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Hazards of Mis-filled Vaporizers: Summary Tables

To the Editor:—Martin[1] describes an incident in which isoflurane was inadvertently placed in a methoxyflurane vaporizer, with nearly disasterous results. Similar incidents have been described over the years.[2–4]

For some time I have used table 1 in resident lectures to summarize the potential hazards of filling vaporizers with the incorrect agent. This table is useful because it permits ready comparison of combinations at equipotent vaporizer settings. The table illustrates what concentration will be delivered if the anesthesiologist, not knowing what is *in* the vaporizer, uses it in a manner appropriate to the agent for which it was designed (in the case of an agent-specific vaporizer) or (in the case of a kettle-type vaporizer) appropriate to what he or she *thinks* is in it.

TABLE 1. Theoretic Concentration* Delivered (and MAC equivalent) for Vaporizers Filled with Various Volatile Anesthetics, When Vaporizer Is Set to a Concentration Equivalent to 1.0 MAC, Appropriate to the Type of Vaporizer

	Agent in Vaporizer (Vapor Pressure at 20° C)			
	Halothane (244.1 mmHg)	Enflurane (171.8 mmHg)	Isoflurane (239.5 mmHg)	Methoxyflurane (22.8 mmHg)
Type of vaporizer (setting at 1.0 MAC)				
Halothane (0.75%)	0.75% (1.0 MAC)	0.46% (0.28 MAC)	0.73% (0.63 MAC)	0.05% (0.31 MAC)
Enflurane (1.68%)	2.69% (3.59 MAC)	1.68% (1.0 MAC)	2.62% (2.28 MAC)	0.18% (1.13 MAC)
Isoflurane (1.15%)	1.18% (1.58 MAC)	0.73% (0.44 MAC)	1.15% (1.0 MAC)	0.08% (0.49 MAC)
Methoxyflurane (0.16%)	2.39% (3.19 MAC)	1.49% (0.89 MAC)	2.33% (2.02 MAC)	0.16% (1.0 MAC)

* Delivered concentration (F′) is calculated as follows:

$$F' = F\frac{P'_v}{P_v}\left[\frac{P_b - P_v}{P_b - P'_v - FP_b\left(1 - \frac{P'_v}{P_v}\right)}\right]$$

Where F is the vaporizer concentration setting, P_v is the vapor pressure of the agent for which the vaporizer is designed, P'_v is the vapor pressure of the agent in the vaporizer, and P_b is ambient (barometric) pressure. This equation is required for the more common vaporizer design in which the *inflow* to the vaporizing chamber is controlled. If the *outflow* were controlled, the correction quantity in square brackets would not be required.

TABLE 2. Theoretic Concentration* Delivered (and MAC equivalent) for Vaporizers Filled with Various Volatile Anesthetics, When Vaporizer Is Set to a Concentration Equivalent to 1.0 MAC, Appropriate to the Agent in the Vaporizer

	Agent in Vaporizer (vapor pressure at 20° C) (Vaporizer setting at 1.0 MAC)			
	Halothane (244.1 mmHg) (0.75%)	Enflurane (171.8 mmHg) (1.68%)	Isoflurane (239.5 mmHg) (1.15%)	Methoxyflurane (22.8 mmHg) (0.16%)
Type of vaporizer				
Halothane	0.75% (1.0 MAC)	1.04% (0.62 MAC)	1.12% (0.97 MAC)	0.01% (0.07 MAC)
Enflurane	1.21% (1.61 MAC)	1.68% (1.0 MAC)	1.80% (1.57 MAC)	0.02% (0.11 MAC)
Isoflurane	0.77% (1.03 MAC)	1.07% (0.64 MAC)	1.15% (1.0 MAC)	0.01% (0.07 MAC)
Methoxyflurane	10.4% (13.8 MAC)	13.9% (8.27 MAC)	14.8% (12.8 MAC)	0.16% (1.0 MAC)

* Delivered concentration (F′) is calculated as follows:

$$F' = F\frac{P'_v}{P_v}\left[\frac{P_b - P_v}{P_b - P'_v - FP_b\left(1 - \frac{P'_v}{P_v}\right)}\right]$$

Where F is the vaporizer concentration setting, P_v is the vapor pressure of the agent for which the vaporizer is designed, P'_v is the vapor pressure of the agent in the vaporizer, and P_b is ambient (barometric) pressure. This equation is required for the more common vaporizer design in which the *inflow* to the vaporizing chamber is controlled. If the *outflow* were controlled, the correction quantity in square brackets would not be required.

The incident described by Dr. Martin is somewhat different, and an alternative summary table is needed. In this case, the anesthesiologist effectively did not know what agent the agent-specific vaporizer was designed for but *did* know what was in it. Here the settings were appropriate for the *agent* but not for the vaporizer. The theoretic concentrations that would be delivered in this second situation are summarized in table 2.

It is reasonable to assume the more likely error is the former. Agent-specific vaporizers usually are clearly labeled, and it is unlikely that these markings would be ignored. However, exceptions do exist, as evidenced by Dr. Martin's experience. Since the pin-index filling system has not been universally adopted, the potential hazards summarized in these tables illustrate the need for vigilance even in such apparently mundane tasks as filling the vaporizer.

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REFERENCES

1. Martin ST: Hazards of agent-specific vaporizers: a case report of successful resuscitation after massive isoflurane overdose. ANESTHESIOLOGY 62:830–831, 1985
2. Chun L, Karp M: Accidental use of trichlorethylene (Trilene®, Trimar®) in a closed system. Case history #39. Anesth Analg 43:740–743, 1964
3. Mark LC, Marx GF, Erlanger H, Joffe S, Kepes ER, Ravin MB: Improper filling of kettle-type vaporizers. NY State J Med 65: 1151–1152, 1965
4. Munson ES: Hazards of agent-specific vaporizers. ANESTHESIOLOGY 34:393, 1971

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Open Eye Injuries

To the Editor:—Libonati *et al.*[1] have confirmed what I believe many anesthesiologists have known or felt for many years: a careful rapid-sequence induction using succinylcholine is the safest total patient care approach to an open eye injury in a patient with a full stomach. Other studies concerning intraocular pressure and succinylcholine have neither accurately simulated the conditions of a rapid-sequence induction nor examined the effects on an open decompressed globe.

Some time ago I attempted to approach this problem from the decision analysis point of view. In doing so I gathered some interesting data that may further support the use of succinylcholine. The 10 ophthalmologists I interviewed agreed that only a small percentage of patients with penetrating eye injuries recovered any useful sight in the injured eye. Among 27 patients who had lost sight in one eye, only two considered monocular vision a handicap.

Using decision analysis, as one would expect, the basic issue became the balance between the probability of worsening the eye injury and the ultimate consequences thereof and the probability of aspiration pneumonitis and its consequences. With all the reasonable probability and utility assignments I could make, the decision to use succinylcholine in a rapid-sequence induction was always favored. Unfortunately, I did not have enough hard numbers to ensure the validity of the decision analysis.

We are fortunate that Libonati *et al.* have published their results. They may save more lives and prevent more morbidity than many of the esoteric articles we read.

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REFERENCE

1. Libonati MM, Leahy JJ, Ellison N: The use of succinylcholine in open eye surgery. ANESTHESIOLOGY 62:637–640, 1985

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Problems in Interpreting Gastric Pressure Measurements

To the Editor:—The article by Dureuil *et al.*[1] concerning the effects of aminophylline on breathing in patients after abdominal surgery is of interest but difficult to interpret. This is partly because their results are expressed as changes, such as ΔPga, the difference between gastric pressure at end-inspiration and gastric pressure during