Management of Tracheal Neoplasms

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ABSTRACT

Patients with tracheal involvement from primary or secondary neoplasms usually present with relatively nonspecific symptoms of cough, wheeze, and shortness of breath. Prompt diagnosis often requires a high index of suspicion. Tomography or computed tomography of the chest will often confirm the presence of a tracheal lesion. A detailed rigid bronchoscopic assessment by an experienced thoracic surgeon is essential for establishing the extent of tracheal involvement. Although advanced tumor stage often precludes surgical resection, the application of current operative techniques allows a significant number of tracheal tumors to be completely excised and primarily reconstructed. Adjuvant radiotherapy is often employed with surgical resection to improve local control and enhance the potential for cure. The Oncologist 1996;1:347-353

INTRODUCTION

Both primary and secondary tumors of the trachea are relatively uncommon clinical conditions which often present a therapeutic challenge to the thoracic surgeon. In the adult population primary neoplasms are usually malignant and generally either squamous cell or adenoid cystic carcinomas [1, 2]. Secondary neoplasms typically result from local tracheal invasion by thyroid, laryngeal, esophageal, or bronchogenic carcinomas. Principle presenting symptoms in all cases include dyspnea, cough, and hemoptysis. Standard curative therapy involves complete tumor resection when feasible. If surgical resection is not possible, alternative therapies such as endoscopic debridement, internal stenting, and local or external radiotherapy may provide reasonable palliation.

HISTORICAL PERSPECTIVE

Current techniques in tracheal surgery have evolved over more than three decades of experimental and clinical development. Early efforts at resection were limited by the belief that no more than four tracheal rings, or approximately 2 cm of trachea, could be safely resected and primarily reconstructed [3]. Considerable attention was thus focused on developing an effective prosthetic material which could be used to bridge resected tracheal defects [4]. Increased experience with post-intubation tracheal injuries in the 1960s, however, led to the development of technical advances which helped to broaden the scope of surgical possibilities for tracheal disease. Specifically, mobilization techniques were developed which made it possible to resect up to half of the length (5 cm to 6 cm) of the adult trachea and safely achieve end-to-end approximation [5]. Furthermore, techniques were developed for resection and primary anastomosis at both the subglottic [6] and carinal [7] levels. Consequently, many localized neoplasms involving the trachea are now amenable to surgical resection.

PRIMARY TRACHEAL TUMORS

Primary tumors of the trachea are rare. Reported frequencies range from 0.075% in autopsy series to 0.19% of all patients with malignancies of the respiratory tract. In adults, approximately 90% of primary tracheal tumors are malignant [8, 9]. The most common of these malignant neoplasms are squamous cell carcinoma and adenoid cystic tumors, together comprising approximately 75% of all primary tumors of the trachea [2]. Both gender distribution and incidence vary with cell type. Squamous cell carcinoma occurs predominantly in men in the sixth and seventh decades, whereas adenoid cystic carcinoma is equally distributed between the sexes and peaks in incidence in the fourth and fifth decades [1, 2].

Squamous cell carcinomas are invariably associated with cigarette smoking. Grossly they range from localized exophytic lesions to diffuse ulcerating tumors. Unfortunately, tracheal squamous cell carcinomas are frequently locally advanced and unresectable at the time of presentation. Grillo reported approximately one-third of patients with either mediastinal or pulmonary metastases at initial diagnosis [2]. Furthermore, metachronous lesions were also common as 40%
reported had prior, concurrent, or later carcinoma of either the oropharynx, larynx, or lung.

In contrast, adenoid cystic carcinomas are not associated with cigarette smoking. These tumors have a propensity to spread along both submucosal and perineural planes. Regional lymph node metastases are reported in 10% of patients and remote metastases to lung, bone, and brain have been observed [10]. Despite these malignant features, adenoid cystic carcinoma often follows a prolonged course. Slow and insidious progression, often over several years, is characteristic of even untreated cases.

