Inadvertent Endobronchial Intubation in a Patient With a Short Neck Length

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Inadvertent placement of the endotracheal tube into the right bronchus during intubation for general anesthesia is a fairly common occurrence. Many precautions should be taken by the anesthesia provider in order to minimize the incidence of endobronchial intubation, including bilateral auscultation of the lungs, use of the 21/23 rule, and palpation of the inflated endotracheal cuff at the sternal notch. These provisions, however, are not foolproof; anesthesia providers should realize that endobronchial intubation may occur from time to time because of variations in patient anatomy, changes in patient positioning, and cephalad pressures exerted during surgery. A 58-year-old man with chronic obstructive pulmonary disease received general endotracheal anesthesia for a laparoscopic cholecystectomy. His height was 165 cm (5 ft, 5 in) and the endotracheal tube was secured at his incisors at 21 cm after placement with a rigid laryngoscope. Bilateral breath sounds were confirmed with auscultation, although they were distant because of his chronic obstructive pulmonary disease. After radiographic examination in the postanesthesia care unit, a right main-stem intubation was revealed to have taken place, resulting in complete atelectasis of the left lung. After repositioning of the endotracheal tube, radiography confirmed that the patient had an anatomically short tracheal length.

Key Words: Endobronchial intubation, Main-stem intubation, Short neck length, General anesthesia.

Effective airway management is the primary concern of the anesthesiologist.[1] During general anesthesia, proper insertion and maintenance of the endotracheal tube are keys to ensuring patient safety; errors or complications during this process can result in significant morbidity or mortality.[2] Among the most common complications of endotracheal intubation is the inadvertent placement of the tube into the right bronchus.

The length of the trachea can be reasonably estimated in the average adult patient; therefore, it is common practice among many anesthesia providers to secure the endotracheal tube within a predetermined range.[3] Anatomical variation among individual patients does exist, and, if not appreciated, can be the genesis of inadvertent malpositioning of the endotracheal tube.

We report here an adult patient with a short neck length that resulted in inadvertent placement of the endotracheal tube into the right bronchus. The case highlights the importance of appreciating anatomical variations of the neck during endotracheal intubation.

CASE PRESENTATION

A 58-year-old Caucasian man presented for a routine laparoscopic cholecystectomy. At his same-day surgery preoperative admission, the patient was recorded to be 165 cm (5 ft, 5 in) and 78 kg (172 lb) with a body mass

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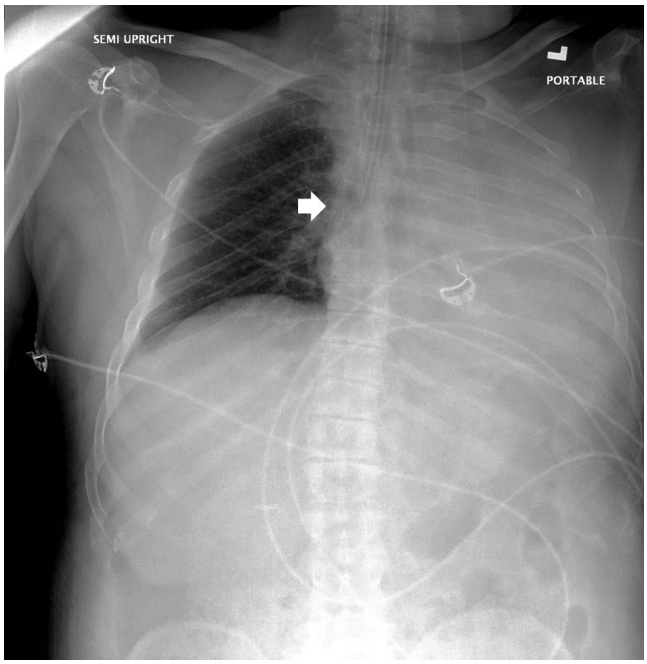

Figure 1. A portable chest radiograph taken at the postoperative care unit showing inadvertent placement of the endotracheal tube into the right bronchus (arrow). Complete atelectasis of the left lung is seen.

