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Internal Common Gas Line Disconnect

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ALTHOUGH anesthesia mishaps caused by equipment failure are uncommon, they occur often enough to be of concern to anesthesia providers.[1–3],* Cooper *et al.*,[3] in a retrospective study of critical incidents, identified equipment failure as the second most common cause of preventable mishaps in anesthesia practice. This report recounts a previously undescribed problem with an Ohmeda model 8000 anesthesia machine (Madison, WI) that could have caused a catastrophic incident. A preanesthetic examination, which checked the internal integrity of the anesthesia machine, could have discovered the problem with the machine before it was used for patient care.

Case Report

A 28-yr-old, 80-kg, G4P1 woman pregnant with twins at 36 weeks of gestational age was admitted for spontaneous delivery. She had no significant medical problems except for a recent hospitalization for treatment of premature labor with bed rest and terbutaline. She was discharged 1 week before this admission.

The on-call anesthesia provider was called on short notice for emergency stand-by for vaginal delivery or possible cesarean section. The first twin delivered uneventfully while the anesthesia provider was enroute to the delivery room (APGAR 7 and 8 at 1 and 5 min, respectively). The second twin rapidly developed fetal bradycardia. The anesthesia provider, on arriving in the delivery room, was informed by the surgeon that an immediate cesarean section may be necessary, and turned on the anesthesia machine (8000 anesthesia machine) and monitors. Given the urgency of the situation, only an abbreviated anesthesia machine inspection was performed. The oxygen flow was turned to 8 l/min, and the flow meter bobbin was noted to rise. The anesthesia circle circuit was pressurized to 40 cm of water *via* the oxygen flush control, and the reservoir bag was squeezed and noted to be firm with no apparent leak. The anesthesia circuit oxygen monitor was turned on and noted to indicate an oxygen concentration of 21% oxygen in room air. The oxygen sensor was returned to the circuit. The suction was turned on and noted to be adequate.

Because the second twin was in fetal distress, the oxygen flow was set at 8 l/min, and the anesthesia mask was placed on the patient in an effort to increase maternal oxygenation. The electrocardiogram, blood pressure cuff, and pulse oximeter were placed at this time. The initial hemoglobin oxygen saturation noted on the pulse oximeter (SpO_2) was 97%. With the mask held tightly to the patient's face and the patient breathing spontaneously, it was noted that the SpO_2 began to decrease. The pulse oximeter probe was checked and found to be placed properly. Because the patient was not in left uterine tilt position, this was established by the anesthesia provider. The circuit oxygen analyzer indicated an oxygen concentration of 28%, despite only oxygen being administered. A new anesthesia circuit oxygen monitor was tried, and indicated the same value. The oxygen monitor was calibrated to room air. The circuit oxygen concentration was again 28%. The SpO_2 continued to decrease to 60%, and the patient developed cyanosis. The system hoses and connections were checked for leaks or disconnects, and none were found. The possibility of the hospital oxygen supply being contaminated was suspected. The inflowing gas supply was switched to oxygen supplied by the anesthesia machine tanks. The anesthesia circuit was flushed with oxygen and the anesthesia circuit oxygen concentration increased to 50% and the SpO_2 increased to 85%. The circuit oxygen concentration decreased to 35% and the SpO_2 decreased to 80%. A new anesthesia machine was obtained. The patient was supplied with oxygen from the hospital oxygen supply *via* an anesthesia mask from the second anesthesia machine. The second anesthesia machine circuit oxygen electrode showed an oxygen concentration of 100%, and the SpO_2 rapidly increased to 100%. The second twin's heart rate returned to normal, and the baby was delivered by vacuum extraction. The second twin's APGAR scores were 7 and 8 at 1 and 5 min, respectively. Both the mother and the twins were discharged from the hospital with no apparent untoward effects from the above incident. The etiology for patient's decrease in SpO_2 was not determined, and the patient left the hospital without any apparent disabilities.

Immediately after the above events, a thorough examination of the first anesthesia machine was performed by the provider with the obstetrical surgeon present. The machine was reconnected to the hospital oxygen supply. The reservoir bag was pressurized to 50 cm of water with the oxygen flush system and held for 2 min. During this phase of testing, the oxygen analyzer read 100% oxygen. No leak was detected with the pressure test. What became immediately apparent was that there was no increase in the pressure within the system with the flow meter at 8 l/min. By disconnecting the common gas line from the absorber head, the anesthesia provider determined that no flow was coming from the anesthesia machine *via* the flow

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Key words: Anesthesia machine. Checklist. Ohmeda 8000.

