9. Tham EJ, Gildersleve CD, Sanders LD, Mapleson WW, Vaughan RS: Effects of posture, phonation and observer on Mallampati classification. Br J Anaesth 68:32–38, 1992

10. Vock P, Soucek M, Daepp M, Kalender WA: Lung: Spiral volumetric CT with single breath-hold technique. Radiology 176:864–867, 1990

Anesthesiology
83:419–421, 1995

The Optimal Breathing Tube for Tracheal Resection and Reconstruction

*Medhat S. Hannallah, M.D., F.F.A.R.C.S.**

TRACHEAL resection and reconstruction involve major disruption of the trachea and result in a fresh tracheal scar. The following case reports illustrate the limitations of currently available breathing tubes during and after these procedures.

Case Reports

Case 1

A 19-yr-old woman sustained facial trauma, which was complicated with orbital cellulitis, generalized sepsis, and acute respiratory distress syndrome. She required prolonged ventilatory support through a cuffed tracheostomy tube. The patient was transferred to Georgetown University Medical Center, 3 months after the initial trauma, for repair of a tracheoesophageal fistula that developed at the site of the tracheostomy tube cuff.

Tracheoesophageal fistula repair was performed *via* a right thoracotomy. The fistula site was reinforced by a latissimus dorsi pedicle flap, which was wrapped around the proximal esophagus. During the initial phases of the procedure, the lungs were ventilated using a 7.0 mm-ID cuffed reinforced endotracheal tube (Mallinckrodt, St. Louis, MO) placed through the tracheostomy to the maximum depth compatible with bilateral lung ventilation. On exposure of the trachea, the tube cuff was seen bulging at the site of the fistula, whose distal limit was approximately 4 cm from the carina. Leaving the cuff at that level of the trachea would have interfered with the fistula repair and would have compromised the chances of successful healing postoperatively. It was obvious that a breathing tube with a short cuff and a short tube segment beyond the cuff was needed. A tracheostomy tube fulfilled this characteristic (fig. 1); however, regular tracheostomy tubes were too short to be advanced far enough into this patient's trachea *via* the existing tracheostomy. An oral RAE cuffed tube was modified and used instead. The oral RAE tube was chosen because of its relatively small cuff length compared to regular or reinforced tubes (fig. 1). The tube was cut proximally at the 18-cm mark. The part of the tube distal to the cuff also was cut to prevent endobronchial intubation when the cuff was advanced beyond the fistula site. However, the cuff lost its seal because the pilot tube extended beyond the cuff to the tip of the tube (fig. 1). To regain the cuff seal, the open distal end of the pilot tube was blocked using a short segment of an appropriate size surgical needle tip. The cuff was tested several times and was found to maintain its seal. The distance between the tip of the modified tube and the proximal end of the cuff was approximately 3 cm.

The modified tube functioned well intraoperatively and postoperatively, allowing bilateral lung ventilation without the cuff encroaching on the fistula site. Postoperatively, when it was clear that prolonged tracheal intubation would be required, a customized tracheostomy tube (Bivona Medical Technologies, Gary, IN) with the appropriate length and cuff characteristics was ordered and used for ventilating the lungs until extubation of the trachea was possible several weeks later.

Case 2

An obese 47-yr-old woman presented with tracheal stenosis as a complication of prolonged intubation after abdominal surgery. She was experiencing progressively worsening dyspnea, deteriorating exercise tolerance, and episodes of severe airway obstruction as a result of sputum accumulation at the stenotic site. A computed tomography scan of the neck and upper mediastinum showed the stenotic segment to be located at mid-trachea. It measured approximately 2 cm in length and 5 mm in diameter at its narrowest part.

After considering all options, general anesthesia was induced using propofol. After confirmation of the ability to ventilate the lungs *via* mask, succinylcholine was given, and the trachea was orally intubated using a 7.5 mm-ID nasal RAE tube cut proximally at the 26-cm mark.

* Associate Professor.

Received from the Department of Anesthesia, Georgetown University Medical Center, Washington, D.C. Submitted for publication December 27, 1995. Accepted for publication April 5, 1995.

Address reprint requests to Dr. Hannallah: Department of Anesthesia, Georgetown University Medical Center, 3800 Reservoir Road NW, Washington, D.C. 20007.