A variety of rare, primary, tracheal malignancies including carcinosarcoma, chondrosarcoma, leiomyosarcoma, mucoepidermoid carcinoma, and carcinoid tumors have also been reported. The overall experience with these tracheal tumors has been so limited that generalizations with regard to natural history and optimal management cannot confidently be made.

SECONDARY TRACHEAL TUMORS

Tracheal invasion from adjacent laryngeal, thyroid, lung, or esophageal carcinoma is more commonly encountered than primary tracheal malignancy. Unfortunately, these secondary tumors are often not amenable to curative tracheal resection. Squamous cell carcinoma of the larynx may involve the upper trachea by direct extension or recur at the tracheal stoma after laryngectomy. In this situation, local irradiation is the treatment of choice. Radical resection of these recurrences with creation of mediastinal tracheostomies has been reported. Significant morbidity and high tumor recurrence rates, however, fail to justify this extensive surgical approach [11]. Similarly, resection of the trachea for direct involvement by esophageal carcinoma is generally not advised. The extent of local involvement and the likelihood of distant disease recurrence are usually so great that a curative resection is unlikely in such cases.

The current international staging system for lung carcinoma classifies carcinoid tumor invasion as T4 or “unresectable” stage IIIB or IV disease [12]. However, several centers have reported favorable survival rates in select patients without mediastinal lymph node involvement following carinal pneumonectomy [13, 14]. Grillo and Mathisen attribute careful patient selection, precise surgical technique, and diligent perioperative management to their reported five-year survival rate of 19% in 37 patients following carinal pneumonectomy [14].

The secondary tumor perhaps most amenable to tracheal resection and cure is thyroid carcinoma. Papillary and follicular thyroid carcinomas are reported to directly invade the airway in 1% to 6.5% of patients [15]. Tracheal invasion tends to be more common in poorly differentiated tumors and in older patients. In addition, the prognosis of thyroid carcinoma correlates with both the site and depth of tracheal invasion [16, 17]. Anaplastic thyroid carcinoma is often widely invasive at initial presentation and usually not resectable.

CLINICAL PRESENTATION

The clinical presentation of patients with tracheal tumors is variable but generally includes signs and symptoms of upper airway obstruction. Often, relatively nonspecific complaints of cough, wheezing, and dyspnea prompt empiric treatment for “asthma” and bronchitis. Definitive diagnosis is often further delayed by the presence of a “normal” chest x-ray. The occurrence of hemoptysis secondary to mucosal ulceration generally prompts more aggressive diagnostic measures. Similarly, new-onset hoarseness or dysphagia secondary to recurrent nerve or esophageal involvement are less common but more ominous presentations of tracheal tumors.

DIAGNOSIS

Tomography and computed tomography (CT) are the most helpful methods of radiologic examination of tracheal tumors [18]. Routine chest x-rays, on the other hand, are relatively insensitive in detecting tracheal pathology. In a series of patients with documented tracheal tumors reviewed by Li and associates, only one-half of plain-chest radiographs demonstrated visible tracheal abnormalities [19]. CT is currently considered the standard imaging modality for diagnosis and staging of tracheal tumors. CT demonstrates the intraluminal and extraluminal extent of tumor and delineates the relationship of the tumor to adjacent structures. Contrast esophagography, when performed with CT, may help to identify esophageal invasion. Three-dimensional (3D) helical CT scanning is a very useful imaging modality which has replaced the conventional tomogram [20] (Fig. 1). When compared to conventional CT, this technique provides complementary details with regard to spatial orientation and precise measurement of tracheal tumor length. These features are particularly helpful when planning for surgical resection. To date magnetic resonance imaging (MRI) provides no clear advantage over CT imaging in the evaluation of tracheal tumors.

Pulmonary function testing may suggest the presence of upper airway obstruction. An obstructive flow pattern which does not respond to bronchodilator therapy should arouse suspicion of a fixed upper-airway obstruction. Flow-volume loops, with characteristic flattening of both inspiratory and expiratory phases, may provide further evidence of upper airway obstruction.

