A Technique for the Handling and Dispensing of Xe-127: Concise Communication

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Xenon-127, which provides photon energies better suited to the Anger camera and reduces radiation dosage to the patient compared with Xe-133, has become commercially available from Brookhaven Laboratories. Its higher cost and longer shelf-life require improved handling and dispensing of shipment ampoules containing gas of high specific activity. The technique described permits individual doses to be prepared for gaseous administration, or dissolved in saline for i.v. injection.

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Until recently, xenon-133 has been used exclusively in clinical studies with inert gases. Xenon-127, which possesses photon energies better suited to the scintillation camera and lowers the radiation dosage to the patient compared with Xe-133 (*1–3*), has become commercially available from Brookhaven Laboratories. No difficulties exist with shipment, and the half-life of 36.4 days is convenient. It is produced with a specific activity of approximately 10 mCi/μg and dispatched in crush-type glass ampoules at any required radioactivity. For convenience in shipment, our ampoules contained 100 mCi Xe-127. Since this quantity is too large for immediate clinical use, we have developed a gas-handling and dispensing system to provide smaller ampoules for individual patient doses.

Xenon-127 handling and dispensing system. A glass-and-metal system must be used to avoid the adsorption of xenon onto such substances as rubbers and elastomers. After breaking the shipment ampoule into a closed system, the gas may be moved about within it by liquid-nitrogen-cooled distillation, and in order that the diffusion times within the apparatus should not be inordinately long, the mean free path of the gas molecules must be of the order of the dimensions of the apparatus. This requires a pressure of the order of 10^{-3} mm Hg (torr). To obtain a high transfer efficiency there must be as little dead space as possible.

To break the shipment ampoule into the closed system, a metal cracking pot was designed whose internal dimensions are just adequate to contain the ampoule after its introduction through a screw cap having an airtight seal. In the side of the pot is a tube through which a threaded rod can be moved, through an airtight bearing, to break the shipment ampoule when it is in position. The pot is sealed to glass tubing to which a spray of ampoules of various volumes is attached (Fig. 1). These are connected through isolating valves and a cold trap to a diffusion pump backed by a rotary pump. With gauges placed as shown, sequential valve opening allows each section of the system to be checked for leakage.

After prior checking of the whole system for vacuum integrity, the shipment ampoule (Fig. 2a) is loaded into the cracking pot, ensuring that fit is correct and that no cracks are present.

The cold trap is cooled with liquid nitrogen and the whole system, except the pot, is evacuated for a few minutes. The pot is then opened to a branch and the ampoule is checked for possible fracture by measuring the radiation dose from this branch during the maneuver. If no fracture is present, the total system is pumped down to 10^{-2} torr and all valves are closed for a leak-test period of 1 or 2 hr. Each section is then checked for leakage. The system is then evacuated to less than 10^{-2} torr for a further 15 min, the cracking pot and ampoule dispenser are

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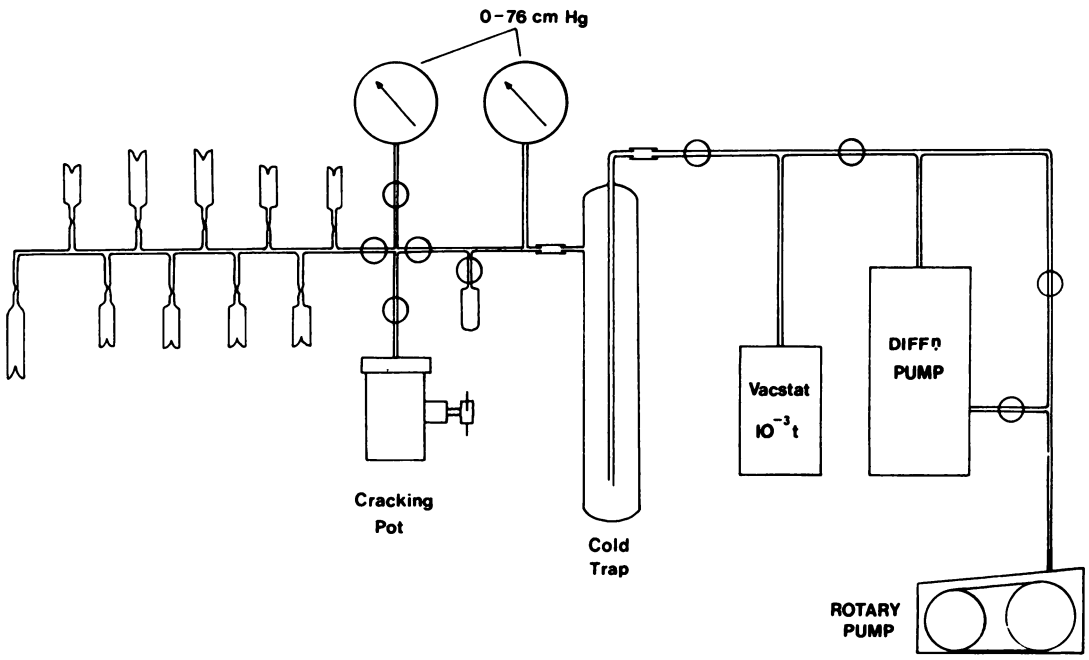

FIG. 1. Handling and dispensing system for Xe-127.

connected together, and the remaining valves are closed. The shipment ampoule is then shattered by means of the threaded rod. The farthest-mounted dosage ampoule is then cooled with liquid nitrogen and distillation takes place for 5 min. Measurement of radiation from the pot provides a useful monitor of the distillation process. The transfer will be complete if the pressure has remained low with no leaks, and the system is moisture-free, since moisture impedes the diffusion process. The cooled ampoule is then allowed to warm to room temperature and the Xe-127 divides into the dosage ampoules according to volume. These are then sealed off by applying a narrow flame to the neck and removed by a sharp twisting action. The last ampoule is first cooled with liquid nitrogen to collect the dead-space gas, then sealed off and removed. Alternatively, the dead-space gas may be transferred to the metal long-term storage ampoule on the system.

