Selective Bilateral Bronchial Intubation for Large, Acquired Tracheoesophageal Fistula

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The anesthetic management of patients undergoing tracheoesophageal fistula repair often involves lung separation, usually selective bronchial intubation with a double-lumen endotracheal tube. However, in patients with airway fistulas arising below the tracheal lumen, selective lung ventilation and separation may require unusual methods of airway management. In the patient described in this report, the airway fistulas involved the distal 3 cm of the trachea, approximately half of the left main bronchus 1.5 cm beyond the carina, and the proximal 0.5 cm of the right main bronchus. To separate and ventilate the lungs during the repair of these large and complex airway fistulas, 2 individual Mallinckrodt microlaryngeal endotracheal tubes were used. While lung separation was achieved, contrary to previous reports, the Mallinckrodt’s larger and more tapered cuff made positioning in the left main bronchus an ongoing issue that required the use of a conventional endotracheal tube and, eventually, intubation of the bronchus from the surgical field. Future cases involving complex airway fistulas should consider endotracheal tube limitations and other methods of providing ventilation such as high-frequency jet ventilation or cardiopulmonary bypass.

Keywords: Acquired tracheoesophageal fistula, general anesthesia, microlaryngeal tube, one-lung ventilation, selective bronchial intubation.

The key anesthetic management concerns for patients undergoing tracheoesophageal fistula (TEF) repair involve risk of aspiration, insufflation of the stomach, loss of tidal volume and minute ventilation, and subsequent hypoxemia. Lung separation is necessary and usually involves selective bronchial intubation with a double-lumen endotracheal tube (DLT). In patients with a TEF arising at the carina, selective lung ventilation and separation may be extremely challenging and may require unusual methods of airway management because the tracheal lumen of the DLT may be affected by the fistula. In the patient described in this report, 3 separate fistulas developed involving the distal 3 cm of the trachea, approximately half of the left main bronchus 1.5 cm beyond the carina, and 0.5 cm of the proximal right main bronchus (Figure 1).

To separate and ventilate the lungs during the repair of these 3 complex fistulas, we used 2 individual 6.0 and 5.0 Mallinckrodt microlaryngeal tubes (MLTs) (Mallinkrodt Inc, St Louis, Missouri) placed side by side in the trachea. Although selective bronchial ventilation and lung separation were successful, the 6.0 MLT’s larger and tapered cuff repeatedly migrated out of position from the left main bronchus proximal to the fistula. This migration necessitated removal of the MLT and insertion of a standard 6.0 endotracheal tube (ETT) with a smaller cuff distal to the fistula.

Case Summary
A 39-year-old, 60-kg, 178-cm-tall man with a 3-week history of purulent cough, dyspnea, and nausea and vomiting was admitted for surgical repair of a series of airway fistulas which involved the distal 3 cm of the trachea, approximately half of the left main bronchus 1.5 cm beyond the carina, and 0.5 cm of the proximal right main bronchus (Figure 1).

Figure 1. Location of Tracheoesophageal Fistulae
Abbreviations: BEF, bronchoesophageal fistula; and TEF, tracheoesophageal fistula.

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fistulas that arose due to esophageal erosion by infection with *Candida* organisms. Preoperative oxygen saturation by pulse oximetry was 91% with oxygen given at 4 L/min by nasal cannula, and a chest radiograph revealed bilateral basilar atelectasis and extensive atelectasis in the left lung, with chronic aspiration. In formulating an anesthetic care plan for this patient, key management considerations included the following: (1) TEF involving the distal trachea, necessitating selective bronchial intubation and ventilation; (2) bronchoesophageal fistula (BEF) of the left main bronchus, necessitating isolation or ventilation of the left lung; (3) BEF of the right main bronchus, necessitating isolation or ventilation of the right lung; and (4) severe hypoxemia, necessitating ventilation of both lungs, with isolation of the trachea and main bronchi by cuff placement distal to the fistulae.

Single-lung ventilation via right endobronchial intubation was not considered based on the patient's low oxygen saturation before surgery, and so, to maintain positive pressure ventilation to each lung, an alternative technique would need to be used. The decision was made to selectively intubate each main-stem bronchus with individual ETTs. Because the distance from oropharynx to each main bronchus was too deep for conventional 5.0 and 6.0 ETTs (24.5 and 28 cm, respectively), MLT tubes were selected (32 cm each). To ventilate each lung successfully, the cuff of each tube would be placed distal to each BEF.

The patient's medical history included human immunodeficiency virus infection, aspiration pneumonia, dysphagia, and pancreatitis. The patient's surgical history included esophagoscopy and bronchoscopy. He had no oral intake for 48 hours and was receiving co-trimoxazole, levofloxacin, vancomycin, metronidazole, and methylprednisolone. Physical examination revealed a Mallampati class II airway with adequate thyromental distance and neck motion. The patient's respiratory rate was 26 breaths/min, the heart rate was 112 beats/min, the blood pressure was 108/54 mm Hg, and the hematocrit value was 32%.

