

Surgical treatment of air way disease

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Abstract: Airway lesions are treated by resecting and subsequent reconstructive surgery. Tracheoplasty and bronchoplasty are applied to inflammatory stenosis, damage due to trauma, and primary tumors of the airways. The indications for lobar (bronchial) sleeve resection are commonly applied to lung cancers that develop at the proximal portion of the lobar bronchus. Recently, extended sleeve lobectomy (ESL) is widely indicated among the routine techniques used to avoid pneumonectomy because of its reliability and effectiveness. In some cases the cancer is limited to the segmental bronchi, segmental sleeve resection is sometimes performed. In the field of respiratory surgery, carinal resection-reconstruction is one of the most rare procedures and challenging issues, involving difficult surgical techniques, anesthetic techniques, and postoperative management. Tracheal surgery was generalized so that it could be applied to any type of tracheal disease that required resection, including tumors.

Keywords: Air way; trachea; bronchus; carina; surgery; tracheoplasty; bronchoplasty; tracheo-bronchoplasty

Submitted Dec 07, 2015. Accepted for publication Dec 21, 2015.

doi: 10.3978/j.issn.2072-1439.2016.01.09

View this article at: <http://dx.doi.org/10.3978/j.issn.2072-1439.2016.01.09>

Airway lesions are treated by resecting and subsequent reconstructive surgery (1). Tracheoplasty and bronchoplasty are applied to inflammatory stenosis (2), damage due to trauma (3-5), and primary tumors of the airways (6,7). For thoracic surgeons, these procedures are mainly required for the resection of tumorous lesions, and the surgical procedures include wedge resection and sleeve resection. With malignant tumors, these are performed to preserve lung function based on functional limitations, though the accumulation of results in recent years has enabled postoperative results that compare well with standard surgeries, so these methods have come to be performed actively for their high likelihood of obtaining a complete cure (7,8).

Bronchoplasty

The most common surgical indication of bronchoplasty is observed for left or right upper lobe sleeve resection. The indications for lobar (bronchial) sleeve resection are commonly applied to lung cancers that develop at the proximal portion of the lobar bronchus (9). Bronchial sleeve

resection is used relatively rarely for middle lobe resection, lower resection, and pneumonectomy (9). Furthermore, sleeve resection of the left and right main bronchi for benign tumors from the bronchial gland and inflammatory scar stenosis were sometimes reported (10,11).

The standard procedures for right upper sleeve lobectomy are follows (12); after closing and cutting the vessels of the right upper lobe, the right main pulmonary artery is separated and passed through cotton tape, taking care not to damage it during bronchial anastomosis. Lymph node dissection after bronchial reconstruction is normally performed before treating the bronchus, since this may place excessive traction on the anastomosis site. If the cancer has invaded the right main pulmonary artery, sleeve resection and reconstruction of the pulmonary artery can also be performed (13). The area around the right upper lobar bronchus is fully separated. The dissection should be performed at least 1 cm from the cancer margin, then the bronchus is dissected in a sleeve shape. Rapid pathological diagnosis must be performed on the stump to check for cancer remnants. The length of the round edge of the proximal end is larger than the peripheral side, so some

surgeons employ telescope anastomosis preferably, in which the peripheral side is slid into the central side and sutured (14). Bronchial anastomosis is performed using synthetic absorbable thread by full-thickness interrupted sutures or continuous sutures supported at two or three points. The membranous portion is sutured last to close the difference in apertures between the central and peripheral sides. Thread is passed through the full thicknesses of the bronchi on the peripheral and central sides, then they are sutured starting from the bronchial cartilage that is farthest from the surgeon.

Recently, extended sleeve lobectomy (ESL) is widely indicated among the routine techniques used to avoid pneumonectomy because of its reliability and effectiveness (7,8). According to results from the reports, ESL is feasible and results in local disease control similar to that achieved with pneumonectomy but with mortality and major complication rates similar to those of classic sleeve lobectomies (15) and substantially lower than those for pneumonectomy (16-19). On the other hand, the proliferation of lung cancer screenings in recent years has led to a large number of X-ray negative lung cancers. In some cases the cancer is limited to the segmental bronchi. For cases in which segmental resection is considered appropriate due to low pulmonary function and to achieve a complete cure, segmental sleeve resection is sometimes performed (20,21).