Bronchoscopy is the mainstay of diagnosis and staging of tracheal neoplasms. Biopsies are obtained for tissue diagnosis. In addition, detailed bronchoscopic assessment of the location and extent of disease in the airway is essential for planning subsequent therapy. When a patient’s clinical status
and CT findings suggest significant airway obstruction, bronchoscopy is best performed in the operating room. In this situation, flexible bronchoscopy is ineffective and potentially hazardous and rigid bronchoscopy is required to gain control of the airway. A coordinated effort between the anesthetist and surgeon is necessary to avoid complication. The airway is locally anesthetized with the patient anesthetized but spontaneously breathing. A rigid bronchoscope is then passed beyond the tracheal obstruction. General anesthesia is deepened once the airway is secured. The tracheal lumen may then be enlarged endoscopically using a variety of debridement techniques.

MANAGEMENT

Tracheal Resection

Surgery represents the primary curative treatment for tracheal tumors. Current tracheal mobilization techniques, including suprathyroid laryngeal release [21], suprathyroid laryngeal release [22], and right pulmonary hilar release maneuvers permit the removal and primary reconstruction of up to one-half the length of adult trachea. Most primary tracheal tumors are amenable to surgical excision using these techniques [23]. Grillo has reported resecting 71% (102 of 144) of tracheal tumors which were operatively explored [24]. Given the anatomic location of the thyroid gland, tracheal resections for locally invasive thyroid cancer will often extend proximally to involve a portion of the subglottic larynx. Additional operative techniques have been specifically described for excising these tumors [25]. Similarly, specific techniques have been developed to operatively approach carinal invasion by bronchogenic carcinoma [14]. Carinal invasion more commonly occurs on the right side resulting from tumor infiltration up the relatively short right mainstem bronchus. With localized tumor involvement and no mediastinal lymph node involvement, carinal pneumonectomy may be curative. Carinal resection with preservation of lung parenchyma is also possible with reimplantation of middle and lower lobes.

A generous cervical collar incision provides adequate operative exposure to the cervical and upper mediastinal trachea (Fig. 2A) [26]. The addition of a median sternotomy exposes the remaining mediastinal trachea for more extended resections (Fig. 2B) [26]. The operative technique for resection of a tumor in the mediastinal trachea is illustrated in Figures 3A through 3C. In select cases requiring distal tracheal or carinal resection, a right posterolateral thoracotomy approach may be preferable.

When a thoracic surgeon commits to tracheal or carinal resection, it is impossible to confidently estimate the extent of excision required. Frozen section assessment of the resection

Figure 1. CT scan (A) and corresponding 3D helical CT (B) of a 75-year-old woman who presented with a several-week history of progressive shortness of breath. Locally infiltrating thyroid carcinoma was found to involve a segment of mediastinal trachea. A total thyroidectomy was performed with en bloc resection of 4 cm of trachea and primary tracheal reconstruction. Pathology confirmed the presence of papillary carcinoma invading the airway.
margins will indicate whether residual tumor exists. In some instances, it may be necessary to accept microscopic disease at a resection margin rather than extend the resection beyond safe limits. In such cases, the addition of adjuvant radiotherapy is felt to be helpful in minimizing local tumor recurrence. In general, the use of prosthetic material to bridge resected tracheal defects has yielded unsatisfactory results [27]. Morbidity and mortality resulting from prosthetic dehiscence and tracheoinnominate artery erosion have been unacceptably high. Consequently, there are presently very few indications for prosthetic reconstruction of the airway.

A few large, clinical series have reported experience with resection and primary anastomosis of primary tracheal tumors. Reported mortality rates range from 5% to 17% [1, 2, 28, 29] and result from pneumonia, pulmonary embolism, tracheoinnominate artery fistula, and anastomotic dehiscence (Table 1). Long-term survival is excellent in patients with adenoid cystic carcinoma but less favorable in patients with squamous cell carcinoma. Reported five-year survival rates range from 66% [29] to 75% [1, 2] following resection for adenoid cystic carcinoma. In contrast, Perelman and Koroleva reported a five-year survival of only 15% in 20 patients who underwent tracheal resection for squamous cell carcinoma [29]. Similarly, Grillo and Mathisen reported a 35% survival rate in 41 patients resected with tracheal squamous cell carcinoma [2].