Key words: Equipment: endotracheal tube design. Trachea: resection.

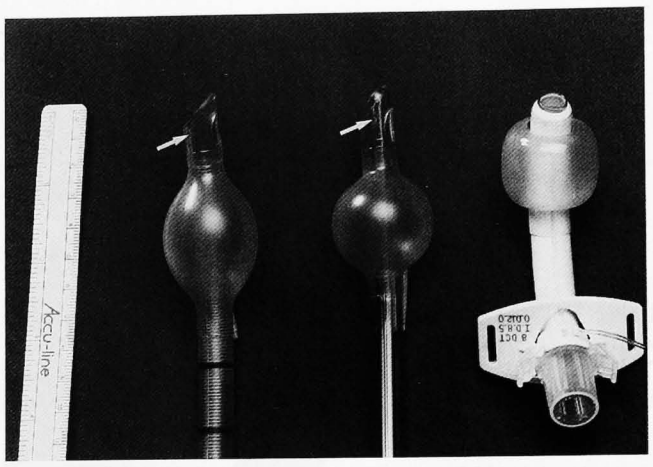

Fig. 1. The cuffs of an 8.0 mm-ID reinforced endotracheal tube (*left*), an 8.0 mm-ID RAE endotracheal tube (*center*), and a size 8 Shiley tracheostomy tube (*right*) are inflated to a 15-ml volume to illustrate the difference in cuff size and design between the three tubes. The arrows indicate the pilot tubes, which extend beyond the cuff to the tip in the first two tubes. Therefore, cutting off the tip of these tubes compromises the cuff seal.

The RAE tube was chosen because of its relatively short cuff compared to that of reinforced or regular endotracheal tubes (fig. 1). The nasal RAE tube was chosen because it had a longer straight segment than the oral type, which allowed more distal placement of the tube in the trachea.

The tube was advanced without resistance until the proximal edge of the cuff was positioned completely beyond the vocal cords. At that depth, fiberoptic bronchoscopy showed the tip of the tube to be positioned close to the proximal end of the stenotic segment.

The trachea was exposed *via* a lower cervical incision and an upper median sternotomy. After dividing the trachea below the stenosis, a 7.0 mm-ID reinforced endotracheal tube was inserted into the distal tracheal segment and connected to a sterile second set of breathing circuit. A reinforced tube was chosen because it could be directed away from the operative site without kinking. However, it became immediately apparent that the segment between the tip of the tube and the proximal edge of the cuff was too long for the tube to function properly inside a relatively short distal tracheal stump. This resulted in either endobronchial intubation or cuff herniation through the tracheal stoma. Alternatively, a size 6 Shiley tracheostomy tube was inserted into the distal tracheal segment and connected to the breathing circuit *via* a short corrugated extension tube. The tracheostomy tube allowed bilateral lung ventilation and clear access to the edge of the distal tracheal stoma.

After resection of the stenotic area, the posterior part of the trachea was approximated with nylon stitches. The tracheostomy tube was removed and the original RAE tube advanced into the distal trachea. The anterior part of the tracheal anastomosis was completed. The most distal position of the RAE tube that was compatible with bilateral lung ventilation was associated with a proximal cuff position 4–5 mm distal to the site of the tracheal anastomosis. Finally, the anterior and posterior parts of the tracheal anastomosis were externally reinforced using pedicled right and left sternohyoid muscle flaps.

Postoperatively, the trachea remained intubated while the neck was maintained in a flexed position. The tube position required frequent adjustments using fiberoptic bronchoscopy. The trachea was successfully extubated 5 days postoperatively, and the patient experienced a full recovery.

Discussion

Several techniques have been described for providing adequate ventilation during tracheal resection.[1] These include high-frequency jet ventilation and cardiopulmonary bypass in addition to standard orotracheal intubation and insertion of a tube into the opened trachea distal to the area of resection.

The optimal breathing tube for use during tracheal resection or reconstruction is a long, flexible, nonreactive thermoplastic reinforced tube with a short, low-pressure, high-volume cuff and a very short segment beyond the cuff. Such a tube can be manipulated easily without kinking during surgery and allows bilateral lung ventilation through short tracheal stumps without encroaching on the operative site or on a fresh tracheal suture line.