Carina reconstruction

In the field of respiratory surgery, this is one of the most rare procedures and challenging issues, involving difficult surgical techniques, anesthetic techniques, and postoperative management (22). The main indications of these procedures are for the management of malignant tumors (23).

The techniques used for carinal resection and reconstruction have been reported in the papers by Grillo (24,25). A few points pertaining to resection of malignant processes were emphasised by them (26).

- (I) Frozen section analysis of resected airway margins by pathologists should be immediately available. Extensive dissection beyond the area of the tumor and the subsequent anastomosis is avoided because of concerns over airway devascularization;
- (II) Extended lymphadenectomy is discouraged and only those lymph nodes involved with or immediately adjacent to the main tumor are resected;

- (III) Special attention should be paid to maneuvers used to reduce tension on the newly constructed airway anastomosis;
- (IV) Development of the pretracheal plane, either through mediastinoscopy or via the operative field, can provide some mobility to the upper airway;
- (V) Freeing the ventral surface of the left main bronchus can produce limited mobility in an analogous manner;
- (VI) Care must be taken to avoid disrupting the blood supply to the airway, which approaches the trachea from the lateral aspect;
- (VII) The use of an inferior hilar release can provide a significant reduction in anastomotic tension. This is accomplished by creating a U-shaped incision in the pericardium beneath the hilum after division of the inferior pulmonary ligament;
- (VIII) Even more mobility to the hilum can be obtained by performing a complete hilar release, dividing the pericardium circumferentially;
- (IX) When this latter release is being performed, the posterior vascular and lymphatic attachments to the hilum should be preserved;
- (X) In general, use of a right hilar release should be considered in any carinal operation in which right-sided lung parenchyma is preserved; a left hilar release results in less cephalad mobility because of the aortic arch;
- (XI) Laryngeal release maneuvers to be of limited use in carinal surgery because they have not translated into more distal tracheal mobility;
- (XII) Mild flexion of the neck allows the upper trachea to devolve into the mediastinum and is used at the time the anastomotic sutures are secured. This degree of neck flexion is maintained for several days postoperatively (by a stitch between the chin and the skin overlying the manubrium) and, more important, discourages neck extension, which places undue tension on the newly constructed airway anastomosis.

Fujimura *et al.* (27) described about the standard approach for sleeve upper lobectomy of right lung is to perform thoracotomy via a posterolateral incision of the right fourth or fifth intercostal. First, the pulmonary vessels of the right-upper lobe are treated according to regular basic techniques. Next, the lower trachea and left main bronchus are separated extensively, and are reserved by

cotton tape. Then, the bronchus intermedius is severed and intubation of the surgical field is performed through the peripheral side of the right lung to ventilate the right, middle, and lower lobes. Connecting the left and right intubation tubes with a Y adapter makes ventilation more convenient. If ventilation via tubes is insufficient, high frequency jet ventilation (HFJV) can be added as needed. Next, the lower trachea is severed and the right-upper lobe and carina are resected.

Tracheoplasty

Dr. Grillo began to do experiments in his dog lab to work out the surgical treatment of tracheal stenosis. He was able to show that it was possible to resect a portion of the trachea and perform a primary reanastomosis (28). After working out the technique in the lab, he successfully applied his tracheal resection and reconstruction techniques to patients who developed tracheal stenosis. Later, this technique was generalized so that it could be applied to any type of tracheal disease that required resection, including tumors (29).

The trachea is a luminal organ that extends from the larynx. It is composed of 15 to 19 pieces of cricoid cartilage and can conveniently be divided into an upper section (neck), middle section, and lower section near the carina (the middle and lower trachea are sometimes called the intrathoracic trachea) (27,30). The blood supply is the very important issue for surgery of trachea. The vessels come into the trachea laterally and form a rich segmental network. Since there are no blood vessels on the anterior or posterior surface of the trachea, the trachea can be mobilized extensively, based on the lateral attachments. The inferior thyroid artery, a branch of the subclavian artery, supplies the upper trachea. Distally, various bronchial arteries that come directly off the aorta or intercostal arteries supply the trachea. Once the blood vessels enter the lateral aspects of the trachea, they send smaller vessels to the anterior and posterior surfaces, which then feed the mucosal tissue (29-31). In addition to primary tumors of the trachea and esophageal cancer with tracheal invasion, other tumorous diseases that involve tracheal invasion are subject to this procedure, such as thyroid cancer in the upper trachea (32) and lung cancer in the middle and lower trachea (intrathoracic trachea). Surgical approaches used in the upper trachea are large cervical wedge resection or U-shaped resection (cervical approach) (33). In the middle trachea median sternotomy (mediastinal approach—cervical

wedge incision is sometimes added) is used, and in the lower trachea median sternotomy or right thoracotomy is used. The approach is selected based on the site of the primary tumor and the extent of the resection (34).

