Simple Elution Aid for Multiple, Fractionated, and Partial Elution of ^{99m}Tc

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Objective: ^{99m}Tc obtained from $^{99}Mo/^{99m}Tc$ generators is playing a key role in the majority of diagnostic scans performed in the world today. The availability of ^{99m}Tc can be increased if it is separated from ^{99}Mo after much shorter growth times (multiple elution). Fractionated elution may provide a high concentration of ^{99m}Tc, whereas partial elution will help reduce doses to nuclear medicine staff members. An "elution aid" apparatus facilitating accurate elution was devised and tested.

Methods: The elution aid consists of a 1-L bottle of physiologic saline connected to a measuring cylinder/graduated column (20 mL) by the flow regulator of an infusion kit. The lower end of the measuring cylinder is connected by Tygon tubing to the spike of a $^{99}Mo/^{99m}Tc$ generator. The desired volume of saline is added to the measuring cylinder with the help of the flow regulator. Using an evacuated collecting vial, the eluent is sucked through the alumina column to obtain sodium pertechnetate solution.

Results: With this simple device, 2- to 20-mL volumes were easily collected. The elution aid, once connected to the generator, provided regular, partial-time elution and fractionated volumes over the whole useful life of the generator.

Conclusion: A simple aid for elution of ^{99m}Tc from 2-vial–based $^{99}Mo/^{99m}Tc$ generators has been devised. Any desired volume of saline can be passed through the alumina column of the generator for the elution of $Na^{99m}TcO_4$. The elution aid works efficiently for the whole useful life of a generator.

Key Words: $^{99}Mo/^{99m}Tc$ generator; dry-type generator; elution aid; fractionated elution

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Technetium-99m is the lifeblood of diagnostic nuclear medicine. Despite the increasing number of nonradioactive tracer techniques developed during the last few decades, such as luminescent, fluorescent, enzyme-linked immunosorbent assay, functional MRI, and the use of stable isotopes in various fields, the application of radioactive tracers in medicine will remain extensive or even increase because of their sensitivity and ease of imaging. PET is a rapidly proliferating technology in diagnostic nuclear medicine. However, most PET studies are performed with short-lived "organic" positron emitters, for example, ^{11}C (half-life [$t_{1/2}$] = 20 min), ^{13}N ($t_{1/2}$ = 10 min), ^{15}O ($t_{1/2}$ = 2 min), and ^{18}F ($t_{1/2}$ = 110 min), and transportation of these radionuclides to a distance is not possible. Demand for ^{99m}Tc has grown as new indications, such as improved neuroimaging studies of patients with dementia, acute stroke, and trauma, have become more prevalent. The potential addition of newer imaging agents such as peptides and monoclonal antibodies will certainly increase this demand. Widespread use of PET in developing and underdeveloped countries is not feasible; hence, the progress of diagnostic nuclear medicine in these countries will rely heavily on the availability of ^{99m}Tc in their nuclear medicine centers.

The widespread application of ^{99m}Tc in diagnostic nuclear medicine is possible only with efficient $^{99}Mo/^{99m}Tc$ generators. The widely accepted ^{99m}Tc generator consists of a column chromatographic system and an appropriate elution device. It comprises a glass column packed with alumina, onto which the fission ^{99}Mo has been adsorbed in the form of molybdate. Evacuated collecting vials are used to suck the eluent (0.9% saline) through the generator column to obtain a sterile and apyrogenic solution of sodium pertechnetate. Two types of generator systems, using a plastic bag or a second glass vial to contain the eluent, are available on the market.

The yield of ^{99m}Tc from column chromatographic generators is drastically reduced by minor traces of organic materials such as alcohols, bacteriostatic agents, tiny rubber pieces, lubricants, and many unidentified substances that are released from plastic bags or tubing under the influence of ionizing radiation (*1–5*). It has been suggested that the hydrated electron is the species responsible for reducing ^{99m}Tc to lower oxidation states that are strongly bound to alumina (*2,3*). Because water within the system is detrimental to the efficiency of the generator, "dry" generators such as PAKGEN, in which

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residual eluent is removed from the alumina bed at the end of each elution cycle, have been developed.

Several other methods to minimize radiation-induced loss of elution efficiency have been applied. For example, an oxidizing agent can be adsorbed onto the column or added to the elution solution (*2–4,6*).

MATERIALS AND METHODS

^{99}Mo/^{99m}Tc Generator

The PAKGEN ^{99m}Tc generator provides a source of sodium pertechnetate ($Na^{99m}TcO_4$) for injection. To meet the demands of various nuclear medicine institutes in Pakistan, PAKGEN generators are manufactured weekly in the ^{99}Mo Loading Facility of the Pakistan Institute of Nuclear Science and Technology, in Islamabad. The generator contains ^{99}Mo (separated from fission products) adsorbed onto alumina contained in a lead-shielded glass column. The internal generator components are contained within a robust galvanized iron casing fitted with a carrying handle. It is a 2-vial system. To elute the generator, a vial of sodium chloride (5, 10, or 20 mL) of intravenous infusion quality is placed onto the inlet spike. The eluate, $Na^{99m}TcO_4$, is collected by placing a sterile evacuated elution vial onto the collection needle. The shipped generator includes a technical leaflet, vial labels, and the following elution kit components and accessories:

- Ten eluent vials each containing 10 mL of physiologic saline solution (vials containing 5, 15, or 20 mL of physiologic saline solution may be provided on request).
- Twenty evacuated sterile, pyrogen-free vials (30 mL) for collection of the generator eluate (some of them may be used for drying of the alumina bed).
- Five sterile inlet spike protectors to maintain the sterility of the generator system if the saline vial is removed between elutions.
- Ten sterile closed-cell foam (polyethylene) collection needle protectors to maintain the sterility of the generator system between elutions.
- Ten sterile needles to enable the user to replace the collection needle (in case the elution needle becomes blocked or damaged).
- Ten bactericidal sanitizing swabs (70% isopropyl alcohol) to keep the saline vial and collection vial closures aseptic when elutions are performed.

