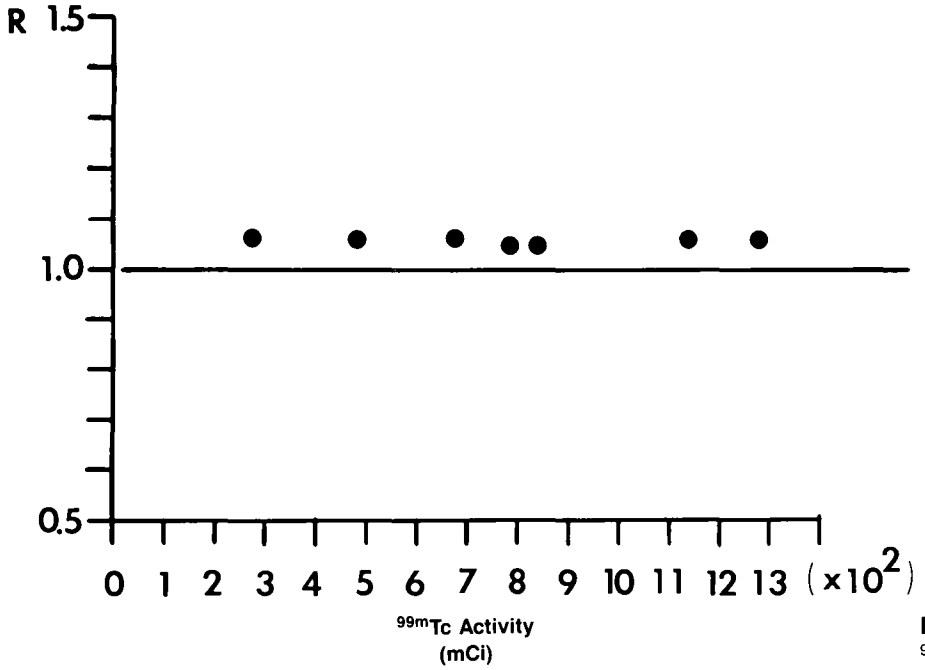

FIG. 2. Activity ratio (R) as a function of ^{99m}Tc activity.

TABLE 1. Implication of Geometric Effect on the Dose Preparation*

	Commercial retractable canister	Vial without a shield (correct activity)
Reading	1600 mCi (59.2 GBq)	1688 mCi (62.5 GBq)
Concentration	160 mCi/cc (5.92 GBq/cc)	168.8 mCi/cc (6.25 GBq/cc)
Volume withdrawn into a syringe	0.2 cc	0.2 cc
Syringe activity	32 mCi (1.18 GBq)	33.76 mCi (1.25 GBq)
Difference	32 − 33.76 = −1.76 mCi	(65.1 MBq) (−5%)

* Assume that a 10-cc vial is used for elution.

dent of the assayed ^{99m}Tc activity. Consider the implication of the geometric effect on the dose preparation. Assuming that ^{99m}Tc is assayed using a 10-cc vial, then the activity ratio of the standard assay to the commerical canister assay is 1.05 (see Fig. 1A). Suppose that 1,600 mCi (59.2 GBq) of ^{99m}Tc is eluted by the commercial canister on Monday morning from the generator (Table 1), then a correct activity is 1,688 mCi (62.5 GBq). Furthermore, suppose that we withdrew 0.2 cc into a syringe during dose preparation, then the difference of activity between the two methods is 1.76 mCi (65.1 MBq) or ~5%. This result is then insignificant because a diagnostic misadministration, as defined by the Nuclear Regulatory Commission (NRC), is one where administration of a dosage is five-fold different from the intended dosage or where the patient is likely to receive an organ dose > 2 rem (20 mSv) or a whole-body dose > 500 mrem (5 mSv) (*3*). The ^{99}Mo contamination measured by the commercial retractable canister (Fig. 3) is always lower than that of the standard canister by a factor of approximately five. However, the measured ^{99}Mo contamination level is usually on the order of 10^{-3} to 10^{-4} μCi of ^{99}Mo per mCi (1 Bq/1 MBq to 1 Bq/10 MBq) of ^{99m}Tc. Moreover, this level is smaller by at least two decades (10^2) than the NRC limit of 1.5×10^{-1} μCi ^{99}Mo per mCi (1.5 Bq/10 kBq) ^{99m}Tc (*4*). Thus, the problem of the commerical canister may be acceptable from the standpoint of clinical usage.