Survival data following tracheal resections for invasive thyroid carcinoma demonstrate that treatment is optimal if the involved airway is excised either at the time of, or soon after, initial thyroid resection. The potential for cure is markedly diminished when thyroid tumor is simply “shaved off” the trachea. Grillo reported 27 patients who underwent tracheal resection and reconstruction for invasive thyroid cancer [30]. Deaths (2/27, 7%) resulted from anastomotic dehiscence and respiratory failure. Additional complications included vocal cord paresis and varying degrees of dysphagia. Five-year survival exceeded 50%. Of note, death usually resulted from metastatic disease rather than local recurrence and airway complications. Ishihara and colleagues reported similar favorable results following tracheal resection for invasive thyroid carcinoma [31]. They reported a five-year survival of 78% following complete resection in 22 patients with thyroid malignancy invading the airway.

Long-term survival following carinal resection has ranged from 19% to 23% [13, 14, 32]. The reported mortality from this procedure was initially moderately high, with rates of greater than 20% quoted by some authors [32, 33]. However, subsequent reports from experienced centers have demonstrated a reduction in operative mortality to approximately 10% [13, 14]. The mortality is due, in part, to the occurrence of an aggressive form of lung injury resembling the “acute respiratory distress syndrome.” The etiology of this unpredictable response to carinal pneumonectomy is
unknown, and progressive clinical deterioration is common despite maximal supportive efforts.

**Radiation Therapy**

Radiation therapy may be administered as either perioperative adjuvant treatment or definitive therapy. The precise role of adjuvant radiation therapy following tracheal surgery has not been clearly defined. Both Grillo and Pearson have advocated adjuvant radiotherapy in select patients. Grillo recommends postoperative irradiation in patients with close resection margins, disease recurrence, or positive lymph nodes [34]. Perioperative radiotherapy (30-35 Gy) was administered to all 26 patients reported by Pearson who were resected for tracheal adenoid cystic carcinoma [1]. Additional irradiation was also administered following incomplete resections in this group. In a series of patients with tracheal tumors treated at the MD Anderson Cancer Center, both local tumor control and median survival were greater following combined surgical resection and postoperative radiotherapy [35]. The authors of this study recommended an adjuvant irradiation dose of 50 Gy or more.

Primary radiation therapy is essentially reserved for patients with inoperable tracheal tumors [35]. Reported local control rates and survival rates have varied widely in such cases [36-38]. In general, tumor response rates are dose-related; however, local complications, such as tracheal and esophageal strictures, also occur in relation to administered dose. Endotracheal brachytherapy has been touted as a method of delivering high-dose radiotherapy while minimizing local complications [39]. Case reports suggest safe and effective symptom palliation when combining this technique with external beam irradiation [40, 41].

**Endotracheal Debridement**

Endoscopic clearance of endotracheal tumor may be performed for palliation in otherwise inoperable patients or as a

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*Figure 3. Operative exposure of the mediastinal trachea with a low-collars neck incision and a median sternotomy (A). The sternal margins and strap muscles are reflected laterally. The airway has been divided 1 cm beyond the gross distal tumor margin (B). Stay sutures are used to stabilize the distal tracheal stump which has been intubated with a flexible armored endotracheal tube for ventilation. Distal tracheal resection margins are submitted to pathology for frozen section analysis. Following tracheal resection, the proximal and distal ends are stabilized with stay sutures in preparation for primary anastomosis (C). Interrupted absorbable sutures are used to complete the anastomosis. Reproduced with permission [26].*
means of maintaining airway patency until subsequent definitive surgical resection can be performed. The earliest reported method of endobronchial tumor management was simple mechanical removal [42]. This technique requires rigid bronchoscopy and involves tumor removal with biopsy forceps and suction. Electrocoagulation has also been used to aid in endobronchial debriement and hemostasis [43]. Similarly, cryotherapy [44] and laser therapy [45] have been reported as effective palliative methods of clearing endotracheal tumor. In practice several of these bronchoscopic techniques are often combined to achieve adequate endotracheal debridement.