index of 28.7 kg/m^2. The patient had a significant medical history that included well-controlled hypertension, gastroesophageal reflux disease, rheumatoid arthritis, and psoriasis. His home medications included atenolol 25 mg daily, hydrocodone-acetaminophen 5–325 mg as needed, and omeprazole 20 mg daily. He claimed allergies to Mentholatum ointment and bupropion HCl. His social history included daily cigarette smoking (30–pack-year history) and social alcohol use (2–3 times a week). In 2012 the patient underwent general anesthesia for orthopedic surgery on his right ankle without anesthetic complications. The patient was evaluated as American Society of Anesthesiologists (ASA) physical classification of 3. Physical examination showed a class II airway, a normal mouth opening, poor dentition with several missing and loose teeth, normal cervical range of motion, and a thyromental distance of 5 cm. Of note, the patient's small stature and overweight status contributed to a shortened thyrosternal distance or "short neck." Before leaving the preoperative area, the patient was administered 2 mg of intravenous midazolam and 50 mcg of fentanyl.

Upon arrival in the operating room, the patient was transferred to the operating table, and the standard ASA monitors were placed. A peripheral nerve stimulator and bispectral index monitor were also applied. After preoxygenation, general anesthesia was induced with 100 mcg of fentanyl and 160 mg of propofol. After muscle paralysis was accomplished with 50 mg of rocuronium, an easy intubation was carried out by direct laryngoscopy using a Macintosh 3 blade and a styleted 8.0-mm Mallinckrodt cuffed oral tracheal tube. After visual conformation of tracheal intubation, the tube was secured with tape at 21 cm at the level of the incisors. Bilateral breath sounds were confirmed via auscultation, and general anesthesia was maintained with oxygen and 1.7% sevoflurane. Because of the patient's significant smoking habit, 5 puffs of albuterol were delivered via metered dose into the circuit and the inspiratory-to-expiratory time (I:E) ratio of the ventilator was set at 1:3. Two grams of cefazolin sodium was administered before the surgical incision was made.

Soon after the surgeon began the procedure, the patient's abdomen was insufflated with carbon dioxide and the patient was placed in reversed Trendelenburg position. His blood pressure was maintained with a phenylephrine infusion at 0.3–0.6 mcg/kg/min along with a crystalloid infusion. Approximately 40 minutes after induction, peak pressures increased significantly from a low of 24 cm H_2O to a high of 39 cm H_2O. At the same time, his pulse oximetry hemoglobin saturation began to steadily decrease to 89%. After checking for a disconnected circuit or a kinked or damaged endotracheal tube, it was suspected that the patient might be experiencing a bronchospasm. The ventilation mode was changed to pressure control ventilation, 5 puffs of albuterol were delivered into the circuit (this was repeated 4 times during the remaining time of the procedure), and the percentage of sevoflurane was increased to 2.0%. Under pressure controlled ventilation (PCV) mode, tidal volumes dropped to 268 mL. Increases in end-tidal carbon dioxide to 42 mm Hg were encountered despite an increase of the respiration rate on the ventilator to 21 breaths per minute.

Until the surgery was completed, it was assumed that the patient was experiencing episodes of bronchospasm. After muscle relaxation was reversed with 5 mg of neostigmine and 0.8 mg glycopyrrolate, it was observed that under spontaneous ventilation, the patient was unable to generate a tidal volume of more than 140 mL. It was therefore decided to delay removal of the endotracheal tube, and the patient was resedated with propofol and transferred to the postanesthesia care unit, where he was kept on a ventilator.

