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Editorial

Potential Hazards of Xenon Inhalation

The computed tomographic (CT) method using stable xenon to measure regional cerebral blood flow (rCBF) was first proposed in 1977 [1–4]. Recently it has found increased clinical application because of the availability of computer software and a xenon delivery system for the GE 9800 CT scanner. Other manufacturers are preparing similar packages for users of their scanners.

This method has many advantages. The spatial resolution surpasses that of single-photon emission and positron emission tomography systems. Correlation with CT anatomy and pathology is exact. It is particularly attractive to neuroradiologists, whose practices center on the CT scanner. No radionuclides are used and there is no dependence on a cyclotron. The cost is not excessive in comparison with other methods.

There is one shadow in this bright picture. The characteristically high lipid solubility that makes xenon a desirable agent for CT rCBF studies also accounts for its well known anesthetic effects. The adjective "mild" is often applied to xenon's anesthetic properties. This is a relative term; if a "strong" anesthetic such as halothane were used at the same partial pressure, the subject would be in a state of central nervous system depression 100 times as deep. The "strength" of an anesthetic is strongly correlated with its lipid solubility. This does not mean that xenon at 30%–35% concentration is free of hazardous or disturbing side effects. Those who have not experienced xenon themselves tend to underestimate its potency.

The anesthetic properties of xenon were investigated in the 1950s, and the findings were summarized as follows in a review article in 1963: "Xenon anesthesia thus seems like that produced by most inhalation anesthetics" [5]. Early experimenters with the xenon rCBF CT technique accepted this summation rather uncritically. It was a convenient assumption at a time when numerous technical problems stood in the way of clinical application. However, it can no longer be accepted at face value. Indeed, an article cited in the 1963 review article contradicted the statement quoted above. Pittenger et al. [6] were surprised to find that rhesus monkeys stopped breathing entirely when the partial pressure of xenon slightly exceeded atmospheric pressure. They observed that the apnea and muscular relaxation were in excess of what one might expect on the basis of the depth of anesthesia (as shown on the animals' electroencephalograms) and from experience with other anesthetic gases. It is very likely that the same central mechanism that causes apnea at high xenon concentrations is responsible for the marked slowing of respiratory rate observed during xenon CT rCBF studies [7]. Characteristically, the respiratory slowing is accompanied by a compensatory increase in tidal volume, resulting in no change in minute ventilation. This is unlike other anesthetics, which increase respiratory rate and decrease tidal volume and minute ventilation [8, 9].

Other less specific reported side effects are hallucinations and transient loss of consciousness. Many subjects report a "hangover," lasting many hours after the study [10].

The xenon CT rCBF method is an important new tool for neuroradiologists. The procedure has had an excellent safety record. There have been no reported deaths or other serious adverse sequelae. In order to maintain this outstanding record of safety, we advise the following:

1. The procedure should continue to be regarded as experimental, requiring approval of human-subjects committees and appropriate patient consent. Since there are many questions about the indications for and utility of rCBF studies in specific clinical situations, limiting studies to patients on protocols will have the added potential benefit of providing some answers.

2. A person should monitor the patient in the scanner room, should be able to see the patient, and should be prepared to terminate the procedure and administer resuscitative measures should the need arise. As with other anesthetic procedures, the patient should be fasting for at least 10 hr before the procedure.

3. Patients with reduced pulmonary function are not can-

didates for this procedure. Not only are there increased hazards to the patient, but the study is invalid because end tidal xenon may not be a reflection of arterial xenon in these patients.

4. Regional reactivity to increased arterial P_{CO_2} has been proposed as a diagnostic test with xenon CT rCBF. This should be done with great caution and the realization that increased blood flow means increased delivery of xenon and thus, increased anesthetic effect.

5. Pharmacologic knowledge is prerequisite to intelligent application of any therapeutic or diagnostic agent. Further basic research is needed on the pharmacology of xenon, with the intent of discovering measures to increase its effectiveness while minimizing adverse side effects.

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