* National Association of Insurance Commissioners: Malpractice closed claim study 1975–1978. Milwaukee, National Association of Insurance Commissioners, 1980.

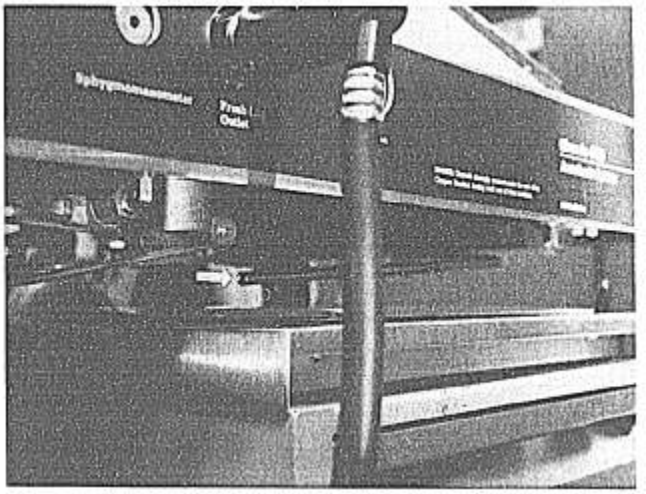

Fig. 1. The common gas line hanging below the anesthesia machine is indicated by an arrow. It is disconnected from its compression fitting at a point before the outlet check valve and the oxygen flush system.

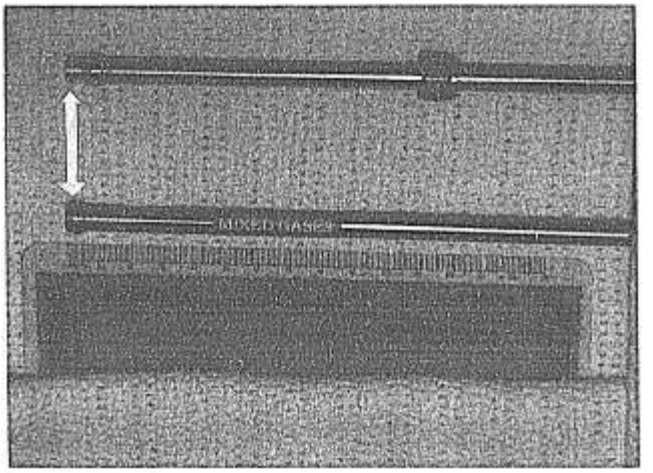

Fig. 2. A properly crimped common gas line is positioned above a improperly crimped line. An arrow points to the crimp. Note that the sleeve in the improperly crimped line is crimped on the very end of the tube and can be pulled off with finger pressure.

meters. Yet, pushing the oxygen flush provided very adequate gas flow. By looking under the anesthesia machine and following the supply source backward, the provider found that the common gas line from the vaporizers/flowmeters had been pulled out and disconnected. The common gas line was disconnected from its compression fitting at a point before the outlet check valve and the oxygen flush system (fig. 1).

A representative and a repair person from Ohmeda examined the anesthesia machine. They found that the sleeve of the compression fitting, which is supposed to be crimped to the common gas tubing several millimeters from the end of the tube, was, in fact, at the end of the tube. The sleeve was loosely crimped to the very end of the tubing, which resulted in a weak joint (fig. 2). In addition, the repair person noted that the common gas line had been installed in the factory in such a way that there was tension on the joint. The common gas line in this machine went around the pressure regulator. Other Ohmeda 8000 anesthesia machines in our department have the common gas line passing under the pressure regulator. We noted that an inexperienced person, perhaps reaching under the anesthesia machine to get a grip for moving it, may grab the common gas line, pulling it out of its compression fitting (fig. 3). After the above incident, we and Ohmeda reported the above event to the Food and Drug Administration. Ohmeda also distributed an urgent device recall advisory and a possible recall of the Ohmeda model 8000 anesthesia system and the Boyle anesthesia system for this problem of internal leak.

