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A Simple Disposal Method for Radioactive Xenon

TO THE EDITOR: Xenon is slightly soluble in water (*1*) (11.9% by volume at 25°C). A standard laboratory water vortex vacuum pump was used to incorporate xenon in the pump's water flow down a sink, as 10 mCi of carrier-free xenon-133 occupies only 9×10^{-3} μl at NTP (2.5×10^{14} atoms).

As a further trap to prevent outgassing back into the laboratory, and increase the mixing time for gas and water, the outlet of the pump was coupled to a 12-mm internal diameter polythene tube which was pushed down the plug hole through to the far side of the water seal.

In practice, the complete disposable xenon breathing system is simply coupled to the pump after use. In 5 min, all the patient's exhaled breath and xenon have been flushed down the sink and the whole apparatus returns virtually to background radioactivity.

Although xenon is easily detected as the water flows through the waste pipes, no activity returns to the laboratory or appears in the external ventilation pipe for this drainage system.

Dilution with the remainder of this institution's liquid wastes render the radioactive level orders of magnitude below the discharge limits allowed in guidelines issued by our National Health and Medical Research Council. Note that if it is intended to adopt this simple form of xenon gas disposal, local regulations must be considered, including the need to identify any inspection traps en route to a trunk sewer. Such traps should be labeled to require a radiation level check before being opened.

It would be simple to make a bedside apparatus for the imaging room that will aspirate xenon during the washout phase of the study. As long as the route of the sink waste is known not to pass near sensitive gamma detecting instruments or trap locally within a building, there should be no problem operating this form of dilution and dispersal safely.

We have disposed of 125 mCi ^{133}Xe within a week, including 25 mCi in 1.5 hr without any alteration of background levels in the laboratory or in the vicinity of the external ventilation sump.

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Left Ventricular Volume Measurements by Radionuclide Angiography

TO THE EDITOR: The recent report by Dr. Verani and co-workers (*1*) establishes yet another attenuation coefficient to be used in the calculation of absolute left ventricular volume from radionuclide angiocardiograms. Among the factors to account for the variation in reported values for attenuation coefficients they might include the use of water as an attenuating and scattering medium in in vitro experiments as a simplification of the chest wall and thoracic contents.

As a general statement, I do not agree that "it is unlikely that the radionuclide technique will have enough accuracy to detect small, physiological, or pathological changes of left ventricular volumes." The problems of reproducing left ventricular depth, background counts, and left ventricular edges manually have to a large extent been overcome by the method for left ventricular volume measurement we now employ routinely in our laboratory (*2*).

We reported that left ventricular count determination (edge detection and background subtraction) is more reproducible using a semi-automated second derivative edge detection algorithm than manual techniques (*3*). Using this method of left ventricular count determination to calculate stroke counts, and with simultaneous stroke volume measurements by thermodilution, we were able to derive a mean *apparent* tissue attenuation coefficient of 0.16 cm^{-1}.

The reproducibility of left ventricular "depth" measurement is, we think, enhanced by use of a computer program to find the center of left ventricular count density in the anterior projection. The center of the left ventricle is identified manually in the left anterior oblique projection, however.

This method of left ventricular count determination and this apparent tissue attenuation coefficient have been prospectively applied in volume determinations for comparison with contrast ventriculographic volume measurements (*2*). Although our radionuclide angiocardiograms and single-plane contrast ventriculograms were performed within 1 hr of each

other, rather than on different days, the standard error of the scintigraphic estimate of left ventricular end-diastolic volume was similar (15.8 ml) to that found by Verani et al. (16.4 ml). We were encouraged, however, that the analysis of our subgroup of patients with angiographically normal wall motion provided a standard error of only 5.1 ml. Mean interobserver variability was 5.4 ml.

We hypothesized that ventricles which best conform to ellipsoid shape as assumed in area-length volume calculations provide the best correlation with our optimized count-based scintigraphic left ventricular volume measurement. If this is so, we may further hypothesize that greater differences which occur between contrast and scintigraphic volume measurements of abnormal ventricles might be on the basis of errors in the area-length technique. While contrast ventriculography remains the most accepted procedure for measurement of left ventricular volume, I feel that a statement of the inability of count-based left ventricular volume measurement to detect small physiologic or pathologic changes is unwarranted, in that our more automated method at least compares favorably with contrast ventriculography.

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REPLY: Dr. Burns reminds us that the use of water as attenuating and scattering medium is an oversimplification of the complex structures present in the thorax. We would certainly acknowledge that this is so. However, as emphasized by Links et al. (*1*), the choice of water seems justified because of the similarity between the attenuation coefficient of water, blood, and soft tissue. The photons emanating from the left ventricle must, of course, transverse the path that includes lung tissue, air, and the chest wall. Although the latter is denser than water because of its bone content, the inflated lungs are less dense than water, thus in effect the average attenuation coefficient is close to that of water. The derivation of the attenuation coefficient as performed by Burns et al. in patients with open heart surgery (*2*) may not be applicable to ambulatory patients because of the presence of blood in the pericardium and mediastinum in the former patients.

Dr. Burns states that his technique, using a semi-automatic edge detection, is more reproducible than manual techniques. There is no doubt that the more automatic the technique, the more reproducible it is. However, the issue here is not simply reproducibility, but rather accuracy. We believe that the commercially available software for semi-automatic detection of ventricular edges, based on a four quadrant threshold, is not very accurate in delineating the true ventricular edges, particularly in regions such as the septal and basal left ventricle. Using a similar semi-automatic technique, based on a second derivative and count-threshold algorithm, Links et al. (*1*) found a consistent underestimation of the ventricular volumes, as opposed to the manual determination, which correlated better with the angiographic volumes. It must be remembered, too, that the regional thresholds are determined by the operator, based on a subjective visual assessment of the best edge tracking.

Dr. Burns suggests that the reproducibility of the left ventricular depth may be improved by using a computer algorithm. We agree with that statement and, in fact, had suggested it in our paper as a potential means to improve the technique. Incidentally, although not clearly stated in their paper (*2*), apparently Burns et al. also determined the left ventricular and marker centers manually. Dr. Burns suggests that, using his technique, a superior correlation was found with contrast ventriculography. However, in his study, the radionuclide angiographic technique consistently overestimated the contrast volumes with a highly significant difference between the two techniques ($t = 7.8$, $p < 0.001$ by paired t-test). In this small series of 18 patients, all but two had normal left ventricular volumes. In these two patients with large left ventricular volumes, the overestimation by the radionuclide technique was very substantial.

Dr. Burns also points out that some of the discrepancies between contrast and radionuclide angiography may lie with deficiencies in the contrast techniques, all of which are well known, such as the ellipsoid assumption, single plane limitations, presence of dyssynergy, etc. We would suggest that in Burns' study, another limitation may have been a poor opacification of the left ventricular cavity due to the small amounts of contrast injected (as little as 25 ml). Although we agree with the potential, theoretical, and practical pitfalls of contrast ventriculography we feel it is a self serving argument to use contrast ventriculography as the "gold standard" and then justify the discrepancies in correlation by denigrating the "gold standard."

Thus, although Dr. Burns takes issue with our statement that "it is unlikely that the radionuclide technique will have enough accuracy to detect small, physiologic, or pathologic changes of left ventricular volumes" it is clear from any published data, including our own as well as Dr. Burns', that this is a realistic statement and may also apply to other techniques used to measure ventricular volumes including contrast angiography.

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