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Severe Intraoperative CO Poisoning

Should Apathy Prevail?

IN this issue of ANESTHESIOLOGY, Berry *et al.*[1] report the most severe case of intraoperative carbon monoxide (CO) poisoning yet identified in a human. This report comes after the probable mechanism of CO formation has been reported,[2] predisposing factors and incidence rates for exposures have been published,[3] and means for monitoring for CO exist at least in some clinical settings. At a time when it appears that nearly all clinically relevant information is known and the issue of CO poisoning has become tiresome and passé, we are presented with a case report that might be construed as a near miss, a preventable fatality barely averted by recognition and treatment of the exposure. This report raises more questions than it answers.

Before this report, it appeared that at least 5–10 l/min fresh gas flow for 1 or 2 days with the proper circuit configuration were required to desiccate the absorbent sufficiently to permit anesthetic breakdown with CO formation. We must now reevaluate all of the possible predisposing factors that can lead to absorbent desiccation. Even the minimum fresh gas flow, given sufficient time, can desiccate absorbents enough to produce severe anesthetic breakdown. This suggests that the configuration and features of the anesthesia machine, such as the minimum fresh gas flow rate, can enhance or degrade patient safety. If the quantity of CO produced depends on the quantity of desiccated absorbent, should the minimum quantity of absorbent be used instead of two completely filled canisters? Because only one or two chemicals that constitute the absorbent can generate CO when desiccated,[2] can the quantity and composition of alkaline materials be changed to enhance safety while maintaining adequate CO_2 absorbing qualities? Further research may answer these questions, but today's answer may be to change to fresh absorbent in *any* situation in which desiccation could have occurred, even if it is extremely unlikely. This is not without the economic disadvantage of requiring more time or more personnel to perform this service, in addition to the cost of the absorbent. Perfectly usable absorbent of unverified water content will be discarded in some situations to enhance safety. Depending on the perceived risk of CO exposures and the cost of absorbent, would this extra cost be permitted by hospital administrators? If financial resources are limited, as they already are, what other equipment or supplies would we forfeit to pay for unnecessary fresh absorbent?

Should monitoring be our first line of defense? Improved monitoring, whether infrared, electrochemical, mass spectrometric, or oximetric, may provide sufficient warning to prevent patient exposure or to discontinue an ongoing exposure before harm is likely. Relatively expensive monitoring may become cost-effective if balanced against the potential cost of absorbent in the absence of monitoring for anesthetic breakdown to CO.

But the real question may be more fundamental. Regarding intraoperative CO poisoning, and with tongue in cheek, I have categorized anesthesia providers into two groups: the Overconcerned and the Apathetic. The Overconcerned may have become so after a patient was actually exposed to CO *via* anesthetic breakdown. The Overconcerned may note similarities in the care of their machines to those that predispose to CO exposures, or the Overconcerned may just be the worrying sort; forever fearful that some harm may come. Just because one

◆ This Editorial View accompanies the following case report: Berry PD, Sessler DI, Larson MD: Severe carbon monoxide poisoning during desflurane anesthesia. ANESTHESIOLOGY 1999; 90:613–6.

Since completion of the preceding editorial view, an additional case of severe carbon monoxide poisoning during anesthesia has been reported in the ECRI Health Devices Newsletter. According to the ECRI Hazard Report, they investigated several incidents of carbon monoxide exposure during inhalational anesthesia. In each case it was concluded that dangerous gas levels were generated (ECRI Editorial Staff: Carbon monoxide exposure during inhalation anesthesia: The interaction between halogenated anesthetics agents and carbon dioxide absorbents (Hazard Report). Health Devices 1998; 27(11):402–4).

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is paranoid does not mean others are not out to get him or her.

And then there are the Apathetic. The Apathetic may be overconfident, uninformed, or in denial of the possibility of a problem. However, there may be scientific bases supporting apathy. No case report has ever documented that patient harm resulted from intraoperative CO exposures. The Overconcerned may retort that most cases of CO exposure go unrecognized for lack of adequate monitoring. However, the Apathetic may counter that many, if not most, CO exposures occur during fires, when other toxic agents may also be present in smoke. The risk of sequelae for physically active firefighters or victims of smoke inhalation may not be directly comparable to pure CO poisoning in anesthetized patients receiving physiologic support. The Overconcerned can reply that in the report by Berry *et al.*,[1] the patient who attained 36% carboxyhemoglobin had an ASA physical status 1 and was the subject of a clinical study. Depending on the nature of the clinical study, the physiologic stress may be much less than in patients undergoing surgical procedures, or from those in the conscious nonoperative settings. It may be possible that comparable CO exposures in the presence of concurrent disease or in other clinical scenarios may predispose patients to far greater risks. As Berry *et al.*[1] noted, CO in far lower concentrations markedly worsened myocardial ischemia in several other studies during the physiologic stress of exercise.

Do unrecognized episodes of intraoperative CO exposure result in or exacerbate cardiac morbidity? If so, what is the cost of these episodes, whether measured in terms of permanent disability to the patient or in terms of health-care dollars spent in intensive care unit treatment or the pursuit of a diagnosis in patients who may have "only" CO poisoning?

The authors also noted that delayed neurologic sequelae after CO exposures were observed in other situations. How often do we as anesthesiologists examine patients for delayed neurologic sequelae? What does this mean for the potentially unrecognized clinical CO exposures in patients undergoing carotid endarterectomy, spinal surgery, or craniotomy? No studies to date have investigated these potential interactions.

The ASA Web site provides the estimate that 25 million anesthetic procedures are performed each year in the US. Although hard statistics are difficult to obtain, if as little as 33% of these anesthetics involve isoflurane, enflurane, or desflurane, and if four cases are performed in the average operating room each day so that 25% of cases will be first cases, then up to 2 million patients may be at risk each yr for intraoperative CO exposure. If the published incidence of CO exposures can be generalized to other institutions and remains between 1/2,000 and 1/200 first cases,[3] then approximately 1,000–10,000 patients may actually be exposed to CO each yr in the US as a result of anesthetic breakdown. Worldwide, these numbers may be far greater. The incidence of massive CO exposures analogous to that reported by Berry *et al.*[1] is also unknown, and even greater exposures are possible, as predicted by mathematic modeling[4,5] and demonstrated in animals by Frink *et al.*[6] In the absence of effective means of detection, it is possible that the majority of these cases go undiagnosed. Berry *et al.*[1] noted no specific signs of CO poisoning during anesthesia in the current report, so it remains possible that any potential problems caused by CO poisoning during anesthesia may be attributed to other causes. The true morbidity from intraoperative CO poisoning is uncertain. The economic costs of intraoperative CO poisoning and its prevention remain unknown.

Is it politically correct to join the ranks of the Apathetic? Or is it safer to affiliate with the Overconcerned? Today, we may still have insufficient knowledge to place this problem in perspective. Perhaps common sense and further study should prevail.

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