

FIG. 1. Inflation of an incompletely retracted blocker's cuff obstructs the tip of the Univent® tube.

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Use of the Capnograph to Detect Leaks in the Anesthesia Circuit

To the Editor:—Capnometry is a commonly used monitor of ventilation of anesthetized patients. It also provides important information about the patient's pulmonary, cardiovascular, and metabolic status.* The following case description illustrates a characteristically abnormal capnograph and its cause.

A 20-year-old man sustained a gunshot wound to the left upper back and extremity. In the emergency department, he was resuscitated and a left-sided chest tube was inserted. Angiography confirmed trauma

* Goode ML: Capnography: Uses, interpretation and pitfalls, ASA Refresher Courses in Anesthesiology, volume 18. Edited by Barash PG, Deutch S, Tinker J. Philadelphia, J.B. Lippincott, 1990, pp 175-193

operative ventilation of his lungs. The attendant ICU nurse was familiarized with the tube and was instructed not to manipulate the blocker part.

Twenty-four hours later, we were called emergently to evaluate the patient, who had suddenly developed severe respiratory distress. He was agitated and tachypneic. His arterial hemoglobin oxygen saturation was 82-84% despite ventilation with 100% oxygen. Inability to pass a suction catheter beyond the tip of the tube and severe resistance to manual ventilation of the lungs suggested tube obstruction.

The episode occurred shortly after "the cuff" was reinflated because of air leak around it. It was noticed that the blocker's pilot balloon was in the inflated position. About 5 ml of air was aspirated from the blocker's cuff, which resulted in immediate improvement of the patient's symptoms and return to normal of his vital signs. It also was possible to retract the blocker approximately 2 cm, which indicated that accidental inflation of a partially protruding blocker's cuff had resulted in severe obstruction of the tip of the tube (fig. 1).

This complication can happen at any time but is more likely to occur when management of the Univent® tube is supervised by staff unfamiliar with its function. Adequate training of ICU nurses in the use of the tube, therefore, is very important. Removal of the blocker's pilot balloon at the conclusion of surgery will eliminate the risk of this complication but also will result in loss of the blocker's function in case lung isolation was required to manage a postoperative complication.

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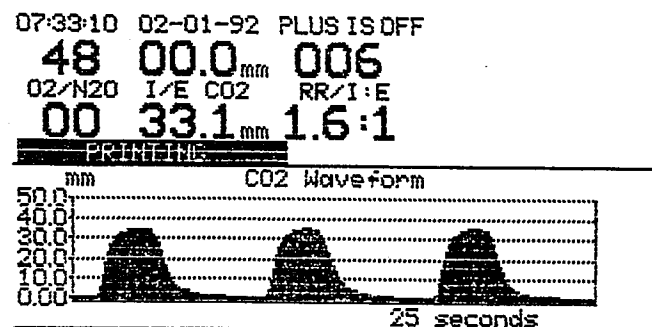


FIG. 1. Capnograph while chest tube on suction.

to the left brachial artery. Preoperative evaluation was significant for a heart rate of 105 and a hematocrit of 25%. The patient was brought to the operating room where an electrocardiogram, a pulse oximeter, and a blood pressure cuff were applied. The chest tube was attached to continuous wall suction. After preoxygenation, a rapid-sequence induction was performed using 375 mg intravenous thiopental, 140 mg succinylcholine, and 150 µg fentanyl. The trachea was easily intubated with a size 8 cuffed endotracheal tube. The position of the tube was confirmed by bilateral equal breath sounds and by presence of end-tidal CO₂ as noted by capnograph.

Anesthesia was maintained by 1–2% enflurane in an air/oxygen mixture, as well as intravenous fentanyl and vecuronium. The lungs were ventilated via a semiclosed circle anesthesia breathing circuit using an Ohmeda® 7700 ventilator. The inspiratory-to-expiratory (I:E) ratio was set at 1:2. The fresh gas flows were set as follows: air, 1 l/min, and O₂, 1 l/min. Once the operation had begun, the capnograph was noted to have the shape seen in figure 1. Of note was the I:E ratio of 1.6:1. A leak was therefore suspected distal to the CO₂ sampling site. Partial deflation of the endotracheal tube balloon lead to an audible leak, which disappeared on full inflation. This confirmed the balloon to be intact. Further search for the leak was unrevealing. By chance, when the chest tube suction was disconnected for a short time, the capnograph was noted to return to normal (figure 2).