After consultation with the surgical team and pulmonologist, the decision was made to perform an inhalation induction by mask using 100% oxygen and sevoflurane. Awake fiberoptic bronchoscopy (FOB) with selective endobronchial intubation was considered to be a more difficult approach, and insertion of a laryngeal mask airway would have interfered with instrumentation of the airway. Glycopyrrolate, 0.2 mg, was administered intravenously as an antisialagogue to reduce oral secretions, and nebulized 4% lidocaine was administered to decrease airway irritability during FOB. Although cricoid pressure and a head-up position were used, the use of a citric acid-sodium citrate combination (Bicitra) was not considered because of the communication between the esophagus and airway. Preoxygenation was implemented for 5 minutes by face mask, and immediately before induction, the oxygen saturation (SpO2) was measured at 99%, the heart rate at 112 beats/min, and the blood pressure at 112/54 mm Hg. Spontaneous respirations were maintained during induction by face mask to avoid insufflation of the stomach through the communication between the trachea and esophagus with positive pressure ventilation.

Direct laryngoscopy of the vocal cords revealed a grade 1 view, and a 5.0-mm MLT was placed in the larynx and then guided into position in the right main-stem bronchus using FOB. Isolated right lung ventilation was confirmed by auscultation and FOB examination. During a second direct laryngoscopy, a 6.0-mm MLT was loaded over a flexible bronchoscope and placed into the larynx for planned positioning in the left main-stem bronchus. The BEF extended from the level of the carina well into the left main bronchus, compressing the lumen. An additional fiberoptic bronchoscope was passed beside the ET to better visualize the bronchus and assisted in placement of the 6.0 MLT in the left bronchus. A standard double lumen Y connector was used to connect both ETs to the circuit. Positive pressure ventilation of both lungs was initiated with a tidal volume of 550 mL, a respiratory rate of 16 breaths/min, a peak inspiratory pressure of 20 cm H2O, and a fraction of inspired oxygen (FiO2) of 1.0 with an oxygen saturation of 96%. While establishing the airway, an arterial line had been inserted along with additional intravenous access.

After initiating selective bronchial intubation, ventilation through the left endobronchial tube became difficult. With only 2.5 cm of viable bronchus between the fistula and the left upper lobe and only half of the circumference of the left main bronchus remaining, maintaining correct positioning of the MLT became challenging. Because of the larger size and tapered configuration of the cuff on the MLT (Figure 2), positive pressure caused migration of the tube proximal to the left bronchial fistula, to just below the carina. With an ongoing communication between airway and esophagus, aspiration would be unavoidable and ventilation would be compromised. After repeated FOB manipulations of the left bronchial tube and with marginal oxygen saturations between 90% and 92% during ventilation of only the right lung, the decision was made to reintubate the left bronchus with a standard 6.0-mm ETT with a smaller, lower profile cuff. The less tapered, smaller cuff had better contact with the 2.5-cm surface area of the nearly obliterated left bronchus. The shorter standard ETT necessitated the use of a 12-cm extension limb to the circuit (Figure 3).

After verification of tube placement by FOB, controlled ventilation of both lungs was re instituted. Ventilator settings were as follows: FiO2, 1.0; tidal volume, 550 mL; and rate, 16 breaths/min via pressure control ventilation with peak inspiratory pressures of 18 cm H2O and
oxygen saturation 96% by pulse oximeter. Arterial blood gases by means of selective bronchial intubation and two-lung ventilation showed an initial PaO₂ of 82 mm Hg, a pH of 7.45, and a PaCO₂ of 42 mm Hg. While positive end-expiratory pressure may have been beneficial, an effort was made to minimize airway pressures to avoid migration of the left endobronchial tube. Pressure control ventilation was also considered, but there were concerns of changes in minute ventilation with constant manipulation of the airway.

After prepping and draping the patient in the supine position, breath sounds were assessed and proper placement of endobronchial tubes reconfirmed by FOB. Maintenance of anesthesia was with sevoflurane, 1% to 2%, 15 μg/kg of fentanyl, and vecuronium in intermittent boluses to maintain muscle relaxation. During the operation, the blunt dissection of the esophagus into the mediastinum exposed a massive defect in the posterior wall of the trachea, and a left thoracotomy was required to address the defect in the lateral decubitus position. Esophageal repair with a retrosternal cervical esophago-gastrostomy was performed, and a large pericardial flap was excised and used to repair the posterior aspect of the trachea, carina, and bilateral bronchi. Throughout the repair with an FiO₂ of 1.0, oxygen saturations ranged from 94% to 97%, and arterial blood gases confirmed a PaO₂ of 82 mmHg, a PaCO₂ 50 mm Hg, and a pH of 7.32. During the repair of the left main-stem bronchus, the left endobronchial tube had to be withdrawn to complete the repair. Placement of a sterile 6.0 endobronchial tube by the surgical team into the left bronchus distal to the fistula was necessary to maintain oxygenation. Intermittent manual ventilation to the left lung via the sterile endobronchial tube was provided via a self-inflating bag with 100% oxygen while the surgeons repaired the large defect in the left bronchus. Ventilation of the right lung was maintained with the anesthesia machine ventilator with an FiO₂ of 1.0, a 250-mL tidal volume, a rate of 16 breaths/min, and peak inspiratory pressures of 20 cm H₂O, with maintenance of the oxygen saturation between 90% and 98%. Arterial blood gases during this time showed a PaO₂ of 78 mm Hg, a PaCO₂ of 37 mm Hg, and a pH of 7.32 and correlated with a pulse oximeter reading of 93% and an SpO₂ of 94%.

