NMT Gadgetry

A Simple and Efficient Method of Dissolving ^{133}Xe into Saline

Vincent L. Sgroi, George R. Jones, William L. Ashburn, and Kenneth M. Moser

University of California, San Diego, School of Medicine, La Jolla, California

During recent years, ^{133}Xe in saline has played an important role in more clearly defining various physiologic parameters. Because of its low dose rate, relatively large quantities can be used. In the past, it has been difficult to achieve high-specific-activity ^{133}Xe in saline in the laboratory. This paper presents a method whereby high-specific-activity ^{133}Xe can be produced simply and economically.

Xenon-133 dissolved in saline has achieved a high degree of popularity as a unique radiopharmaceutical. The clinical use of ^{133}Xe in evaluating regional pulmonary perfusion and in a variety of other circulatory disorders is well known. Although ^{133}Xe solution can be obtained commercially from a number of sources, these commercial materials have at least two disadvantages. First, if the quantity used is in excess of 30 mCi/week, it becomes an economic burden. Second, if high-specific-activity material is required, the expense becomes substantial. Consequently, we have developed a method which achieves the following objectives: (A) a yield of consistent high-specific activity, (B) ease of operation, and (C) fast, safe, and economical procedure.

Many techniques of handling and dispensing ^{133}Xe have been reported *(1-5)*. The technique described in this communication focuses around the use of a 1-curie source of ^{133}Xe gas compressed into a Pyrex ampule. These ampules are delivered to the laboratory on a weekly basis and are available from several commercial suppliers*. The purpose of this paper is to describe the system and relate our experience with this device which was originally developed in our laboratory.

*General Electric, Pleasanton, Calif. 94566 and Oak Ridge National Laboratory, Oak Ridge, Tenn. 37830.

Materials and Methods

Apparatus. The system developed (Fig. 1) contains two basic components: (A) a variable-volume chamber and (B) an ampule crusher. The variable-volume chamber was constructed out of 1/2-in. stainless steel with a valve attached at the base. This chamber has a volume range of 0–100 ml. Placed within the lid of this chamber is a Tygon O-ring which is used to assure a gas-tight seal. The ampule crusher contains two segments. The upper portion which serves as the ampule housing during transfer is lined with 1/8 in. of lead to reduce radiation exposure to the operator. The lower portion

For reprints contact: Vincent L. Sgroi, Div. of Nuclear Medicine, University Hospital, 225 W. Dickinson St., San Diego, Calif. 92103.

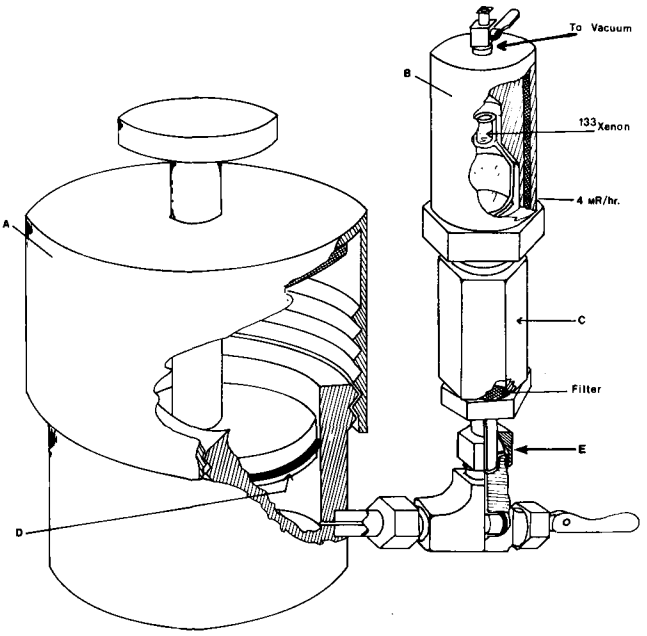

FIG. 1. System for xenon production. (A) Variable-volume chamber. (B) Upper portion of crusher. (C) Lower portion of crusher. (D) O-ring. (E) Millipore filter insertion site.

contains a 0.22-micron Millipore filter that stops all glass from entering the chamber after the ampule is broken. Since the entire system depends upon the achievement of a high vacuum, a commercially available single-phase vacuum pump is used. The system pressure is monitored with a static vacuum gage.

