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A SIMPLE ^{133}Xe DELIVERY SYSTEM FOR STUDIES OF REGIONAL VENTILATION

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An apparatus for delivering ^{133}Xe for studies of regional ventilation and its mode of operation is described. The apparatus is constructed from commercially available parts. The apparatus has proven simple to operate and satisfactory studies can be obtained with 10 mCi of ^{133}Xe.

Studies of regional ventilation are of considerable value in showing when defects in perfusion are related to obstructive airway disease. Experience with more than 400 ventilation and perfusion studies suggested that to make any reasonable interpretation of a perfusion lung scan a knowledge of regional ventilation is of considerable diagnostic and therapeutic importance (*1*).

To perform ^{133}Xe studies on a routine basis to accompany each perfusion scan, a system that is simple to operate and requires little ^{133}Xe seems essential. Our earlier experience using a dual bag-box spirometer system indicated that a washin period of 3–4 min followed by a washout period recorded at intervals on Polaroid or 35-mm film provided a sound basis for clinical interpretation (*1–3*).

This paper describes a ^{133}Xe delivery system with a volume of less than 3 liters that can be used for rebreathing or single-breath studies. It is constructed from commercially available parts and is considerably cheaper than any currently available nondisposable ^{133}Xe delivery system.

APPARATUS

The apparatus consists of a 5-liter anesthetic bag, two T-valves, a J-valve, and a CO_2 absorber (all from Warren E. Collins, Inc.) connected by appropriate tubing and shielded in a simple lead box.

The apparatus is shown in Fig. 1, and the arrangement of its component parts is shown schematically in Fig. 2. The anesthetic bag is connected by a three-way connection to the outlet from the CO_2 absorber and to one of the T-valves (A). The nipple on the lower end of the anesthetic bag is connected to a narrow-bore tube fitted with a small three-way tap. This tube is used to introduce either oxygen or ^{133}Xe into the system.

T-valve (A) is connected to the J-valve and has one port open to the air. The J-valve supports the mouthpiece and is connected to the second T-valve (B) which is modified by removing its stop-pin so that the T-valve can provide connections between all its ports. One port is connected to the inlet of

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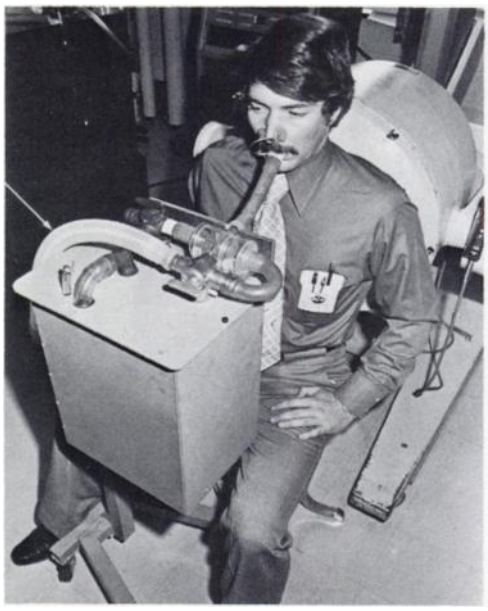

FIG. 1. General view of ^{133}Xe delivery system. When in operation exhaust tube (→) is connected to exhaust fan system.

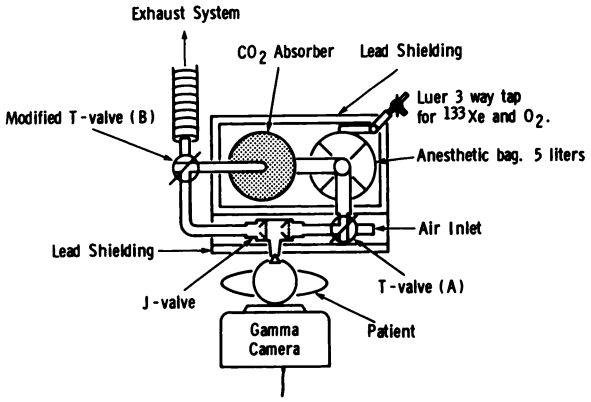

FIG. 2. Schematic diagram of ^{133}Xe delivery system. Parts and mode of operation are described in text.

the CO_2 absorber, and the other leads to the exhaust system.

