The Failure of Capnography to Properly Assess Endotracheal Tube Location

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DIRECT vocal cord visualization and end-tidal carbon dioxide measurement are the only methods described that definitively confirm proper endotracheal tube placement.¹ Unrecognized esophageal intubation was the mechanism of injury in 196 (38% of 522) adverse respiratory events reported in an ASA closed claims analysis. Within this esophageal intubation subgroup, chest auscultation erroneously indicated successful endotracheal intubation 48% of the time.² Pulse oximetry and capnography were believed to have averted 93% of 346 mishaps considered preventable, in a separate closed claims analysis.³ Based partly on these studies, the ASA stated, in an amendment to its original basic intraoperative monitoring standards:

"When an endotracheal tube is inserted, its correct positioning in the trachea must be verified by clinical assessment and by identification of carbon dioxide in the expired gas."⁴

We describe a case in which capnography failed to diagnose improper endotracheal tube location.

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Case Report

A 26-yr-old man was scheduled for a left paracapular microvascular free flap transfer after having had multiple uncomplicated general anesthetics for reconstructive procedures of both mandibles. He had full dentition but could not open his mouth more than 1 finger breadth. Cervical flexion and extension were severely limited by extensive scar tissue. Midazolam, 2 mg, and glycopyrrolate, 0.2 mg, were given 1 h prior to induction of anesthesia.

A five-lead EKG, automatic oscillometric noninvasive blood pressure monitor, precordial stethoscope, and pulse oximeter were placed. Incremental doses of midazolam and droperidol were given before awake blind nasotracheal intubation. Topical nasal and pharyngeal mucosal anesthesia was then achieved with 5 mL of aerosolized cocaine 4% and lidocaine 2%.

A no. 7 standard endotracheal tube connected to the airway adapter of a sidestream capnograph was inserted through the left nares with the supine patient's head in the "sniffing" position. Blind tracheal intubation was unsuccessful with and without movement of the patient's head. Some mucosal bleeding occurred. A no. 7 Endotrol® (Mallinckrodt, Glens Falls, NY) endotracheal tube was then passed into the left nares. Tracheal intubation was done with the assistance of some neck flexion and maximal traction on the distal hook of the tube. The characteristic capnograph waveform seen after normal tracheal intubation was noted (fig. 1). Bilateral breath sounds were heard during spontaneous ventilation. The endotracheal tube cuff was then inflated. The air leak heard with positive pressure ventilation persisted until 20 mL of air was injected into the cuff. Anesthesia was then induced with thiopental 100 mg intravenously followed by 60% N₂O and 2% isoflurane. Mechanical ventilation was established at 10 breaths/min and V̇ₑ = 700 mL. Because of the abnormally large cuff inflation volume needed to achieve seal, flexible fiberoptic bronchoscopy through the endotracheal tube was attempted several times to confirm proper tube placement. Enough resistance to passage of the bronchoscope occurred at the distal end of the endotracheal tube.

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Footnotes:

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# CAPNOMAC II®, Datex Instrumentation, Helsinki, Finland.

Fig. 1. Normal capnography waveform seen after placement of the Endotrol® endotracheal tube.
to prevent the bronchoscope from exiting the endotracheal tube. During the 30-min period taken by the attempts to pass the scope, \( \text{SpO}_2 \) and \( \text{EtCO}_2 \) remained 99–100% and 33–35 mmHg, respectively, and the capnograph waveform pattern remained unchanged. Peak airway pressure, however, was 30–35 cm H\(_2\)O. A portable AP chest film showed a virtual 180° endotracheal tube bend at the C\(_3\) level (fig. 2).

The distal end of the tracheal tube was actually visualized by passing a fiberoptic bronchoscope through the right naris. This confirmed that the endotracheal tube was kinked and wedged against the pharyngeal mucosa at about 90° to the glottic opening. The “Murphy eye” of the tube was just above, but not through, the vocal cords. After the bronchoscope was advanced into the larynx, the endotracheal tube cuff was deflated, and the Endotrach\(^6\) tube was withdrawn. Another standard no. 7 cuffed endotracheal tube was then passed into the trachea. This had been threaded over the bronchoscope before insertion in the right naris. The cuff sealed completely with only 8 ml of air. Peak airway pressure decreased from 35 to 22 cm H\(_2\)O. Repeat AP chest x-ray confirmed proper endotracheal tube placement. Surgery proceeded uneventfully. The endotracheal tube was removed without sequelae shortly after the procedure ended.

**Discussion**

Capnography with a normal analog waveform display is the best way to verify the absence of esophageal intubation.\(^6\) This case appears to be the first report in which capnography during mechanical ventilation showed a normal waveform although the endotracheal tube had not actually passed through the vocal cords.

A normal capnograph waveform after tracheal intubation is well described and generally accepted to indicate proper endotracheal tube position. This case demonstrates that a normal waveform clearly can be present and sustained with unrecognized pharyngeal ventilation and that normal end-tidal CO\(_2\) or a normal analog capnograph waveform may not always guarantee proper endotracheal tube placement. Esophageal intubation can essentially be diagnosed with certainty using capnography, but normal end-tidal CO\(_2\) and capnograph waveform alone do not guarantee proper tracheal intubation. Any analysis of endotracheal tube position should always take into account the occluding volume of cuff air, as well as peak inspiratory pressure. In this case, although the capnography waveform was normal, had greater significance been initially given to interpreting the unexpectedly increased peak inspiratory pressure, improper tube position would have been diagnosed earlier.

**References**