Operation and dispensing. Before operation of the system, both the ampule and the unit are gas sterilized. The ampule, which is placed in the upper portion of the crusher, has an internal pressure in the order of 5—10 mmHg. To assure optimum transfer, a minimum vacuum of 0.1 mmHg must be achieved throughout the unit by connecting a vacuum pump to the upper valve and opening all valves throughout the system. Once the desired vacuum is reached, the ampule is broken by rotating the upper portion of the crusher. The filter at the base of the crusher stops all glass from entering the chamber. After this maneuver, approximately 80% of the gas is transferred to the lower chamber. Saline is then introduced into the system through the valve at the top of the crusher while the vacuum state is maintained. The saline flow flushes the majority of the residual gas from the crusher into the chamber. The entire procedure takes 1 hr to complete and has a maximum exposure to the operator of 4 mR/hr at the surface of the crusher.

The crusher is then replaced by a metal-housed Millipore filter with a sterile three-way stopcock for protection at Point E. The lid to the chamber is then rotated clockwise to create an internal pressure of approximately 30 psi. The solution is allowed to equilibrate 24 hr to assure maximum degree of incorporation of the gas into saline. To dispense the xenon solution, the lid is rotated counterclockwise to achieve zero pressure. The value is then opened slowly until a small meniscus appears at the mouth of the stopcock. A glass syringe similarly sealed with saline is attached to the unit, and the desired amount is dispensed by further clockwise rotation of the lid. Upon completion of each withdrawal, the chamber pressure is then restored to approximately 30 psi and left in this state until the next usage.

Results and Discussion

This system has been used in our laboratory for the past 3 years, and some 125 transfers have been performed. Depending on the desired specific activity, dilution volumes ranging from 20 to 100 ml of saline have been introduced into the chamber. When 100 ml of saline is used to flush the system, 85% of the xenon goes into saline. The average specific activity is 8.5 mCi/ml, and allowing for decay, the degree of specific activity is proportionally maintained throughout the useful life of the system. When a volume of 20 ml is used, the average yield is 43.1 mCi/ml with a transfer efficiency of 86%. Regardless of volume, approximately 85% of the total gas transferred is dissolved into saline using this method. The remaining xenon is accounted for by the absorbing proportion of the Tygon O-ring within the unit and minimal loss during dispensing.

Based on an initial system cost of approximately $1,000 and assuming the purchase of a total of 26 curies of ^{133}Xe throughout the year with an average transfer efficiency of 85%, the cost per millicurie was $.13 for 1 year. This compares with an approximate cost of $1.50 per mCi assuming the purchase of commercial xenon-in-saline with an average specific activity of 10 mCi/ml. This comparison obviously depends upon a variety of factors relating to specific purchase agreements, transportation costs, etc., but no longer becomes competitive when quantities of less than 30 mCi/week are needed.

Most mechanical devices have their own peculiarities, and this one has two which should be recognized. When using this system, one must be aware first of a minimal loss of efficiency due to absorption of ^{133}Xe by the Tygon O-ring and second of a 24-hr down-time period for reaching solution equilibration. The overall operation of this system has proven to be economical and requires minimal maintainence.

Acknowledgment

This work was originally presented at the 20th Annual Meeting of the Society of Nuclear Medicine in June 1973 and at the SNM Northern and Southern California Chapter Annual Meeting in October 1973. It was supported by National Institutes of Health SCOR HL 14169.

References

1. Veall N: The handling and dispensing of xenon-133: Gas shipments for clinical use. *Int J Appl Radiat Isot* 16: 385-387, 1965

2. Steinmann K, Aspin N: A device for dispensing radioactive xenon gas. *Radiology* 90:800, 1968

3. Loken M, Kush G S: Handling, use, and radiation dosimetry of xenon-133. In *Medical Radionuclides: Radiation Dose and Effects.* USAEC Symp Series 20, Springfield, Va, NBS, 1970, pp 253-269

4. Tilbury R A, Dramer H H, Wahl W H: Preparing and dispensing xenon-133 in isotonic saline. *J Nucl Med* 8:401, 1967

5. Rummerfield P S, Jones G R, Ashburn W L: Health physics aspects of xenon-133 lung studies. *Health Phys* 21: 547-552, 1971