During the first case, a RAE tube was modified so that it would fulfill some of these criteria. Although the modified tube functioned adequately, such a modification cannot be recommended as a standard practice.

During the second case, it was possible to use the RAE tube during and after the case. However, there was no margin of safety in the tube position. As a result, repeated fiberoptic bronchoscopies were required intra- and postoperatively to correct tube malpositions.

In 1969, Geffin *et al.*[2] stated that anticipating a need for postoperative ventilatory assistance constituted a relative contraindication to tracheal resection because positive-pressure ventilation with an inflatable cuff at the tracheal suture line might cause dehiscence. However, this approach would deny some patients surgery when it offers them the only chance of survival. Significant improvements in intensive care over the past 25 yr warrant reconsideration of this recommendation. In addition, the availability of specifically designed tubes should allow postoperative ventilation while bypassing the tracheal suture-line in most patients. In patients with very low tracheal or carinal lesions, where the endotracheal tube must be proximal to the anastomosis, a decreased tidal volume (6–8 ml/kg) with an increased respiratory rate and a low level of positive end-expiratory pressure can be used postoperatively.

Abou-Madi *et al.*[3] modified a Foley catheter to serve as a tracheal tube during resection of a tumor situated

approximately 4 cm from the carina. They cut off the tip of the size 28 Fr. catheter whose rounded balloon measured less than 1.5 cm in length and whose internal diameter was 6 mm. After division of the trachea below the lesion, the modified catheter was placed in the short tracheal stump, and bilateral lung ventilation was maintained successfully. When the tracheal anastomosis neared completion, the Foley catheter was withdrawn, and ventilation was restored *via* the trachea. At the end of the procedure, the trachea was extubated and the patient allowed to breathe spontaneously. Such a tube is not suitable for long-term use because of its small internal diameter and the high-pressure nature of its cuff.

Red rubber tubes can be cut off beyond the cuff without compromising the cuff seal. In a report of two cases of carinal resection by Theman *et al.*,[4] each divided bronchus was ventilated separately using an armored (reinforced) red rubber tube that was cut off square immediately beyond the cuff to avoid occluding lobar bronchi. For orotracheal intubation during the case, they used a red rubber, short-cuffed endobronchial tube of the Mackray type, which is designed for endobronchial intubation. Red rubber tubes, however, have a high-pressure, low-volume cuff and, therefore, are unsuitable for long-term ventilation.

The optimal tube for tracheal resection and reconstruction (long, reinforced tube with a short, low-pressure cuff and a short tip) is not available. Several publications depict in their illustrations of tracheal resection an endotracheal tube with a short cuff and a short segment distal to the cuff.[2,5,6] This is most likely the Tovell tube, which is no longer manufactured. Although it may not be cost-effective to mass produce and market a tube for such relatively rare procedures, manufacturers of endotracheal and tracheostomy tubes are capable of modifying existing tube designs to meet the specific needs of rare cases. With advanced planning, the desired tube design can be requested before surgery. This clearly requires a team approach and communication between the anesthesiologist and the surgeon in advance of surgery and is surely to be rewarded with significantly improved surgical conditions and ventilatory management.

The author thanks Tisa Reeves, for her help in the preparation of this manuscript.

References

1. Benumof JL: Anesthesia for special elective therapeutic procedures, Anesthesia for Thoracic Surgery. Edited by Benumof JL. Philadelphia, WB Saunders, 1994, pp 513–590

2. Geffin B, Bland J, Grillo G: Anesthetic management of tracheal resection and reconstruction. Anesth Analg 48:884–894, 1969

3. Abou-Madin M, Cuadin L, Domb B, Barnes J, Trop D: Anaesthesia for tracheal resection: A new way to manage the airway. Can Anaesth Soc J 26:26–28, 1979

4. Theman TE, Kerr JH, Nelems JM, Pearson FG: Carinal resection: A report of two cases and a description of the anesthetic technique. J Thorac Cardiovasc Surg 71:314–320, 1976

5. Boyman CP, Privitera PA: Resection of stenotic trachea: A case presentation. Anesth Analg 55:191–194, 1976

6. Akdikmen S, Landmesser C: Anesthesia for surgery of the intrathoracic portion of the trachea. ANESTHESIOLOGY 26:117–119, 1965