Discussion

This case highlights the importance of testing the anesthesia machine for internal leaks. Often, testing for leaks by pressurizing the circle breathing circuit will not detect leaks within the machine.[4] Many anesthesia machines, including the Ohmeda 8000 anesthesia machine, are equipped with unidirectional check valves near the common outlet to prevent pressures in the breathing system from affecting the accuracy of the flowmeters or vaporizers. Testing the circle breathing circuit for leaks by pressurization will reveal only leaks downstream of the check valves, as occurred in this case.[5]

Ohmeda recommends performing a back pressure leak test to verify the integrity of the low-pressure gas

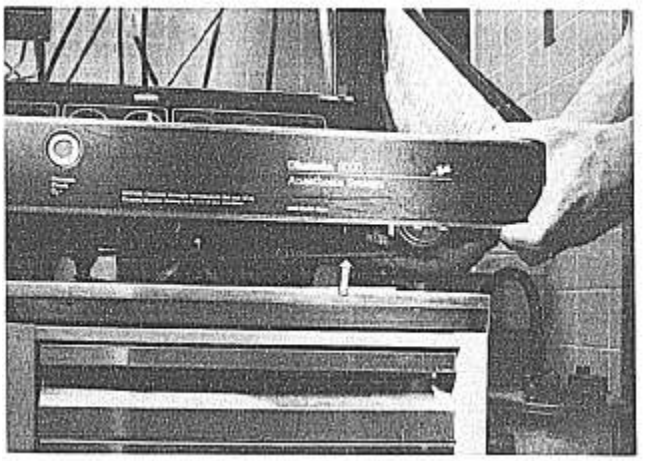

Fig. 3. A person using this grip to move a Ohmeda 8000 anesthesia machine could produce significant traction on the common gas line. The common gas line is indicated by the arrow.

circuitry before each case. The back pressure leak test is performed with a back pressure leak test device, which is included with each Ohmeda anesthesia machine. The back pressure leak test device consists of a syringe that is depressed while monitoring a pressure gauge inserted into the common gas outlet of the anesthesia machine. A leak in excess of 30 ml/min at a pressure of 30 cm water indicates that repairs are necessary to the anesthesia machine.†

Another way to test the anesthesia machine for internal leaks is suggested by Dorsch and Dorsch.[5] A pressure gauge is attached to the common gas outlet or the fresh gas hose. The flow control valve of the machine's flowmeter is slowly opened until the pressure reaches 30 cm of water. The flow is then lowered until a static equilibrium between the gas flow and the leak is established at a pressure of 30 cm of water. The flow rate on the flowmeter is then equal to the leak rate in the machine, which should be less than 50 ml/min. This procedure can also be performed using the pressure gauge in the anesthesia machine's circle breathing circuit, as suggested by the first version of the Food and Drug Administration (FDA) anesthesia apparatus checklist.‡ The pressure relief (pop-off) valve is closed, and the outlet of the circuit at the patient end is occluded. The system is filled with oxygen flush until the bag is just full. The oxygen flow is then set to 5 l/min. The flow from the machine is then lowered to the point at which the pressure gauge no longer rises above 20 cm of water. The oxygen flow should then approximate the total leak rate when the pressure just stops rising. The leak rate should be no greater than a few hundred ml/min. These two test procedures do not work with machines with minimum oxygen flow. The Ohmeda 8000 has a minimum oxygen flow of 200 ml/min.

The FDA checklist has recently been revised, and now recommends the use of a negative pressure leak check bulb (a squeeze bulb) being connected to the common gas outlet. Such a leak test will apply to machines with and without check valves, and the test is universally applicable, simple, and sensitive. All three of the above techniques would have detected the leak caused by the failure we have described. It would, therefore, be prudent to perform some type of internal leak test before using an anesthesia machine.

† Ohmeda 8000 anesthesia machine operation and maintenance manual. Madison, BOC Health Care, 1987, pp 21–22.

‡ Anesthesia apparatus checkout recommendations. Washington, DC, Food and Drug Administration, 1986.

Craig and Wilson[2] determined that a "failure to perform a preanesthetic check [was] the commonest factor" in 33% of the 81 incidents studied. Human error was found by Cooper *et al.*[6] to be the dominant issue in anesthesia mishaps, with only 4% of incidents involving equipment failure. A study by Buffington *et al.*[7] noted that only an average of 2.2 out of 5 prearranged faults in an anesthesia machine were detected by a range of people of different professional backgrounds.

The current FDA checklist may not detect all machine faults. March *et al.*[8] determined that the average number of prearranged anesthesia machine faults detected with the individual anesthesiologists' checkout methods was 1.03/4; with the FDA checklist, the average number was 1.20/4. Furthermore, March *et al.*[8] also found that less than 50% of the anesthesia personnel found a prearranged low-pressure leak between the flowmeters and the common gas outlet, which was the area of our leak. This may indicate that many anesthesia personnel are not checking regularly for internal anesthesia machine leaks.

All anesthesia personnel at our institution have been informed of this case, and they perform a test of the integrity of the low-pressure gas circuitry within the anesthesia machine before each case. As a result of the above events, the anesthesia machines used for emergency cases are inspected every day, and an oxygen source external to the anesthesia machine has been made available in each anesthetizing location.

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