REVIEW ARTICLE

Paul G. Barash, MD
Giovanni Landoni, MD
Section Editors

Airway and Ventilatory Management Options in Congenital Tracheoesophageal Fistula Repair

Anthony M.-H. Ho, MD, FRCPC, FCCP,* Joanna M. Dion, MD, FRCPC,† and Joyce C.P. Wong, MBChB, FANZCA‡

MANAGEMENT OF AIRWAY and ventilation in tracheoesophageal fistula (TEF) repair is challenging. A thoughtful approach with alternative options readily available as well as an understanding of the merits and pitfalls of each strategy is important. In this review, the authors focus only on important aspects of airway and ventilation management based on the most common type of TEF—esophageal atresia and distal tracheoesophageal fistula (type C)—which accounts for 86% of cases of this congenital anomaly.[1] The VACTERL association (including vertebral defects, anal atresia, cardiac anomalies, TEF, renal agenesis and dysplasia, and limb anomalies), issues related to the newborn and prematurity, and neonatal anesthetic concerns in general, are covered extensively in the literature, and discussion of these is not repeated here. Management of complicated neonates is highly technical. High-level evidence on how best to manage the airway and ventilation in TEF is scarce or nonexistent. It is important to acknowledge that although the authors have incorporated much of the published evidence into the present review, much of the authors' personal experience and probable bias also have been included.

BACKGROUND INFORMATION

Several factors are critical to consider before the creation of an airway and ventilation management plan, including size, location, and orientation of the TEF; clinical respiratory status of the neonate; planned surgical approach; and necessary patient positioning.

Location of TEF

In 113 patients, Holzki[2] noted the location of the TEF to be below the carina 11% of the time and to be within 1 cm of the carina 22% of the time. Very rarely, there can be 2 fistulae. When the fistula is close to the carina or even within a mainstem bronchus, it can be challenging or impossible to position the endotracheal tube (ET) tip between the TEF and the carina (the textbook approach) or to ventilate both lungs without ventilating the TEF.

Size and Orientation of TEF

The fistula can be as wide as a mainstem bronchus or the trachea. TEFs subtend at an angle to the trachea similar to that of the mainstem bronchi.[1,2] These 2 characteristics make inadvertent intubation of the TEF during the initial intubation or during subsequent adjustments of ET position a real possibility. A wide orifice also increases the risk of excessive insufflation of the stomach should the ET tip be cephalad to the TEF.

Positioning

The neonate is positioned in the left semiprone (approximately 45° to allow the right lung to fall away from the posterior mediastinum) or lateral position. The head typically is covered while the surgeons work in close proximity. Major adjustments of a well-taped ET and instrumentation of the airway during resection can be difficult. Every measure should be taken to reduce the need for intraoperative ET adjustment.

Surgical Technique

Surgical exposure is usually via a right thoracoscopic approach or fourth intercostal posterolateral thoracotomy. In the former, a thoracoscope is inserted just caudad to the right scapula tip through which carbon dioxide (CO_2) is insufflated at a rate of 0.5 L/min to a pressure of 6 mmHg into the right pleural cavity to collapse the right lung gradually; this should provide exposure to the surgical field. Coordination between the anesthesiologists and surgeons at this point is important because oxygen desaturation and almost total loss of end-tidal carbon dioxide ($ETCO_2$) tracing are common. These alarming episodes may be caused partly by compression or kinking during right hemithorax insufflation of the trachea, bronchi, and TEF. Also, the increased intrathoracic pressure can decrease venous return. Repeated gentle, partial re-expansion of the right lung by brief easing of retraction and release of the CO_2 insufflation may be necessary. During the frequent periods of desaturation, the anesthesiologist must be mindful of excessive

*From the *Department of Anesthesiology and Perioperative Medicine, Queen's University, Kingston, Ontario, Canada; †Department of Anesthesiology and Pain Medicine, Nationwide Children's Hospital, Columbus, OH; and ‡Department of Anaesthesia, The Tweed Hospital, Tweed Heads, Australia.*

Address reprint requests to Anthony M.-H. Ho, MD, FRCPC, FCCP, Department of Anesthesiology and Perioperative Medicine, Victory 2, Kingston General Hospital, Queen's University, 76 Stuart Street, Kingston, Ontario, Canada, K7L 2V7. E-mail: hoamh@hotmail.com

1053-0770/2601-0001$36.00/0
http://dx.doi.org/10.1053/j.jvca.2015.04.005
Key words: tracheoesophageal fistula, esophageal atresia, congenital, neonate

airway pressure, which could distend the abdomen (depending on the technique used; see later), further causing cardiorespiratory embarrassment and obscuring the surgical field. Conversion to a thoracotomy secondary to difficult esophageal anastomosis or refractory desaturation is sometimes needed. In 6% of patients, there may be a right-sided aortic arch, in which case a left-sided surgery is preferred.[3]

Comorbidities

Of the numerous possible comorbidities, lung immaturity and pneumonitis may affect airway and ventilatory management. Higher airway pressures necessitated by pulmonary pathologies increase the chance of pushing gas into the stomach if the ET tip is proximal to the fistula. In 1 series, about 30% of nonintubated infants presented for surgery already had a distended abdomen.[4] Massive gastric/duodenal distention or rupture or both have been reported.

