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Segmental tracheal resection (nine rings) and reconstruction for carcinoma showing thymus-like differentiation (CASTLE) of the thyroid

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Abstract

Background: Tumors invading the trachea are rare, and although literature often suggests five tracheal rings as the maximum limit of tracheal resection with primary closure, longer tracheal resections and primary closure are possible in many patients. One such locally invasive tumor with propensity for tracheal invasion is carcinoma showing thymic-like differentiation (CASTLE) of the thyroid.

Methods: A 53-year-old woman presents with a 2-year history of hoarseness, newly diagnosed right vocal cord paralysis, and a thyroid mass with significant tracheal and esophageal muscularis invasion. Pathology suggests CASTLE. Segmental nine-ring tracheal resection with primary closure is illustrated, demonstrating important tracheal reconstructive techniques.

Results: At the completion of total thyroidectomy and central compartment dissection (not illustrated), the area of tracheoesophageal tumor involvement is isolated. First, the disease is sharply dissected from the tracheal wall and esophagus, excising 4 cm of esophageal muscularis. Next, a plane is established between the membranous trachea and esophagus. The intact left recurrent laryngeal nerve is released from the left tracheoesophageal groove. Substernal thoracic tracheal attachments are released, and a suprahyoid muscle release is performed. Tracheal rings 1 through 9 are resected en bloc, and circumferential tracheal closure is illustrated, with careful attention to technique of tracheal closure and management of the endotracheal tube. Finally, given the degree of tracheoesophageal resection and indication for postoperative radiation therapy, a pectoralis muscle flap is rotated over the trachea and esophagus.

Conclusion: To our knowledge, this is the first video demonstration of a segmental resection and reconstruction of a CASTLE of the thyroid in the peer-reviewed literature. Unique to this case is the significant length of tracheal resection with primary closure, as well as demonstration of concurrent esophageal muscularis resection. Resection and reconstruction of longer segments of cervical trachea require stepwise surgical technique to safely preserve recurrent laryngeal nerve (s), while

releasing the larynx and thoracic trachea to minimize tension on the tracheal closure.

KEYWORDS

carcinoma showing thymic-like differentiation, CASTLE, esophageal resection, suprahyoid release, surgery, thyroid cancer, tracheal reconstruction, tracheal resection

A 53-year-old woman presents with a 2-year history of hoarseness, newly diagnosed right vocal cord paralysis, and a thyroid mass with significant tracheal invasion.

An axial CT scan with contrast is shown, starting at the level of the mandible and scrolling inferiorly. First, we can see radiographic evidence of a right recurrent laryngeal nerve paralysis. Scrolling more inferiorly to the thyroid, we see a mass emanating from the posterior aspect of the right thyroid lobe and invading the trachea immediately below the cricoid cartilage. This tracheal invasion extends for multiple tracheal rings. The trachea at the level of the sternal notch is free of disease, and there are no apparent lymph node metastases.

Thyroid cancers (including rare tumors such as CASTLE) are almost always treated with surgery when possible, as they are not typically particularly radiosensitive. In cases where there is a targetable mutation with systemic therapy available, neoadjuvant systemic therapy may be considered, although there is no such option currently available for CASTLE. Therefore, surgery, although complex and with associated potential complications and morbidity, is the clear best option for such a disease presentation. However, these surgeries are complex and should be performed at centers with high-volume experience with aggressive thyroid malignancy.

This surgery includes total thyroidectomy, bilateral central compartment dissection, segmental tracheal resection (nine rings), esophageal muscularis resection, right lateral neck dissection, and pectoralis muscle flap. A neural integrity monitor (NIM) endotracheal tube is used to monitor recurrent laryngeal nerve function throughout the case. The endotracheal tube is prepped into the surgical field, so that the surgeon has full control over the endotracheal tube throughout the case. In this case, because intratracheal tumoral extension is clearly apparent on CT imaging, there is no need for tracheoscopy. Additionally, the authors do not routinely perform either tracheoscopy or esophagoscopy even in cases where tracheal or esophageal involvement is questionable, as it does not typically add to what can already be appreciated from intraoperative inspection. However, it is important that surgeons be prepared for tracheal resection and/or esophageal resection and reconstruction in cases where preoperative imaging demonstrates concern for such, as the morbidity of an incomplete resection (and need for subsequent revision surgery) can be significant. Additionally, if the tracheal tumoral involvement is extending below the sternum (not present in this case), a thoracic surgeon should assist with the tracheal resection, as an upper sternotomy may be required in such cases.