Anesthetic considerations are always important, since during the resection, the anesthesiologist team will cede control of the airway to the surgical team, which always causes a bit of anxiety. Almost all patients can have a small endotracheal tube passed distal to the lesion, allowing surgery to be safely initiated. If there is concern about a severe obstruction, a rigid bronchoscope can either core out a tumor or dilate a stenosis, allowing the endotracheal tube to pass. After the trachea is opened, an endotracheal tube can be passed into the distal end of the trachea and cross-table ventilation is performed. The use of cardiopulmonary bypass or jet ventilation is rarely necessary (29).

In cervical approach for upper tracheoplasty, the laryngotracheal area is opened with a large incision to the anterior neck (27,35,36). Proceeding along the intrathoracic trachea by separating the anterior and lateral tracheal surfaces sufficiently releases the trachea, though this varies depending on the extent of the resection. It is frequently impossible to determine the resection range from the surgical field, so the location often needs to be confirmed by inserting a fine needle to obtain bronchoscopy findings. After taping the full circumference of the trachea at the tumor location and while being careful of the recurrent laryngeal nerve, the trachea is dissected at the tumor location. After placing supporting thread on both lateral surfaces of the peripheral side of the tracheal area to be resected, the trachea is severed at the peripheral side. On the central side, the trachea is dissected at a place sufficiently far from the tip of the tumor, all while carefully observing the tracheal lumen. The resected trachea is removed for specimens for rapid diagnosis. If suspected findings are observed on a stump, additional tracheal resection should be performed. Intubation of the surgical field is performed immediately from the tracheal stump to maintain ventilation. After suturing about two-thirds of the circumference, remove the intubation tube from the surgical field, insert and fix an oral intubation tube from the peripheral side of the anastomosis (reverse intubation from the mouth side of the surgical field will prevent contamination of the surgical field). Supporting thread is also placed on both lateral surfaces of the central side of the trachea. Anastomosis is performed using absorbable sutures by full-thickness interrupted sutures or continuous sutures supported at two or three points. Whichever is used, take

sufficient margins of about one cartilage ring on both the central and peripheral sides, draw them together with the supporting threads on the lateral tracheal surfaces, and proceed with suturing starting from the lateral surfaces of the posterior tracheal wall. While maintaining ventilation, suture the remaining one-third circumference.

Resection of the middle and lower trachea is performed for large resections of upper airway tumors with mediastinal approach (27,37,38). When there is a large amount of tension at the anastomosis site or when there is concern over complications involving the anastomosis site, such as openings or stenosis, releasing the larynx by adding a wedge resection or U-shaped resection (cervical-mediastinal approach) can reduce tension at the anastomosis site. This should create about 2 cm of mobility for the larynx, though postoperative aspiration needs to be borne in mind. Other options are infrahyoid release [Dedo method (39,40)] and suprahyoid release [Montgomery method (41)]. Methods for securing the trachea during surgery, resecting the trachea, and anastomosis follow those for upper tracheoplasty. The anterior mediastinum is detached extensively, and a vertical incision is made in the pericardium as necessary to expose the right main pulmonary artery and carina. When securing the airway during lower tracheal resection, sufficient ventilation can be maintained with only deep intubation from the surgical field to the left main bronchus in patients with good lung function.

Right thoracotomy is often selected for resection of the lower trachea, particularly near the carina (27,42). Thoracotomy is performed via a posterolateral incision at the right fourth or fifth intercostal. The lower trachea and left-right main bronchi are separated and released. Methods for securing the airway and tracheal resection and reconstruction should follow those for the upper and middle trachea (43-45).

Acknowledgements

None.

Footnote

Conflicts of Interest: The author has no conflicts of interest to declare.

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Cite this article as: Maniwa Y. Surgical treatment of air way disease. *J Thorac Dis* 2016;8(1):E78-E82. doi: 10.3978/j.issn.2072-1439.2016.01.09