Letter to the Editor

PRECAUTIONS FOR AVOIDING ^{133}Xe RELEASE FROM CHARCOAL XENON TRAPS

The widespread use of ^{133}Xe as a lung-imaging radiopharmaceutical has led to the development of a variety of ^{133}Xe handling devices. One of the most popular of these is the activated charcoal xenon trap. Through our experience with such a system we have found that these devices can cause excessive release of ^{133}Xe if certain precautions are not observed.

It should be noted that the activated charcoal used in most units is type G210, available from North American Carbon, Columbus, OH, and has specific absorption characteristics. These characteristics are dependent on (A) the amount of charcoal in the trap and (B) the method used to pack the cartridge. Item B is particularly important with horizontal units where care must be taken to prevent top channeling through settling.

The K_D (dynamic absorption coefficient) for G210 is 725 cm^3/gm at 25°C, 7.6×10^{-3} mm Hg (10 ppm), and a velocity of 2.0 ft/min. This translates into an absorption capacity of 7.24×10^5 cm^3 of xenon. The theoretical specific activity of ^{133}Xe is 2.0×10^5 Ci/gm, which converts to 1.18×10^3 Ci/cm^3 at STP. Therefore, a trap using G210 will have an absorption capacity of 8.56×10^8 Ci ^{133}Xe/1 kg of charcoal, ignoring decay! However, it is important to note that this activated charcoal will not only absorb radioactive xenon, but also a tremendous amount of airborne contaminants. In its simplest sense, it can be used to remove odors from refrigerators and smoke from rooms. It has no capacity to selectively absorb xenon in the presence of contaminants and therefore will reach its total absorption capacity long before it reaches the calculated ^{133}Xe absorption capacity. Moisture will deactivate the charcoal very rapidly; therefore, an efficient desiccant system is absolutely necessary.

A second observation relates apparently to the total amount of air in a time relationship which passes through the trap. It has been determined previously by other developers in the area, and we concur, that best absorption takes place below a flow rate of 5 to 10 l/min. This is, of course, geometry dependent and relates to xenon dwell time in the charcoal. However, an additional factor affects the trapping, and that is the total amount of air which passes through the system in a given period of time.

At one installation our xenon trap was inadvertently left running continuously over a 48–72-h period. The built-in saturation detector alarm activated, indicating ^{133}Xe in the exhaust port. Since the unit was new, we concluded that an electrical malfunction had occurred and proceeded to replace the alarm system. The second alarm system activated immediately. A scintillation camera image of the cartridge pack indicated ^{133}Xe distributed throughout the six cylinders uniformly across the circumference but continuously declining along the longitudinal flow path from intake to exhaust. The trap was leaking as indicated by the detector alarm system. This phenomenon is easy to understand if we consider the process a chromatographic one with charcoal as the suspension media and air as the solvent.

Another problem was detected in our development work which we have not seen discussed in the literature. People normally breathe at a rate of 15 l/min and charcoal traps are most efficient at 5-10 l/min. The pressure buildup against a patient breathing faster than the trap air movement can approach 5 cm of water, which is considerable even for a healthy person. The situation is readily eliminated by use of an expandable interface which allows the excess exhaled air to expand a bag and later be pumped from the bag after the patient has been removed. An alternative is to collect the washout in a bag and later attach it to the intake port of the xenon trap. If an expandable interface is used, it must have sufficient capacity to store the excess until washout is completed. In our experience a minimum capacity of 50 l is required.

Discussion

From our development work we have concluded and recommend the following.

1. All xenon traps will saturate, which will subsequently result in dumping of ^{133}Xe into the nuclear medicine department where the procedures are performed. The overall situation is probably a very complex function of many variables such as air flow rate through the charcoal, geometry of charcoal filter system, total air volume through the filter, humidity, temperature, air pollution, amount of charcoal, type of charcoal, concentration of ^{133}Xe in the air, and perhaps even what the patient had to eat the night before.
2. The desiccant should be checked frequently and changed or reconstituted when early signs of saturation appear.
3. Maximum flow rate through a charcoal trap should not exceed 10 l/min and preferably be around 5 l/min.
4. Xenon traps should run only when necessary.

5. Expandable interfaces should be used between the patient and trap to facilitate patient breathing.

6. Charcoal cartridges may or may not be reused after decay depending on what caused the leak in the first place. Saturation with moisture or air pollutants would seem to negate reuse after decay, whereas leakage caused by excessive air movement could be eliminated by decay, thus allowing reuse.

7. The exhaust port of xenon traps should be monitored continuously or at least daily for ^{133}Xe.

Perhaps our experiences with the xenon trap system will lead others to more thoroughly investigate the dynamics of the system.

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