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Unsuspected Endobronchial Intubation—Detection by Continuous Mass Spectrometry

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Accidental insertion of an endotracheal tube into a mainstem bronchus may occur during endotracheal intubation or at any time during the course of anesthesia. This problem may be detected by bilateral auscultation of breath sounds, observation of chest wall movement, change in airway pressure, bronchoscopy, chest roentgenographic examination, and knowledge of trachea and tube size.[1] Early discovery of unintentional endobronchial intubation is required to avoid the consequences of one-lung ventilation (OLV) such as atelectasis in the nonventilated lung and systemic hypoxemia.[2] We describe a case of unsuspected endobronchial intubation occurring during surgery, which was revealed by use of an on-line, time-shared medical gas analyzer.

REPORT OF A CASE

A 9-kg, 15-month-old boy presented for elective right orbitotomy and insertion of a Broviak catheter. One week earlier he had undergone an uncomplicated general anesthetic for needle biopsy of a right retroorbital tumor.

He was premedicated with morphine sulfate 0.6 mg, secobarbital 20 mg, and scopolamine 0.1 mg im 1 h before surgery and was sleepy upon arrival at the operating room. Electrocardiogram electrodes were applied, and an infant precordial stethoscope was taped near the left nipple. An uneventful inhalation induction was performed using oxygen, halothane, and nitrous oxide. Following placement of two iv catheters, gallamine 40 mg, and fentanyl 50 μg were given. A rectal temperature probe was inserted. A 4.5-mm ID Portex uncuffed oral endotracheal tube was inserted under direct vision without difficulty. Breath sounds were auscultated bilaterally and judged to be equal. The endotracheal tube was taped in position and breath sounds were rechecked. Controlled ventilation commenced with a tidal volume of 120 ml at a rate of 30 breaths per minute. Peak airway pressure was 10 cm H_2O. A gas-sampling connector for a Perkin-Elmer® Medical Gas Analyzer MGA-1100 (Pomona, California) continuous on-line mass spectrometer was inserted at the top of the endotracheal tube. This gas analyzer displays inspired and expired gas concentrations with a real-time carbon dioxide waveform. Initial end-tidal CO_2 ($P_{E_{CO_2}}$) levels of 4.6% were obtained. Surgery commenced with the patient in the supine position while the vital signs remained stable.

Twenty minutes after induction the ophthalmologist rotated the head slightly to the left to obtain better surgical exposure, and within minutes the $P_{E_{CO_2}}$ rose to 6.1% (fig. 1). Heart rate, arterial blood pressure, and temperature did not change. Following rapid inspection of the ventilator, gas machine, and the disposable coaxial rebreathing circuit the chest was auscultated. Breath sounds could not be heard over the right chest, and surgery was halted while the head was repositioned and the endotracheal tube withdrawn slightly and retaped. With bilateral breath sounds reestablished, the $P_{E_{CO_2}}$ returned to 4.1%. Surgery recommenced and was uneventful until 2¼ h later. At this time the head was rotated slightly to the left before insertion of the Broviak catheter in the right subclavian vein. Mindful of the earlier incident, the mass spectrometer monitor was examined closely, and once again the $P_{E_{CO_2}}$ began to rise (fig. 1). Right-sided endobronchial intubation was confirmed by loss of breath sounds heard through the left-sided precordial stethoscope. After further repositioning and taping of the endotracheal tube, breath sounds again could be heard over the left chest, and the $P_{E_{CO_2}}$ fell to prior levels. Surgery proceeded without further incident, and the trachea was extubated in the operating room. The patient was transported to the recovery room in good condition.