Role of Fiberoscopy

Fiberoscopy is needed to delineate the tracheobronchial anatomy and TEF location and size, to verify the ET position, and potentially to assist the surgeons with fistula ligation.[2,5–7] Deanovic et al[5] published a series of patients in whom the fiberscope was passed through the ET (with the tip proximal to the TEF) after intubation and directed to enter the fistula. The lighted end of the fiberoscope helped to guide the surgical team to locate the fistula efficiently. In 47 patients, there were no complications secondary to gastric distention from intermittent positive pressure during the fiberoscopy before fistula ligation. Fiberoscopy without interruption to ventilation can be achieved with a pinhole diaphragm found in laparoscopy sets that fits nicely onto a swivel connector (Fig 1).[8]

AIRWAY AND VENTILATORY MANAGEMENT OPTIONS

Several airway and ventilation management options are available, and they all work, at least some of the time. Often it is difficult to predict which option will work best.

ET Tip Proximal to Fistula

The advantage of this technique is simplicity, especially because many TEFs are very close to or below the carina.[2] A higher ET causes the distal end of the trachea to dilate and contract with ventilation and may help surgeons with identification of the anatomy.[9] The risk is insufflation of the stomach (see airway complications published in the literature). It is important to limit airway pressure and the duration of positive-pressure ventilation (PPV). This technique is a risky choice in neonates with stiff lungs or an already distended abdomen and a large fistula (if known).

ET Tip Distal to Fistula

The classic teaching is to pass the ET tip beyond the fistula (but proximal to the carina) to prevent insufflation of the stomach. If this is the option chosen, the anesthesiologist should be aware of the potential movements of the ET during positioning and surgical manipulation. If the carina-to-fistula distance is small,[2] it takes little movement for the ET tip to migrate distally into the right mainstem bronchus or cephalad toward the fistula. Corrective actions that follow also may result in intubation of the right mainstem bronchus or the fistula. To complicate matters, poor ventilation (desaturation and declining $ETCO_2$) sometimes is not due to shift in ET tip location, but simply to kinking of the bronchus or trachea from surgical retraction, blood or mucus in the ET or airway, or hypotension. For these situations, ET depth adjustment is the wrong corrective action and may worsen the situation. If this textbook technique is chosen, during intubation the ET bevel should be turned to face backward after it is through the larynx to reduce the chance of inadvertent fistula intubation. The authors prefer to use ETs without a Murphy eye. Because this technique is best when the bevel faces anteriorly to increase the chance of blocking the fistula, the ET orientation may need to be rotated 180° after placement. When the fistula-to-carina distance is not too short, the relative simplicity of this useful technique makes it attractive.

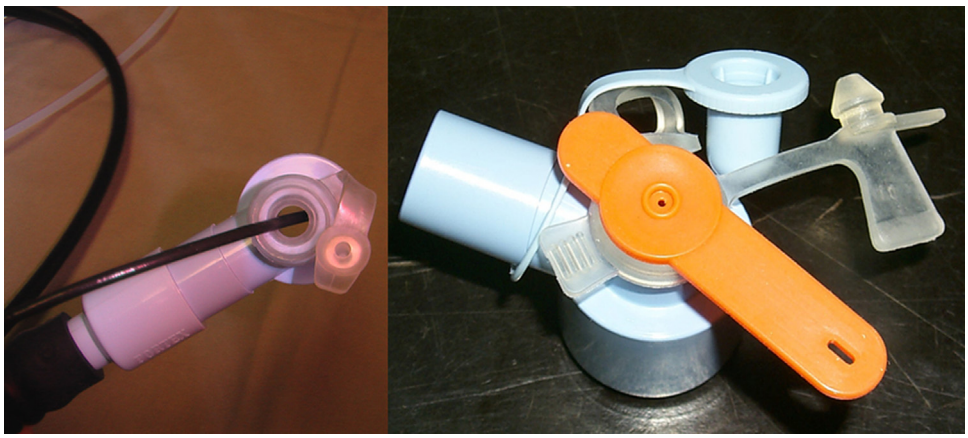

Fig 1. During fiberoscopy, ventilation is ineffective because of the big discrepancy between the sizes of a pediatric fiberscope and the opening of the swivel connector (left panel). Use of a pinhole laparoscopic reducer diaphragm allows for uninterrupted ventilation.