



Editorial on tracheal resection and reconstruction

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Tracheal resection and reconstruction is an infrequently practiced surgical procedure. Those who have a special interest in this area of surgery will encounter this problem much more frequently than the occasional airway surgeon. All who are involved in this type of airway surgery need to have a firm understanding of the principles of evaluation and management, a sound understanding of airway management both at presentation and during surgery, understand the limits of resection, have in mind a firm understanding of a surgical technique that is reliable, reproducible, and familiar, understand the principles of postoperative care and the management of complications. As more people become interested in airway surgery, it is important to share knowledge of all of these to ensure the best possible outcomes for patients (1). The old adage that the best opportunity for success is the first operation clearly holds for airway surgery.

A basic understanding of anatomy and the implications for tracheal resection and reconstruction is imperative. The two most obvious anatomic considerations are the location of the blood supply and the position of the recurrent laryngeal nerves. The blood supply of the trachea predominantly is through a delicate network of blood vessels that enter in the mid lateral position on both sides of the airway. The blood supply must be carefully preserved in order to ensure proper healing of the anastomosis. It is best not to divide this blood supply from the point of transection more than 5 to 10 mm at the most. Recurrent laryngeal nerves are in close proximity to the trachea and are located near the tracheoesophageal groove on both sides. The path of the right recurrent nerve is different because it loops around the subclavian artery before returning to the airway. The left recurrent nerve loops around the ligamentum arteriosum and then ascends in the

tracheoesophageal groove. In most circumstances, it is best to avoid trying to identify the nerve as it may be damaged in that process. Careful dissection absolutely on the surface of the trachea allowing the nerves to fall away laterally is the preferred method to avoid injury to these nerves. It is important to minimize the use of cautery in the area of the recurrent nerves.

Patients with tracheal stenosis may present in acute respiratory distress. There is often a history of recent intubation or decannulation from a tracheostomy tube to give a high-index of suspicion that tracheal stenosis may exist. Simple maneuvers of elevating the head of the bed, elevating the jaw to align the airway properly, use of oxygen, Heliox, a diuretic to reduce any edema, and steroids to reduce any component of edema all may help in the initial management. Unnecessary radiologic tests often times subject the patient to unneeded risks of possible critical airway stenosis and should be avoided. If the simple maneuvers do not stabilize the airway, further evaluation and management should be done in the operating room with preparation for emergency tracheostomy, urgent dilation, and intubation with clear understanding between anesthesia, nursing, and surgery. Having everything available in these critical moments is essential. There is almost never a need for emergency tracheal resection and reconstruction, but there is often a need for stabilization of the airway. Dilation can predictably palliate patients for weeks to months. Those inflammatory strictures that sometimes are present following an acute airway injury are more likely to be palliated for shorter period of time than the more mature stricture that is found in most patients. Surgeons must be skilled in the use of various dilators, airway balloons, and graduated rigid bronchoscopes. If a tracheostomy is elected, it should be placed through

the stenosis to preserve as much normal trachea for future reconstruction.

Once the airway is stabilized or if the patient presents in an elective fashion, thorough workup of the airway and the exclusion of other medical problems is important. Computed axial tomography with 3D reconstruction including axial, sagittal, and coronal views have become the standard radiologic test to evaluate the airway. Simple X-rays can sometimes be helpful, but the airway is sometimes obscured because of the location or the patient's anatomy.

The most essential part of evaluation is the use of careful bronchoscopy and precise measurements. Bronchoscopy will identify the quality of the mucosa and assessment of the severity of retained secretions and suitability of the uninvolved trachea for reconstruction. Precise measurements are best done with a rigid bronchoscope. This allows for careful measurements of the distance from the carina to the bottom of the stenosis, from the carina to the top of the stenosis, and from the carina to the vocal cords. These measurements define the extent of the lesion and how much airway remains for reconstruction.

Airway surgeons must have a sense of the limits of resection for each patient as it differs from one individual to the next. Body habitus, location of the stenosis, previous operations, prior radiation and age all play a role in determining extensive resection. It is commonly stated that up to one-half of the trachea can be resected and reconstructed. It is important to understand this is in the most extreme of circumstances incorporating both a laryngeal release, a hilar release and division and reimplantation of the carina to give maximal relaxation for removing half of the trachea. This extreme approach is suitable for only certain individuals. Surgeon must not be lulled in to a false sense of security that half the adult trachea can always be resected and reconstructed.

At the time of surgery, airway control is still important. If a stenosis exists, it must be dilated to allow the anesthesiologist to conduct safe anesthetic management of the patient. It is preferable to dilate the stenosis only to a degree that allows the placement of a small-cuffed endotracheal tube. Minimizing the amount of dilation minimizes the risk of perforation, tearing, disruption, or inflammation of the airway. Virtually all patients can be managed with a #5.5 endotracheal tube if need be. If the stenosis is high in the airway, the oral endotracheal tube can be secured with red rubber catheter and then pulled back into the oropharynx while maintaining control of the operative field. Cross-field ventilation has been our

method of ventilation during the operation and rarely high-frequency ventilation or other more extreme measures. Surgeons and anesthesiologist must be familiar with this anesthetic technique. Anesthesiologist must be familiar with various methods of maintaining safe anesthesia. We have increasingly utilized total intravenous anesthesia during the course of the operation; it has many advantages.

Each surgeon must be familiar with a technique of their own for resection and reconstruction that works for them. The first principle is to mobilize the anterior surface of the trachea by dividing the thyroid isthmus and freeing up the pretracheal plane, in most cases to the level of the carina. It is imperative to preserve the maximal amount of airway for reconstruction. A safeguard against this is to carefully identify the proximal and distal extent of the stenosis. This can be done by passing a bronchoscope through the endotracheal tube and carefully pulling it back until both the proximal and distal ends are identified. A small needle can be inserted and observed by the endoscopist. Once the limits of the stricture are identified in this fashion, and marked with a suture, the surgeon is secure in knowing the precise point of resection of the airway. This will avoid needlessly sacrificing normal trachea for reconstruction.