Outline of the steps of the surgery is shown. First, perform standard thyroid and central dissection, mobilizing the specimen to isolate the area of tracheoesophageal involvement. Second, dissect disease from the tracheal wall (sharp dissection illustrated). Third, dissect disease from the esophageal muscularis. Fourth, resect esophageal muscularis with residual tumor. Fifth, establish a plane between the membranous trachea and the esophagus. Sixth, release the intact recurrent laryngeal nerve from the trachea and the esophagus. Seventh, release substernal anterior tracheal attachments as necessary. Eighth, suprahyoid muscle release as necessary. Ninth, tracheal resection. Tenth, tracheal closure. Eleventh, pectoralis muscle flap to cover tracheal closure as necessary.

The first step is to perform a standard thyroid and central neck dissection, mobilizing the specimen to isolate the area of tracheoesophageal involvement. This step is not shown in the supporting video. The orientation is shown demonstrating the head of the bed to the right of the screen and the patient's feet to the left of the screen.

The next step is to dissect disease from the tracheal wall. Sharp 15-blade dissection is illustrated. The tumor is dissected free from the tracheal wall, leaving the aspect of the tumor invading the trachea. The specimen is then flipped to show the right lateral aspect of the thyroid bed, including the carotid artery, the internal jugular vein, the thyroid cartilage, the esophagus, and the tumor.

The disease is then dissected free from the esophageal muscularis. A superior parathyroid gland is preserved in situ. The bulk of the tumor is removed with the en bloc resection, but the trachea and esophagus can be visualized with residual tumor involving and invading the tracheal wall and esophageal muscularis. The left intact recurrent laryngeal nerve can be visualized.

The esophageal muscularis with residual tumor is then sharply dissected to remove the residual esophageal muscularis disease. A 15-blade knife is employed to establish a plane between the esophageal muscularis and the esophageal submucosa. An inferior esophageal muscularis margin is resected. The superior aspect of the esophageal muscularis is freed from the underlying submucosa as well as the lateral aspect of the

esophageal muscularis. The dissection extends superiorly to involve resection of the inferior aspect of the inferior pharyngeal constrictor muscle. An approximately 4-5 cm segment with tumor involving esophageal muscularis is excised en bloc. A superior esophageal muscle margin is excised.

The plane between the membranous trachea and the esophagus is then established, typically aided with blunt finger dissection. The remaining aspects of the esophageal muscularis are freed from the membranous trachea.

It is critically important to release an intact recurrent laryngeal nerve from the trachea and membranous esophagus to avoid injury during tracheal resection and reconstruction, particularly when the tracheal reconstruction extends to the cricoid, where the nerve is entering the cricothyroid joint and very close to the anastomosis. Although this is always a critically important step, in the present case where a unilateral nerve is preoperatively paralyzed by disease and sacrificed with surgery, the contralateral nerve must be preserved to avoid a likely permanent tracheostomy tube. In the present case, the left recurrent laryngeal nerve is released from the membranous trachea and the esophagus as the nerve enters the cricothyroid joint, allowing protection of the nerve during the tracheal resection and tracheal closure. The plane between the trachea and esophagus has been established, and the disease can be visualized involving the right lateral tracheal wall with fragments of esophageal muscularis attached. The tracheoesophageal plane has been established from the level of the cricoid through the level of the cervical trachea.

In cases of longer tracheal resections, the substernal anterior and lateral tracheal attachments may need to be released with gentle finger dissection. A suprahyoid muscle release may be necessary for tension-free closure in cases of longer tracheal resections. Suprahyoid muscle release is often associated with temporary dysphagia, and therefore patients with short tracheal resections generally do not require suprahyoid releases. To perform the suprahyoid release, an incision in the muscle is made along the superior aspect of the hyoid bone, between the lesser cornua of the hyoid. The suprahyoid muscles along the superior aspect of the hyoid bone are released between the lesser cornua of the hyoid bone.

The tumor can be visualized involving nine tracheal rings. These tracheal rings have been marked with a purple marker and can be counted. The perichondrium overlying the 10th tracheal ring is freed from the underlying cartilage in order to establish a margin for soft tissue resection. The space between the 9th and 10th tracheal rings is outlined with a marker, as is the space between the cricoid cartilage and the 1st tracheal ring. This is an approximately 4-cm tracheal resection.

The NIM neuromonitoring endotracheal tube is demonstrated prepped into the surgical field to allow the surgeon to control the endotracheal tube throughout the tracheal resection and closure.

The tracheal cut between the 9th and 10th tracheal ring is made with a 15-blade knife. The cuff of the endotracheal tube is deflated before making this incision in order to avoid popping the endotracheal tube balloon. The posterior aspect of the membranous trachea is beveled superiorly in order to preserve as much tracheal mucosa as possible. The distal trachea is intubated with a wire-reinforced endotracheal tube.