**Endobronchial Stents**

Internal stents may be placed through malignant stenoses in a palliative effort to maintain airway patency. These stents exist in a variety of shapes and styles to suit the location of the stricture and the preference of the surgeon. The largest clinical experience in the management of tracheal stenting to date has been gained with the silicone T tube [46]. These soft rubber tubes are positioned operatively through tracheal stomas and may function effectively for long periods of time. Custom-made T-Y and Y silicone tubes are also available to provide stenting at the level of the carina and mainstem bronchi.

In recent years, the use of expandable wire stents to palliate malignant tracheal obstruction has become popular [47]. Covered metal stents are recommended in the presence of endobronchial tumor to avoid tumor ingrowth through the interstices of the wire mesh. Early experience with this form of stent has generally been favorable. Wire stents are often technically easier to insert and generally do not require airway dilation prior to placement. Despite the lack of an external limb, stent migration is uncommon. Unfortunately, these stents are rapidly incorporated into airway tissues such that subsequent removal is difficult, if not impossible.

**Summary**

Malignant tracheal tumors are infrequently encountered in clinical practice. Tracheal involvement usually results from secondary invasion by adjacent thyroid, laryngeal, esophageal, or lung carcinomas. Primary tracheal tumors are rare and usually are either adenoid cystic or squamous cell carcinomas. Patients with tracheal tumors initially present with nonspecific respiratory symptoms which typically delay efforts at definitive diagnosis. Chest tomography and CT are important imaging modalities used to diagnose and stage patients with suspected tracheal neoplasms. When available, helical CT scanning provides complimentary imaging information which may help in planning a surgical resection.

Bronchoscopy is essential in all cases to adequately assess the extent of tracheal tumor involvement. Rigid bronchoscopy in a controlled operative setting is mandatory if significant upper airway obstruction is suspected on the basis of clinical or radiological examination. Complete resection with primary tracheal reanastomosis should be regarded as the cornerstone of management. Current operative techniques allow for up to one-half of the length of trachea to be safely resected and primarily reconstructed. This allows most patients with localized disease to undergo complete resection.

A number of surgical centers have accumulated considerable experience with tracheal resection for malignant disease. Worthwhile survival can be obtained in select patients with either primary tracheal malignancy or secondary tracheal involvement from thyroid or lung carcinoma. In experienced hands, operative morbidity and mortality are acceptably low. Postoperative mediastinal radiotherapy is recommended in most patients. If the extent of disease is such that definitive tracheal resection cannot be performed, a variety of palliative procedures are available to maintain airway patency.

**Table 1. Primary tumors of the trachea and carina: reported series of resected cases and operative mortality**

<table>
<thead>
<tr>
<th>Author (year)</th>
<th>Total cases resected</th>
<th>Adenoid cystic carcinoma</th>
<th>Squamous cell carcinoma</th>
<th>Operative mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Echapasse et al. (1974)</td>
<td>75</td>
<td>19</td>
<td>27</td>
<td>12</td>
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<tr>
<td>Pearson et al. (1984)</td>
<td>44</td>
<td>28</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Perelman et al. (1987)</td>
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<td>56</td>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>Grillo et al. (1990)</td>
<td>132</td>
<td>50</td>
<td>41</td>
<td>5</td>
</tr>
</tbody>
</table>

**References**

6 Pearson FG, Cooper JD, Nelems JM et al. Primary tracheal anastomosis after resection of the cricoid cartilage with preservation of recurrent laryngeal nerves. J Thorac Cardiovasc Surg 1975;70:806-816.


17 Shin DH, Mark EJ, Suen HC et al. Pathological staging of papillary carcinoma of the thyroid with airway invasion based upon the anatomic manner of extension to the trachea. Hum Pathol 1993;24:866-870.


37 Rostom AY, Morgan RL. Results of treating primary tumors of the trachea by irradiation. Thorax 1978;33:387-393.