DISCUSSION

Multipatient anesthetic mass spectrometry systems are available commercially, and their use has been reviewed previously.[3] They incorporate real-time monitoring of expired carbon dioxide levels, which is recommended for rapid documentation of the status of ventilatory and metabolic systems of anesthetized patients.[4] In 1983, Murray and Modell[5] investigated how rapidly endotracheal tube accidents in dogs could be detected by monitoring changes in carbon dioxide concentration. Maneuvers such as esophageal intubation, obstruction, disconnection, or kinking of the endotracheal tube were performed, and response times to detection of these maneuvers were monitored. In all instances there was immediate recognition of absent or diminished ventilation. However, the CO_2 waveform during endobronchial intubation was not studied. Pyles[6] reported the intraoperative discovery of a dysfunctioning expiratory valve while routinely monitoring $P_{E_{CO_2}}$. The onset of unexplained tachycardia, hypertension, and diaphoresis was accompanied by elevation of both inspiratory and expiratory segments of the CO_2 waveform, which suggested rebreathing. Although not shown here, the waveform we observed had a normal baseline but an elevated expiratory segment. Similarly, Hornbein and Glauber recently reported discovery of an incorrectly placed expiratory valve within a circle system after elevated levels of inspired CO_2 were detected.[7]

An acute elevation of $P_{E_{CO_2}}$ may result from ventilator failure, increase in dead space, rapid administration of

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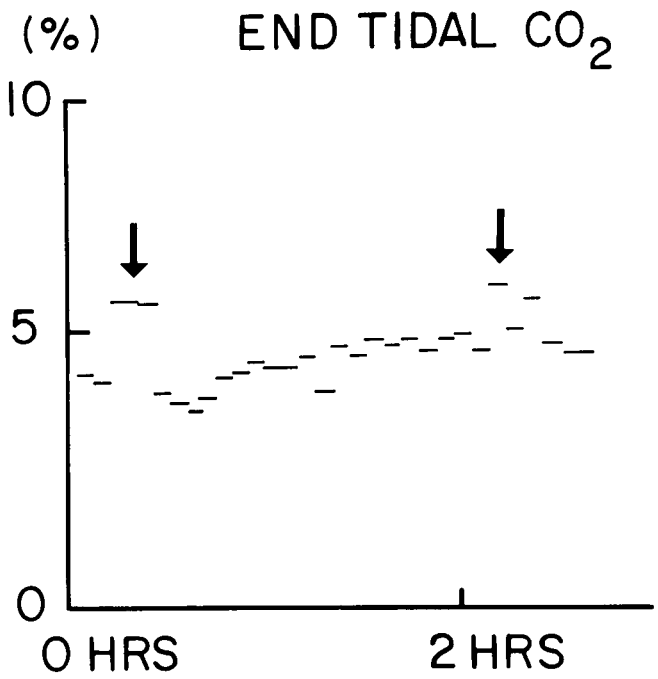

FIG. 1. Mass spectrometer trend recording of end-tidal CO_2 (PE_{CO_2}) levels. Arrows indicate periods of elevated PE_{CO_2} associated with endobronchial intubation.

dextrose[8] or bicarbonate,[9] or an acute hypermetabolic state. During OLV systemic hypoxemia is usually a greater problem then hypercarbia. Indeed, CO_2 elimination generally is not troublesome, and only a modest increase in respiratory rate is recommended to maintain normocarbia when commencing OLV.[2] Assuming that the arterial/end-tidal CO_2 gradient was unchanged in this patient, then Pa_{CO_2} probably increased by at least 10 mmHg. Since minute volume and hemodynamics appeared constant during the anesthetic period, a large quantity of venous admixture would have to be present to account for the observed increase in PE_{CO_2}. This is explained by overdistention of the ventilated lung; pulmonary blood flow is rerouted to the nonventilated lung. Accordingly, dead space would be increased and a venous admixture of more than 70% would be occurring.[10]

It seems more likely, however, that there was a significant reduction in alveolar ventilation during the periods of OLV. The area between bronchus and endotracheal tube may have acted as a threshold resistor, with escape of delivered gas around the tube when a critical pressure was attained. The net result would be reduced delivery of tidal volume to that lung. That peak airway pressure did not rise, as would be expected if overdistention of the lung was occurring, lends support to this supposition. Fortunately, the 1.5% increase in PE_{CO_2} in our case was enough to arouse suspicion of a mishap.

In summary, a case of accidental endobronchial intubation secondary to head repositioning during surgery is described. Its detection by an elevated PE_{CO_2} is further endorsement for the routine monitoring of CO_2 waveforms. Although mass spectrometer systems may themselves display erroneous information,[11] they are valuable monitors for use by anesthesiologists.

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