A portable chest radiograph in the postanesthesia care unit revealed a right bronchial intubation and complete atelectasis of the left lung (Figure 1). The endotracheal tube was adjusted and resecured at 19 cm at the incisors. A repeated chest radiograph showed the endotracheal tube terminating just above the level of the carina. Interval re-expansion of the left lung was observed, although there was persistent lower left lobe atelectasis

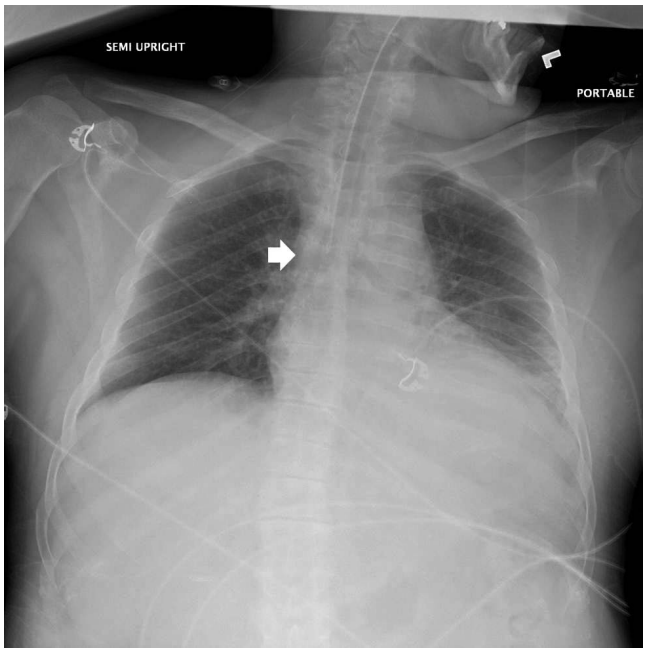

Figure 2. A portable chest radiograph after the endotracheal tube was adjusted and resecured at 19 cm at the incisors. The tip of the endotracheal tube is still at the carina level (arrow). Interval re-expansion of the left lung is seen.

(Figure 2). No pneumothorax or pleural effusion was identified and the cardiomediastinal silhouette was unchanged. The oxygen saturation returned to 100% with inspiratory oxygen fraction of 0.4.

The patient was weaned from the ventilator, the endotracheal tube was removed, and the patient was discharged from the hospital 4 hours later. Follow-up communication with him 2 days later assured an uneventful recovery.

DISCUSSION

The leading cause of hypoxemia and death during general anesthesia, as reported in 2005, was failure to recognize incorrect placement of the endotracheal tube.[2] Malpositioning of the endotracheal tube can result in esophageal intubation, bronchial intubation, or inadvertent extubation.[4] Right bronchial intubation, or main-stem intubation, has been shown to occur in up to 5–28% of intubation attempts and accounts for 2% of adverse respiratory claims in adults and 4% in children.[5–8] If left uncorrected, main-stem intubation can result in overinflation of the intubated lung and partial to complete atelectasis of the contralateral lung.[9] Secondary complications can result in hypoxemia, barotrauma, cardiac arrhythmias, hypotension, or tension pneumothorax.[2,10,11]

There are 3 traditional methods used by anesthesia providers in an effort to prevent and detect bronchial intubation. They are (a) bilateral auscultation of the lungs, (b) the "21/23 rule," where the tube is taped at 21 cm at the incisor teeth for women and at 23 cm for men, and (c) palpation of the cuff of the endotracheal tube at the sternal notch.

Bilateral auscultation of the chest is the standard method for detecting improper placement of the endotracheal tube.[2,10] In order for bilateral breath sounds to be properly confirmed, 5 foci must be auscultated: bilateral axillae, bilateral fifth intercostal spaces, and the epigastrium.[4] Many authors have shown that effective lung auscultation is highly skill dependent and can be misleading nearly two thirds of the time.[2,12,13] The use of endotracheal tubes with a Murphy eye can result in bilateral breath sounds in 48% of patients who have an esophageal intubation and in 60% of patients who have a main-stem intubation.[6,14,15]