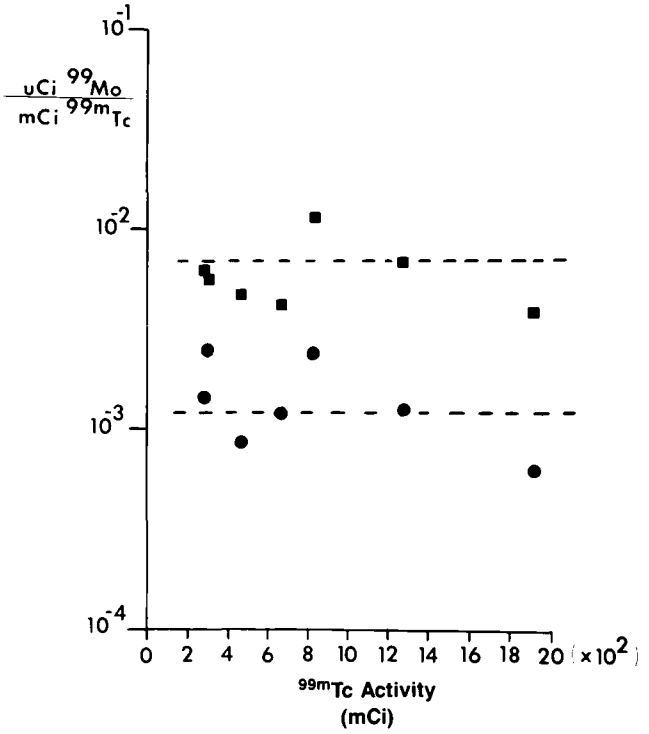

FIG. 3. Molybdenum-99 contamination level measured by the commercial canister ● and the standard canister ■.

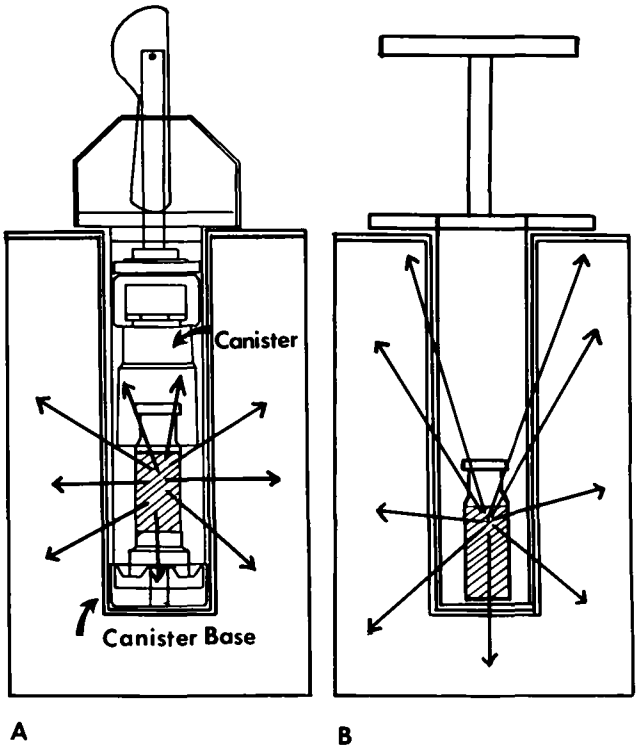

FIG. 4. Assay geometry for the ^{99m}Tc. (A) Retractable canister and (B) standard canister.

In summary, there exists a geometrical variation in the ^{99m}Tc assay reading as a function of the elution volume up to 5% in the commerical canister as compared to the standard assay. The commercial canister molybdenum assay yields a lower ^{99}Mo contamination level by a factor of approximately five as compared to that of the standard kit. It could not be determined which method yielded correct information. However, it was observed that there was a discrepancy between the two methods. Scientists at other institutions are encouraged to repeat and check these results. From the clinical standpoint, these variations may be tolerated. For the absolute assay of the ^{99m}Tc, the commercial retractable canister is not practical; one must measure the volume of the elution and the calibration curve, but this would defeat the original philosophy of the retractable canister. With the retractable canister, the radiation exposure to nuclear medicine personnel is significantly reduced.

NOTES

*CAP-MAC, Capintec, Inc., Montvale, NJ
†CRC-22NB, Siemens Medical Systems, Inc., DesPlaines, IL
‡CRC-10, Capitec, Inc., Montvale, NJ

REFERENCES

1. Operational manual. Radioisotope calibrator CRC-22NB. Des Plaines, IL: Searle Radiographics.
2. CAP-MAC owner's manual. Montvale, NJ: Capintec, Inc.
3. U.S. Nuclear Regulatory Commission, Title 10, Code of Federal Regulations, part 35.33c (10CFR 35.33c).
4. U.S. Nuclear Regulatory Commission, Title 10, Code of Federal Regulations, part 35.204 (10CFR 35.204).