Title: CLINICAL UTILITY OF RESPIRATORY GAS MONITORING BY MASS SPECTROMETRY

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Introduction The use of mass spectrometry (MS) is now being incorporated into the practice of anesthesia in many operating rooms; however, little research has been done to document its clinical relevance. The ability to measure both inspired and expired gas tensions of O_2, CO_2, N_2, N_2O, and volatile anesthetics provides a wealth of previously inaccessible information which may enhance patient safety by providing early evidence of esophageal intubations, disconnection of the anesthesia circuit, vaporizer errors, and other critical events. The purpose of this study was to determine the clinical significance of the MS in regard to patient management and patient safety.

Methods With institutional approval, 339 adult patients undergoing all types of operative procedures except open heart surgery were studied. Patients were ASA I-IV and the same ten attending anesthesiologists were responsible for the administration of general anesthesia. Cases were randomly divided into two groups. In Group I patients, the anesthesiologist had full access to the data from the MS, and in Group II they were blinded to the data. In all cases, the MS was in operation and data was monitored and recorded by a computerized data acquisition system. All cases had in-line inspired oxygen analyzers and the anesthesiologist was allowed to use a pulse oximeter or capnograph (neurosurgery). Blood gases were obtained when requested by the anesthesiologist. Values for mildly and grossly abnormal concentrations of gases were assigned for O_2, CO_2, N_2, and the inhalation agents (Table 1). Comparisons between the computerized data from the MS and the anesthetic record were made with regard to events missed by the anesthesiologist that were documented by the MS. Statistics included student's T-test and chi square analysis.

Results There were 164 cases in Group I and 175 cases in Group II. The groups were the same with regard to age, weight, ASA physical status, and types and lengths of procedures. There were no significant differences between groups in the number of mildly or grossly abnormal events missed for CO_2, N_2, or inhaled anesthetic agent (Table 2). However, 10 patients in Group II had abnormally low inspired O_2. There were also two events of clinical significance in Group I that were detected by use of the MS. The first of these was the simultaneous administration of two anesthetic agents (1-2% each) following service on the anesthesia machine the preceding evening. The MS was the only means of detecting this problem. The second event was disconnection of the anesthetic circuit first recognized with use of the MS. There were no major clinical events missed by the anesthesiologists in Group II working without the MS.

Discussion Various monitoring devices have been developed to measure inspired oxygen concentration and end-tidal carbon dioxide on a continuous basis. These are useful in determining the adequacy of oxygen delivery by the anesthesia machine and for diagnosing inadequate ventilation during surgery, respectively. However, there are many other measurements of adequacy of gas delivery and exchange that could provide useful information to the anesthesiologist and the MS has incorporated these capabilities into a single device which provides continuous monitoring as well as trending of each parameter over several hours. The resulting amount of information could allow the diagnosis of problems in gas delivery, adequacy of ventilation, and significant changes in a patient's physiologic status. Our study found no significant advantage with the use of the MS versus clinical observation with regard to abnormal levels of gases. The lack of significance in most areas may be due to review of a relatively small number of cases. Studies of cardiac arrest while undergoing anesthesia have demonstrated that 10-33% of these incidents have been due to gross overdose of an inhalation agent.[1] Such an error is easily detectable with an MS as is the identification of the agent being delivered. In one case in Group I, the MS demonstrated a significant vaporizor error with administration of 2 agents simultaneously. The MS also demonstrated surprisingly high incidences of air leaks and air emboli by analyzing for N_2, and rebreathing of CO_2. In addition, in 10 Group II patients, the anesthesiologist felt comfortable giving a high concentration of volatile agent with monitoring by the MS. In conclusion, the MS was not shown to be needed for routine gas monitoring. However, consistent with other reports,[2,3] it was useful for diagnosing rare, life-threatening clincial events.

References

1. Keenan RL, Boyan P: Cardiac arrest due to anesthesia. JAMA 253:2373-2377, 1985.
2. Swedlow DB: Capnometry and capnography: the anesthesia disaster early warning system. Seminars in Anesthesia 5:194-205, 1986.
3. Whitcher C: Monitoring of anesthetic halocarbons: self-contained ('stand-alone') equipment. Seminars in Anesthesia 5:213-224, 1986.

Table 1

	Values (%) for Abnormal	Grossly Abnormal
I O_2	$\angle$ 30	$\angle$ 20
I CO_2	0	-
E CO_2	$\angle$ 4 or $\succ$ 6	$\angle$3 or $\succ$ 7
I N_2	.1-5	$\succ$ 5
E N_2	.1-5	$\succ$5
I Inhal	$\succ$ 2	$\succ$4

Table 2

	# of events Abnormal		Grossly Abnormal	
	B	U	B	U
I O_2	10	1	-	-
I CO_2	23	19	-	-
E CO_2	93	114	21	34
I N_2	13	6	29	24
E N_2	6	7	31	23
I Inhal		7		10