Elution Aid

Figure 1 shows the elution aid for the PAKGEN ^{99m}Tc generator. It consists of a 1-L physiologic saline bottle (PAKSOL; M.S. Enterprises) connected to a measuring cylinder/column (20 mL) by the flow regulator of the infusion kit. The lower end of the measuring cylinder is connected by Tygon tubing (Saint-Gobain Performance Plastics) to the spike of the PAKGEN generator. An air filter fitted at the upper end of the measuring cylinder/column provides an air vent into the system for pressure compensation. The desired volume of saline is first added to the measuring cylinder with the help of the flow regulator. An evacuated collecting vial is used to suck the eluent through the alumina column to obtain sodium pertechnetate solution.

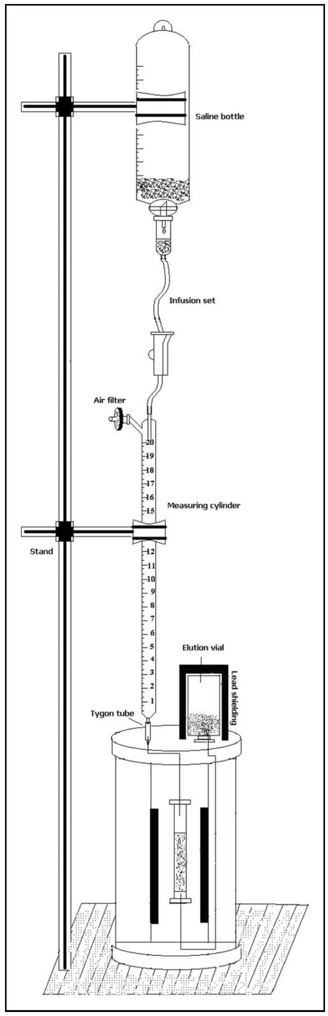

FIGURE 1. Elution aid for ^{99}Mo/^{99m}Tc generator.

The generator was eluted with vials containing 5, 10, 15, and 20 mL of saline. The eluates collected in evacuated vials were measured. After the elution aid had been connected, different fractions (2–20 mL) of saline were added to the graduated column and eluted with the help of evacuated vials. The volume of saline collected in the vials was measured.

RESULTS

^{99}Mo/^{99m}Tc generators were eluted with 2- to 20-mL fractions of physiologic saline with the help of the elution aid. The volume of eluate collected was insignificantly less than the volume of saline applied (Table 1). A similar trend was found when the generator was eluted using individual eluent vials. Less than 0.1 mL of eluate was lost and not recoverable by either procedure. With this simple device, any volume (fractions of high specific volume of ^{99m}Tc) desired was collected. Usually, 10 mL of saline is recommended for quantitative elution of $Na^{99m}TcO_4$ from fission

TABLE 1
Elution Performed with Elution Aid Connected to 2-Vial–Based ^{99m}Tc Generators

Saline applied (mL)	Saline collected (mL)
2	1.98 ± 0.02
3	2.98 ± 0.02
4	3.98 ± 0.02
5*	4.98 ± 0.02
6	5.98 ± 0.02
8	7.97 ± 0.03
10*	9.97 ± 0.03
12	11.97 ± 0.03
15*	14.97 ± 0.03
18	17.96 ± 0.04
20*	19.96 ± 0.04

*Elution of generators was also performed with individual eluent vials containing 5, 10, 15, and 20 mL of saline generally provided with generator shipment. Loss of eluate in both methods was same.

^{99}Mo-based commercial generators, whereas 5–6 mL of saline are used for concentrated $Na^{99m}TcO_4$ solutions. When extra ^{99m}Tc was needed, 2 elutions/separations per day per generator were performed with a milking aid. ^{99m}Tc eluate yields were lowered by decreasing elution volumes (3–4 mL) when full elution yields were not needed, thus lowering the technologist's radiation exposure during elution of ^{99m}Tc and the labeling procedure.

DISCUSSION

The elution aid, once connected to the generator, provides regular, partial-time elution and fractionated volumes over the whole useful life of the generator. The sterility and apyrogenicity of eluates are retained. Although sufficient isotonic saline remains in the bottle to allow reuse with a second generator, economic savings do not outweigh the risk of compromised sterility; therefore, reuse with a second generator is not recommended. Recently, Amersham has started to supply DRYTEC ^{99m}Tc generators, a 2-vial system similar in design and principle to the PAKGEN. The same elution aid worked efficiently when applied to DRYTEC ^{99m}Tc generators. The elution aid is of very low cost relative to the cost of the ^{99m}Tc generator. Furthermore, net savings may be achieved by reducing the use of elution kit accessories.

CONCLUSION

An elution aid has been developed that offers a simple, efficient, economic, and practical method of providing regular elutions, partial-time elutions, or fractionated-volume elutions of 2-vial–based ^{99m}Tc generators.

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