The trachea, in most adult patients, is between 10 and 15 cm long, beginning at the cricoid cartilage and ending at the carina.[16] The carina is found approximately at the level of the second rib.[13] The average distance from the vocal cords to the carina is 12.7 cm, with a standard deviation of 1.6 cm.[3] This estimate, however, is extremely variable and is affected by age, race, and gender, among other factors.[3] Most clinicians agree that there is no consistent predictor of whether or not a patient's trachea will be shorter or longer than normal.[3,16] Correct positioning of the distal tip of the endotracheal tube is between 2.5 and 4 cm above the carina.[7,17] Securing the endotracheal tube in the 2.5–4-cm range above the carina ensures that the tube will not be advanced into the right bronchus during head flexion or accidentally dislodged during head extension.[18] Traditionally, endotracheal tubes have been taped at 21 cm at the incisors of the female patient and 23 cm for the male patient.[10] A recent study, however, recommended that the ideal length be amended to 20 cm for women and 22 cm for men.[7]

External palpation of the inflated cuff of an endotracheal tube at the sternal notch is another way of determining proper placement. One study found that palpation of the trachea between the larynx and the sternal notch was more accurate at placing the endotracheal tube 2.5 to 4 cm above the carina than any other method.[17] Palpation requires no additional equipment and can be done in less than 5 seconds.[17]

Several factors can affect the positioning of the endotracheal tube, even after it has been secured in the correct position. Placing the patient in the Trendelenburg position and insufflating the abdomen during laparoscopy can advance the diaphragm and lungs in a cephalad direction.[3,19] This can result in the endotra-

cheal tube migrating closer to the carina and possibly entering the right bronchus. Forward flexion of the neck can advance the endotracheal tube toward the carina by 3.1 cm, and backward extension of the neck can move the tube toward the vocal cords 5.2 cm.[10,18] Simple lateral rotation of the head can cause the endotracheal tube to migrate 0.7 cm.[18] Individual anatomical features of patients such as a large tongue and a long or short neck can complicate intubation and ultimately result in placement of the distal end of the endotracheal tube closer or farther away from the carina than in the average patient.[3,12,16,20] Some studies have shown that a patient's height and thyrosternal distance can be moderately useful in predicting patients with short vocal cord–carina distance; however, most efforts to relate vocal cord–carina distance to anatomical surface measurements have shown a poor correlation.[3,16] Therefore, it is important to approach each patient individually, to physically check for main-stem placement, and to be vigilant in watching for the signs and symptoms of endobronchial intubation, even after prior confirmation of a proper placement before the start of surgery.

A commonly used approach to ensure the proper placement of the endotracheal tube in men is to secure it at 23 cm at the level of the incisors.[10] In this case, the endotracheal tube was originally secured at 21 cm. Chest radiography concluded that the level of the patient's carina was at 19 cm from the incisors; thus, in order to keep the tip of the endotracheal tube a minimum of 2.5 cm away from the carina, the safe and proper place to secure the endotracheal tube for this specific patient was no deeper than 16.5 cm.[7,17] This was 6.5 cm shorter than the distance for the average male; clearly, the patient's anatomical variation, or short neck, was a contributing factor to the subsequent endobronchial intubation. Chest radiography has been recommended to confirm proper endotracheal tube placement.[4,8] However, we feel that chest radiography is expensive and time consuming and should be reserved for cases, such as the one discussed in this study, where anatomical variation or other complicating factors cast doubt on the proper placement of the endotracheal tube. A flexible fiber-optic scope inserted into the tube to observe where the tip of the tube is located is an excellent alternative technique to determine proper placement above the carina.

One of the biggest problems in this case was the failure to properly recognize the signs and symptoms of a main-stem intubation. As discussed earlier, it was assumed from the signs of hypotension, desaturation, increasing end tidal carbon dioxide production, increasing peak pressures, and decreasing tidal volumes that the patient was suffering from bronchospasm.[21] Although the endotracheal tube was checked for disconnects and kinks and bilateral breath sounds had been heard through auscultation, the possibility of main-stem intubation should still have been considered. A correction could have been done by reducing the depth of the endotracheal tube 2–4 cm perioperatively.[7]

In conclusion, a case of inadvertent placement of the endotracheal tube into the right bronchus was reported. An unusually short neck length was the major reason for the incident. Higher vigilance and appreciation of the potential risk of bronchial intubation based on this anatomical feature is warranted.

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