The tumor can be visualized in the inferior aspect of the tracheal resection. The superior tracheal cut between the cricoid cartilage and the first tracheal ring is then made. A small segment of the cricoid cartilage is resected with the nine-ring tracheal resection. The tumor can be visualized involving the first tracheal ring and extending to abut the cricoid cartilage. A 4-cm, nine-ring tracheal segment has been removed. The trachea is opened demonstrating tumor extending close to but not involving the superior and inferior margins of the resection. The cricoid and distal trachea are then digitally reapproximated to ensure primary closure will be possible. A 2-0 silk suture is inserted through the endotracheal tube in order to ensure that the patient is not inadvertently extubated during the tracheal closure.

The tracheal closure is begun in the posterior midline with interrupted 3-0 Vicryl suture, leaving the knot of the suture on the outside of the tracheal lumen. Each individual stitch is clamped with a hemostat, and all tracheal sutures are placed before any of them are tied. The tracheal sutures are then placed from posterior to anterior on each side. On the left side, this is counterclockwise from posterior to anterior. Along the anterior aspect of the trachea, the stitch is placed through the entire cricoid cartilage superiorly and through two tracheal rings inferiorly in order to provide strength to the closure. The anterior stitches are interrupted 2-0 Vicryl sutures.

The procedure is repeated along the right aspect of the trachea, proceeding in a clockwise fashion from posterior to anterior. Similarly, the anterior stitches are placed through the cricoid cartilage superiorly and two tracheal rings inferiorly using 2-0 Vicryl suture. The hemostats are kept organized on each respective side by keeping them in sequential order from posterior to anterior, so that the posterior stitches can be tied first.

Beginning on the left side, the posterior membranous tracheal stitches are tied. The sutures are then sequentially tied and cut from posterior to anterior, beginning with the posterior membranous trachea in the midline and proceeding counterclockwise on the left side to the anterior trachea. It is important that these tracheal ties be square and tight, avoiding any potential air-knots. The interrupted Vicryl sutures are similarly tied along the right side, beginning posteriorly in the midline and proceeding clockwise anteriorly. When only the anterior aspect of the tracheal closure remains, the distal endotracheal tube is removed. The oral endotracheal tube is reinserted back through the tracheal

FIGURE 1 Nine-ring tracheal segment specimen, approximately 4 centimeters in length [Color figure can be viewed at wileyonlinelibrary.com]

FIGURE 2 The opened trachea demonstrates intraluminal tumor invasion with the superior and inferior resection margins free of disease [Color figure can be viewed at wileyonlinelibrary.com]

closure into the distal trachea. The stitch which was holding the oral endotracheal tube is then cut.

The interrupted 2-0 Vicryl suture along the anterior trachea is tied. Again, it is important to ensure a square knot with a tight closure. A Debakey forceps can be employed to hold the knot, ensuring tight closure without an air knot. These anterior tracheal sutures which again are through and through the cricoid cartilage superiorly and two tracheal rings inferiorly provide the strength to the closure.

The intact recurrent laryngeal nerve is visualized, and stimulation is confirmed with the nerve probe. Lastly, a pectoralis muscle flap is rotated over the tracheal closure.

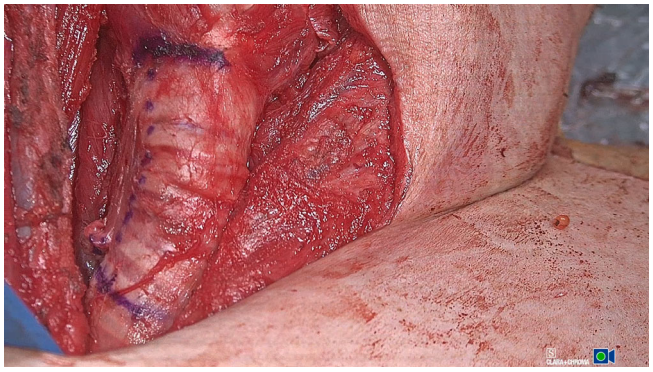

FIGURE 3 The tracheal rings, as well as the superior and inferior margins of the resection have been denoted with a marker (the superior margin of resection is made between the cricoid cartilage and the first tracheal ring; the inferior margin of resection is made between the 9th and 10th tracheal rings) [Color figure can be viewed at wileyonlinelibrary.com]

Muscle covering the tracheal closure will reduce tracheal dehiscence risk and/or the morbidity of a small anterior tracheal dehiscence in high risk cases, especially in patients who will be receiving postoperative radiation therapy.

The patient was immediately extubated after the surgery. Although the potential use of a Grillo stitch (chin-to-chest suture) to decrease the risk of tracheal dehiscence has been well described, the authors did not use a Grillo stitch for this case and do not routinely use a Grillo stitch following segmental tracheal resection and reconstruction. It is important, however, to counsel patients to avoid neck extension for the first week after surgery (Figures 1–3).

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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