The patient's brachial artery was repaired with an autologous vein graft. The remainder of the anesthetic was uneventful. Neuromuscular blockade was antagonized, the trachea was extubated and the patient made an uneventful recovery.

The capnograph consists of four phases; the inspiratory baseline, the expiratory upstroke, the expiratory plateau and the inspiratory downstroke.* The expiratory plateau is flat only when a circle system with intact valves is utilized. When a Mapleson D or other continuous flow circuit is used, exhaled gas is continuously washed out. In the case described, the patient had a continuous leak of air into his left hemithorax caused by the chest tube suction. Had this leak been large, a failure of the ventilator bellows to return to the inspiratory position would have been seen. As this did not occur, we speculate that the leak was less than the fresh gas flow. During exhalation, a fraction of the patient's exhaled gas exited via the chest tube rather than the endotracheal tube. During the expiratory pause, the continued flow through the chest tube resulting from the suction led to the flow through the endotracheal tube being inward rather than outward. Because gas flowing past the end-tidal CO₂ monitoring device contained

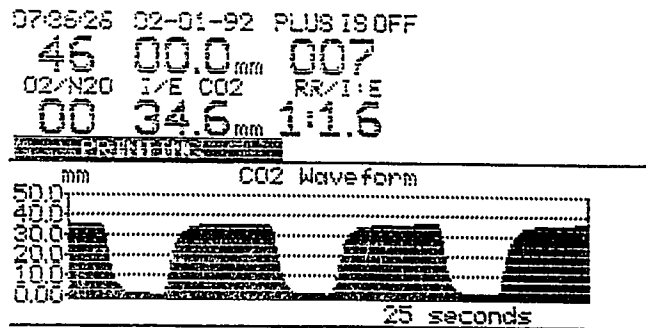


FIG. 2. Capnograph after chest tube suction disconnected.

no CO₂, the device incorrectly interpreted this as the beginning of the inspiratory phase, thereby yielding an abnormal value for the I:E ratio. When suction to the chest tube was disconnected, the air leak decreased, there was no inward flow of gases through the endotracheal tube during the expiratory pause, and the capnograph returned to normal. At the beginning of the case, only the presence of CO₂ was sought from the capnograph. Only later when the operation had begun was the capnograph noted to be abnormal.

This case demonstrates another use of the capnograph. It displayed a characteristic abnormal I:E ratio when a continuous leak of gas from the breathing circuit occurred. An important lesson to be drawn is that the shape and I:E ratio as well as the presence of CO₂ on the capnograph should be noted after intubation.

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Electroencephalographic Effects of Sedative Hypnotics

To the Editor:—We read with interest the recent report by Drummond *et al.*¹ We have conducted volunteer studies examining the electroencephalographic (EEG) effects of midazolam, thiopental, and propofol and their relation to cognitive effects in sedative doses. All three agents appear to produce similar cognitive² and EEG effects. All three agents produce increases in high-frequency EEG beta (13–30 Hz) activity, which, by and large, are statistically identical at these dose ranges. All subjects in these experiments were sedated but able to perform moderately complex cognitive tasks (*e.g.*, memorizing word lists). Propofol clearly causes high-frequency EEG beta activity during sedation, and the effect appears to be related to the serum concentration.^{3–5}

The phenomenon is not a transient effect, and beta activity appears to be maintained as long as the serum concentration remains constant.

In a separate report, Kalkman *et al.* show that the electrophysiologic effects of propofol appear to be prolonged in relation to the clinical sedative effects of the drug.⁶ We have noted a similar discrepancy with midazolam at sedative concentrations on long latency evoked potentials (P300).⁷ Preliminary analysis of our data during propofol sedation show a similar effect, with depression of P300 amplitude lasting more than 2.5 hr after the termination of the infusion.

With the introduction of new surgical technology, more anesthetic practice will be targeted toward the production of a satisfactory state