Once the damaged segment of the trachea has been identified, dissection takes place absolutely on the surface of the airway. Dissection can be done at various points of the stricture, but staying absolutely on the airway is imperative to avoid injury to the recurrent nerves and the posterior lying esophagus. Sharp lines of transection are important. Traction sutures placed around a tracheal ring at least one or two rings below the point of transection allows control of the distal airway for placement of the cross-field endotracheal tube. The segment of the trachea remaining can be separated carefully from the esophagus and avoiding injury to the adjacent nerves. Once the damaged segment has been removed, traction sutures are utilized proximally and distally in the mid lateral position on either side of the airway. This allows an assessment of reapproximation to be certain excessive tension does not exist and the two ends will come together. If concern exists about excessive tension, this is the appropriate time to add an additional relaxing maneuver, usually the suprahyoid laryngeal release of Montgomery as described in the article. One should be familiar with the technique to avoid complications to allow attainment of maximal relaxation. Authors differ on the technique of reconstruction. We have always preferred an interrupted open technique using fine absorbable sutures. Sutures are placed so that the knots will eventually be

tied on the outside of the airway. By convention, the first suture is placed posteriorly in the midline. Subsequent sutures are placed from this stitch to the level of the lateral traction sutures. Each suture is placed so that it is inside the previous suture so that when tying the sutures they are not incorporated by tying the anastomotic sutures. Careful attention to this detail is important. Each surgeon must have a method of keeping these sutures straight. We prefer to clip them to the drapes sequentially and tie them in reverse order in which they are placed. The anterior row is placed between the two traction sutures and are clipped to the drapes inferiorly in the operative field.

Once the anastomotic sutures have all been placed, the distal airway is carefully cleared off secretions, the oral endotracheal tube which has been pulled back is carefully advanced across the operative field into the distal airway, being careful to avoid entangling it in anastomotic sutures. The patient's head and neck are flexed and placed in moderate flexion and secured there by the use of blankets underneath the occiput. One wants to avoid overly flexing the neck as spinal cord ischemia can occur in some patients resulting in paralysis. At the completion of flexing the neck, the traction sutures are drawn together and tied. This reduces the tension on the individual anastomotic sutures. It is important the anastomosis is airtight. At the completion of tying all of the sutures, we deflate the endotracheal balloon and give a breath of 20 to 30 cm of water pressure to hear a rush of air around the tube through the larynx, knowing that the repair is structurally adequate. We then submerge the anastomosis in saline, the mouth and nose are occluded by the anesthesiologist and again ventilate the patient with the cuff down to a pressure between 20 and 40 cm of water to check for an air leak. Any air leak must be repaired before leaving the operating room. This should be done even if it requires taking the anastomosis down and repairing a posterior defect that has occurred. This should be a rare occurrence. Once the integrity of the anastomosis is confirmed, the wound is copiously irrigated. It is important to cover the anastomosis, and in our hands is done on every case. This is to buttress the wound, provide additional blood supply to the anterior aspect of the anastomosis and to separate the anastomosis from the subcutaneous tissues and skin in case a superficial infection develops. Infections should be exceedingly rare, but one would want to avoid contamination of the suture line by superficial infection. We generally use the strap muscles from both sides to cover the anastomosis with carefully placed horizontal mattress sutures. To hold the patient's

neck in flexion, a chin stitch is placed from the submental crease to the presternal skin and should not be overly tight, but placed so as to be a reminder not to hyperextend the neck in the postoperative period.

It is important to understand the management and presentation of postoperative complications. For high reconstruction, edema is sometimes an issue and generally presents between the second and fifth postoperative day. We have used 24 h of steroids to manage this problem along with diuretics and elevation of the head and neck. Heliox may be helpful. If it can be anticipated that problems exist with either the integrity of the repair or edema there are two ways of managing this before leaving the operating room. One is to place a small endotracheal tube, uncuffed and leave it for 48 h while edema is aggressively treated. If it appears the problem is more structural in nature, a protecting tracheostomy should be done. The strap muscles provide a way to separate a tracheostomy from the anastomosis to avoid contamination. This again is imperative that the anastomosis be covered by a strap muscle. The tracheostomy should be placed at least two rings below the anastomosis. If there is uncertainty about the airway, a mini tracheostomy can be placed which does provide some measure of safety in the marginal airway. It is not big enough, however, to provide a stable airway to discharge patients, and if the problem does not resolve, it must be converted to be a standard small tracheostomy tube. The goal, however, in the vast majority of patients is to have them extubated at the end of the procedure and breathing spontaneously on their own. This requires very experienced anesthesiologists and has been enhanced by our use of total intravenous anesthesia which allows for smooth emergence from anesthesia, relatively quick reversal and lack of suppression of airway drive. The other main complication in the postoperative period is air leaks or separation of the anastomosis. This should be a very rare complication. The most important feature is to identify the problem and secure the airway. The patient should be returned to the operating room, endoscopy performed, and assessment of the anastomosis done. If the airway is patent and stable, one might explore the wound to identify and repair the small air leak. If the airway has separated or is threatening separation, exploration and placement of a tracheostomy or T-tube is necessary.

The author should be applauded for the careful description of the operative technique of tracheal resection and reconstruction and a general description of many of the aspects in this editorial. It is important that those wishing to perform airway surgery be familiar with all of the nuances

that are described to ensure the best possible outcome for the patients. The goal is preservation of the airway and voice and avoidance of life-long dependency on an airway appliance.

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