The anesthetic bag and CO_2 absorber are housed in a lead-shielded box 24 × 32 × 40 cm high, the shielding being 3.2 mm thick on the side that faces the gamma camera and 1.6 mm thick on the other five sides. Inspection of the contents can be made through a removable partition in the top. The apparatus is supported on a mobile adjustable stand and weighs less than 100 lb.

OPERATION OF APPARATUS

Rebreathing studies. The patient is seated with his back to the gamma camera and is made familiar with the mouthpiece and nose clip. T-valve (A) is turned to allow air to enter while T-valve (B) is connected to the exhaust system. One and one-half liters of oxygen and 10 mCi of ^{133}Xe are introduced into the anesthetic bag followed by another 0.5 liters of oxygen. T-valves (A) and (B) are then turned to close the circuit for washin. Rebreathing is carried out for 3–4 min. If a longer washin period is required, oxygen should be added slowly to the anesthetic bag at 150–200 ml/min.

For the washout procedure T-valves (A) and (B) are turned to their original positions. After the washout is complete, ^{133}Xe is removed from the apparatus by setting T-valve (A) for washin and T-valve (B) to connect all three ports and flushing the apparatus with air or oxygen.

Perfusion studies. After the ^{133}Xe in saline has been given intravenously the expired gas can be rebreathed. The apparatus then requires no priming with ^{133}Xe although 2 liters of oxygen must be added to the anesthetic bag.

Single-breath studies. A larger volume of oxygen, and hence more ^{133}Xe, should be added to the anesthetic bag so that up to 5 liters can be inhaled.

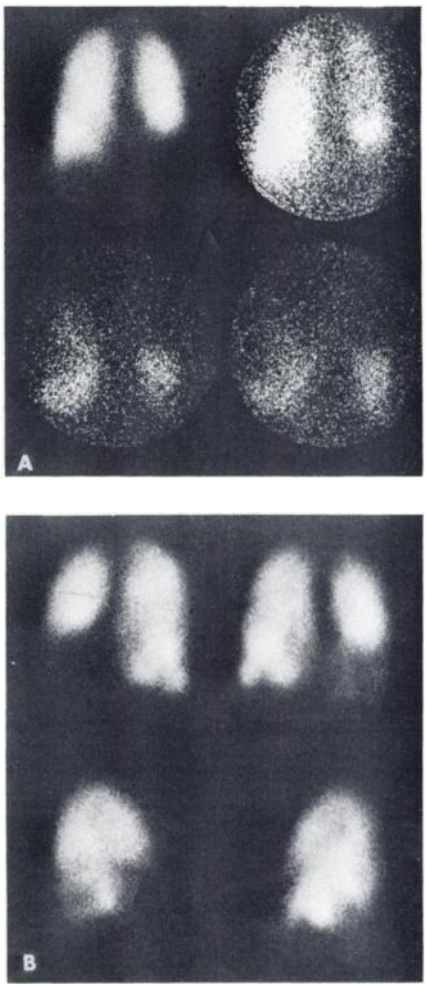

FIG. 3. (A) Xenon-133 ventilation study showing image of washin (400,000 counts) and selected images at 1.0, 5.0, and 10.0 min during washout from patient aged 14 with Kartagener's syndrome. Failure to fill lower zones during washin (top left) and delayed clearance from same regions are readily apparent. (B) Perfusion scan (anterior, posterior and right and left lateral views) showing dextrocardia and diminished perfusion in regions of abnormal ventilation.

COMMENT

The system has proved simple to operate. Images of the washin procedure accumulate 400,000–500,000 counts in 3–4 min using a 10 mCi dose of ^{133}Xe. Serial images of the washout procedure provide good evidence of regions of impaired clearance when these are present (Fig. 3). The shielding is sufficiently thick so that no activity from the ^{133}Xe in the apparatus is recorded by the gamma camera. A study can be completed in 6 min if ventilation is normal but can be prolonged for 15 or more minutes depending on the length of the washout procedure.

The apparatus was deliberately designed without a spirometer because in everyday practice little, if any, clinically useful information is gained from knowing tidal volume and respiratory frequency. However, should such information be required, the

lead box can be made airtight and a spirometer linked to the box.

ACKNOWLEDGMENT

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