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Title: HIGH FREQUENCY RESPONSE OF A CENTRAL MASS SPECTROMETER SYSTEM TO HALOTHANE

Author: F. L. Scamman, MD

Affiliation: Department of Anesthesia, University of Iowa Hospitals and Clinics, Iowa City, Iowa 52242

Introduction. Monitoring of anesthesia gases utilizing a centrally located mass spectrometer is now very common. Previous work has shown that the long sampling catheters cause errors in the determination of carbon dioxide, particularly at high respiratory frequencies[1,2]. Similar investigations for halothane have not been reported.

Methods. The mass spectrometer system tested was an operational Perkin-Elmer Advantage system serving 12 operating rooms. The halothane mixture was obtained by setting the vaporizer on an anesthesia machine to 4% at a 1 l/min oxygen flow, closing the pop-off valve on the circle, and sampling from the patient Y-connector. Rapid changes in halothane concentration were created by an electronically driven solenoid valve switching between the halothane mixture simulating inspiration and 7% CO_2 in 50% O_2 balance N_2 simulating expiration. The mass spectrometer sampled from the output of the solenoid at 250 ml/min through 160 feet of catheter. The inspired-expired time ratio was was fixed at 1:2 and the frequency varied between 6 and 98 per min. Halothane values were derived by the system and taken from the paper copy of the screen image of the display unit in the operating room. Both the digital values as reported on the master screen and the analog values of the actual waveforms were analyzed.

Results. The data are reported in table 1. Values of the expired halothane concentration, all of which should have been zero, were already non-zero at the lowest frequency tested and increased rapidly until there was a 10% (of inspired) error at 32/min. The waveform-determined and digital values agreed closely. In contrast, values of the inspired halothane concentration varied greatly between the waveform-determined and digital measurements. At 6/min, the halothane waveform indicated 4.69% while the digital value was 2.80%, a 40% error. The digital value did not change appreciably from 6 to 40/min. However, during this frequency interval, the waveform-determined value dropped to 3.20%.

Discussion. Long sampling catheters are known to limit the highest frequency at which CO_2 concentration values may be determined accurately[2]. Now, there is a limitation imposed on the accurate determination of halothane, extending even to low frequencies. The algorithm by which the system computer determined the inspired value was in error by 40%. There are at least two possible explanations for this error. The first is that the transport of a concentration change down a long catheter distorts a halothane waveform more than one for CO_2. This is demonstrated in fig 1 by the crisp waveform of CO_2 and the sloppy waveform of halothane, captured simultaneously at a rate of 19/min. Secondly, the computer uses CO_2 concentration changes to detect inspiration and expiration. Once the computer decides, from a CO_2 increase, that a valid expiration has started, it must obtain the values of the other gases. This expiration determination and the sampling of the other gas values takes time, evidently so much time that the halothane value has fallen considerably from its peak inspiratory value by the time its digital value is determined.

The clinical implications of errors in halothane determination are confined primarily to induction and emergence. The errors are such that on induction the anesthetist might be prompted to increase the inspired halothane concentration more than necessary, with adverse effects. On the other hand, the expiratory value will be erroneously high, prompting him to reduce the halothane concentration. As the frequency increases, the two values converge towards the mean of the two. Therefore, during maintenance when the inspired-expired concentration differences are small, the maximum error would also be small. For critical applications where respiratory frequencies exceed 32/min, a centrally located mass spectrometer may not be adequate for the measurement of halothane.

References. 1. Scamman FL. Accuracy of a central mass spectrometer system at high respiratory frequencies. Anesthesiology 65:A136, 1986. 2. Scamman FL, Fishbaugh J. Frequency response of long mass-spectrometer sampling catheters. Anesthesiology 65:422, 1986.

Table 1.

HALOTHANE VALUES FROM MASS SPECTROMETER

	INSPIRED		EXPIRED	
RATE/MIN	ANALOG	DIGITAL	ANALOG	DIGITAL
6	4.69	2.80	0.16	0.22
13	4.45	2.91	0.23	0.24
19	4.14	2.95	0.31	0.36
32	3.52	2.96	0.47	0.53
40	3.20	2.88	0.55	0.56
53	2.73	2.26	0.70	0.95
98	1.95	1.73	1.41	1.66

Figure 1.

CO_2 AND HALOTHANE WAVEFORMS AT 19/MIN