Continuous Monitoring of Alveolar and Inspiratory Concentrations of Anesthetic and Respiratory Gases Is Safe, Simple, and Cost-Effective

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Severinghaus JW. Continuous monitoring of alveolar and inspiratory concentrations of anesthetic and respiratory gases is safe, simple, and cost-effective.

J Clin Monit 1987;3:123

KEY WORDS. Anesthetics: gases. Carbon dioxide. Oxygen. Monitoring: anesthetic gas; carbon dioxide; oxygen. Measurement techniques: capnometry; mass spectrometry.

There are at present no legal or ethical considerations forcing anesthetists to monitor end-tidal and inspired gases except for inspired oxygen, and I assume that not to be at issue here. My position is that patient safety is sufficiently enhanced by the monitoring of end-tidal carbon dioxide tension and either inspired or end-tidal anesthetic gas concentration to justify its routine use. Although there are also side benefits, such as cost saving by the use of closed circuits, facilitation of learning about uptake and distribution of anesthetics, and possible benefits to research, these are not the foci of my argument.

In a pragmatic rather than an ideal world, we cannot argue for monitoring just because it would be nicer, better, or safer. We need to justify it quantitatively in terms of the cost-benefit ratio. In the United States, cost includes the rare but enormous expense of malpractice settlements, whereas in most of the rest of the world this is far less important. Can we make a favorable cost-benefit case favoring monitoring, discounting possible legal action? I believe we can. The reasons are few but critical.

Carbon dioxide monitoring (capnometry) detects esophageal intubation with the first expiration through the endotracheal tube. It permits adjustment of ventilation to a desired level of carbon dioxide tension. It detects hypoventilation and provides warning of sudden decreases in cardiac output, or of possible air embolism. It detects an exhausted carbon dioxide absorber or stuck valves that may cause rebreathing.

Anesthetic monitoring detects vaporizer malfunction, incorrect flowmeter settings, and wrong gas supplies. End-tidal monitoring provides assurance that the patient who is paralyzed and ventilated is neither awake nor grossly overdosed. It provides adjustable alarm limits for all gases.

When end-tidal monitoring of anesthetic agents is unavailable, there is a tendency to use intravenous rather than inhalation agents. Without entering the debate about the relative merits of these two methods, let me point out that American anesthetists equipped with continuous anesthetic agent monitoring capability employ inhalation agents for most general anesthesia.

Are there disadvantages to gas monitoring?

(1) There were fears that trainees would become dependent on the equipment. The opposite seems to be true. Trainees learn the relationship between administered and alveolar concentrations, and thus may be better able to work without monitoring later.
(2) There were fears that recorded gas concentrations, especially those from mass spectrometer systems, would be used as damaging legal evidence. In my nine years of using such systems I have experienced no legal test. However, it seems that these data would be, if anything, supportive of the user's case. No case has been recorded in which monitored data were used against an anesthetist in court.
(3) There were objections that monitoring was too much trouble and would not be used. These were valid objections when one had to cart a heavy infrared carbon dioxide analyzer to the operating room, with a separate detector head that had to be near the patient, as well as a calibration gas cylinder and a suction pump. These objections are no longer valid with modern equipment, especially with multiplexed mass spectrometers in which sampling occurs in all operating rooms although none of the analytic equipment is actually in these rooms.
(4) There were objections that monitoring would diminish attention to patients and impair the training of anesthetists in the use of their own senses. In fact the opposite seems to have happened, perhaps because these monitors permit anesthetists to "calibrate" their senses.

A sum of $100,000 will buy and install a mass spectrometer in a 10-room suite and, including maintenance costs of $20,000 per year for five years, the yearly cost is $40,000. Assuming that 20,000 hours of monitored anesthesia is provided per year, the total cost is $2 per hour. Expected recovery of monitoring costs is about $15 per hour in those instances where such charges are permitted. Even if this service were included in the physician's fee, it would represent only 2% of a typical professional fee, surely very little considering the improvement in quality of service.

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Received Nov 24, 1986. Accepted for publication Nov 26, 1986.

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