When the repairs were near completion, the 5.0-mm MLT in the right bronchus was removed and the patient’s trachea was reintubated via direct laryngoscopy using an 8.0-mm ETT. The cuff was placed proximal to the repair, and the surgeon withdrew the sterile 6.0-mm left bronchial tube and placed the final sutures. The airway reconstruction was noted to be airtight up to 35 cm H₂O, and ventilation was resumed at an FiO₂ of 1.0, a tidal volume of 550 mL, and a rate of 16 breaths/min with an oxygen saturation of 100% and a PaO₂ of 209 mm Hg. The patient was transferred to the surgical intensive care unit intubated and sedated 6 hours after the beginning of the procedure. Approximately 4,000 mL of normal saline was administered; the urine output was 625 mL, and estimated blood loss was 600 mL.
On arrival in the intensive care unit, the ventilator settings were as follows: tidal volume, 500 mL; FiO2, 0.40; and respiratory rate, 14 breaths/min. Initial blood gases showed a PaO2 of 77 mm Hg, a PaCO2 of 36 mm Hg, and a pH of 7.31; the hematocrit value was 31%. Although the operation was considered successful and the initial admission to the intensive care unit satisfactory, approximately 18 hours after surgery, profound left bronchial atelectasis developed. Chest radiographs showed total collapse of his left lung due to mucous plugging because of residual narrowing of the left bronchus. Despite repeated bronchoscopies, high doses of vasopressors, optimal positive end-expiratory pressure and volumetric diffusive respiration support, the patient died 48 hours postoperatively of hypoxemia due to atelectasis and pneumonia.

### Discussion

Acquired nonmalignant TEFs in adults may arise from a variety of causes, and although the most common cause is mechanical ventilation, autoimmune deficiency syndrome and opportunistic infection have been reported. Treatment is with surgical repair and is usually done as a one-stage procedure, typically involving primary closure or stent. However, surgical intervention is associated with high mortality and morbidity rates related to critical illness and comorbidities, and lower airway surgery is associated with postoperative pulmonary atelectasis, decreased mucociliary clearance, and aspiration. In pediatric patients, a variety of techniques have been used for single-lung ventilation, including intentional main-stem (endobronchial) intubation and one-lung ventilation, balloon-tipped bronchial blockers, Univent (Fuji Systems Corporation, Tokyo, Japan) ETTs, and DLT if the child is large enough.

Other maneuvers used for airway management include spontaneous ventilation with endotracheal intubation, occlusion of the TEF with a Fogarty catheter or neonatal cuffed ETT, and cardiopulmonary bypass. In adults, lung separation and ventilation are usually individualized based on the location of the lesion and the clinical picture. Selective bronchial intubation usually involves intubation of the left or right main bronchus and very rarely involves bilateral endobronchial intubation (Table). Other maneuvers used to facilitate ventilation include use of a modified esophageal balloon, use of a Sengstaken-Blakemore tube, high-frequency jet ventilation, DLT, a Univent endobronchial blocker, and selective bronchial intubation. In addition, cardiopulmonary bypass may be kept on standby for certain airway cases and has been used in adults with complex mediastinal lesions.

In this case, selective bronchial intubation was used to maintain ventilation to both lungs. Although this technique was effective, other options may have included endobronchial intubation of the right lung and high-frequency jet ventilation of the left lung. However, the size...
and location of the BEF made any ventilation of the left lung impossible without sealing the airway with a cuff. In addition, the introduction of 100% oxygen into the surgical field during the use of electrocautery increases the risk of an airway fire. A more controlled approach in managing this case may have been through the use of extracorporeal membrane oxygenation or cardiopulmonary bypass, as used for discontinuous airways in pediatric patients. In this manner a more absolute repair of the airway fistulas may have been allowed. In this case, only with surgical placement of the left endobronchial tube in the field was repair of the left main bronchus accomplished, and this appeared to be the definitive method of managing the airway.

Future recommendations based on this case involve the logistical implications of inserting 2 endobronchial tubes in a patient with multiple fistulas arising in the trachea and both main bronchi. Airway management in patients with TEF or BEF should be individualized and involve decreasing the risk of aspiration and stomach insufflation. Lung isolation should take into consideration the ability to oxygenate during one-lung ventilation, and two-lung ventilation techniques should be based on fistula location. The use of 2 endobronchial tubes may have several limitations, including location and size of the fistulas, individual anatomy, and endobronchial tube characteristics, such as length and cuff profile. Delineation of the patient’s anatomy and unconventional means of ventilation (eg, surgical, cardiopulmonary bypass) should be considered as part of any anesthetic technique.

REFERENCES


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