An ion-chamber calibrator was used to compare the sum of the activities of all the dose ampoules with that of the shipment ampoule, and this indicated that the transfer efficiency of the system is better than 97%.

Ampoule design. The important feature of the dosage ampoule (Fig. 2b) is its re-entrant break-seal, which allows convenient puncture with a hypodermic needle. With an aspirating syringe whose volume is three to five times that of the ampoule, the needle enters through the break-seal and is pushed to the far end of the ampoule (Fig. 2c). Aspiration of air entering around the needle flushes the active gas into the syringe. Gas dispensing is volumetric, so that different activities may be dispensed by controlling the volumes of the ampoules. This provides a simple and convenient method of rapid transfer of an aliquot of gas into a spirometer system.

Xe-127 in saline. The requirement is to produce sterile solutions of Xe-127 conveniently, using read-

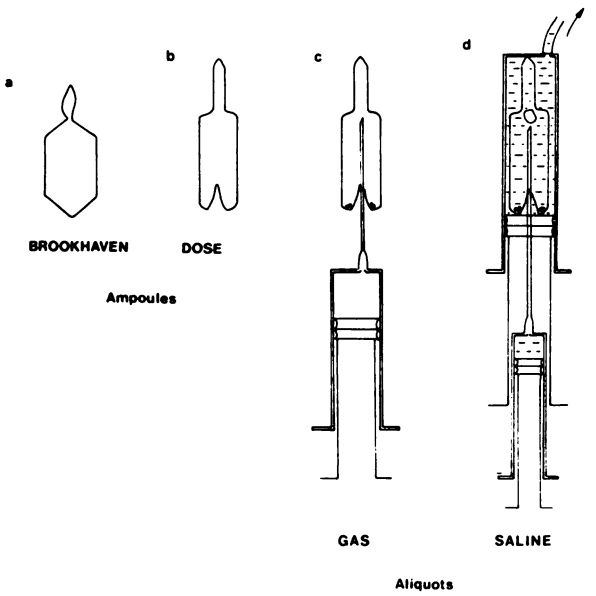

FIG. 2. (a) Brookhaven shipment ampoule. (b) Dose ampoule. (c) Extraction of gas from dose ampoule into syringe. (d) Dispensing of xenon in saline.

ily obtainable, sterile hospital supplies. Aseptic technique is used throughout the procedure to be described.

The selected ampoule is cleaned and then sterilized by heating at 160°C for 2 hr. The plunger is removed from a newly opened, 20-ml, disposable plastic syringe, and the sterile ampoule is inserted into the syringe, seal-pip end first, as far as it will go (Fig. 2d). The syringe is then connected to an inverted saline bag through a tube and a needle through the septum, and sterile saline is allowed to surround the ampoule and fill the syringe. The plunger is then reinserted and saline is expelled until the ampoule, axially located, is caught between the plunger and the far end of the syringe (Fig. 2d). A newly opened 5-ml disposable plastic syringe, which fits inside the handle of a 20-ml syringe, is fitted with a lumbar-puncture needle long enough to reach the seal-pip of the ampoule and strong enough to pierce the soft plunger of the larger syringe (Fig. 2d). The small syringe is primed with saline to displace air, its plunger is pushed home, and its long needle then pushed through the plunger of the larger syringe and through the break-seal into the ampoule. Saline from the bag is promptly sucked into the ampoule, xenon and evolved air forming a small bubble at the seal-pip. The system is allowed to equilibrate for 1–2 hr, the xenon dissolving in the saline.

The saline solution of Xe-127 is then withdrawn into the smaller syringe from the area adjacent to the gas bubble and is ready for i.v. injection. Fresh saline replaces the withdrawn solution and a second dose may be withdrawn after a suitable equilibration period. As measured by ion-chamber calibrator, between 30 and 60% solution of the xenon contained in the small bubbles dissolves on each occasion, and it is relatively easy to obtain requisite activity in 5 ml of solution. The amount of xenon passing into solution depends on the saline-air partition coefficient (approximately 0.1) and the concentration of xenon in the bubble.

To eliminate the possibility of glass-fragment transfer, a saline-primed millipore attachment may be fitted to the withdrawal syringe.

The system could easily be adapted to recycle the used xenon, thus providing economy and improved radiological safety. Gas exhaled by the subject or contained in respiratory equipment can be collected in a shielded plastic bag and the contents then passed through a molecular sieve and cold traps at low pressure. The Xe-127 can then be collected by vacuum distillation into an ampoule and used again.

REFERENCES

1. GODDARD BA, ACKERY DM: Xenon-113, ^{127}Xe and ^{125}Xe for lung function investigations: A dosimetric comparison. *J Nucl Med* 16: 780–786, 1975

2. COATES G, NAHMIAS C: Xenon-127, a comparison with Xenon-133 for ventilation studies. *J Nucl Med* 18: 221–225, 1977

3. ATKINS HL, SUSSKIND H, KLOPPER JF: A clinical comparison of Xe-127 and Xe-133 for ventilation studies. *J Nucl Med* 18: 653–659, 1977