Pediatric Tracheal and Endobronchial Tumors
An Institutional Experience

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Objectives: To report the pathologic findings in cases involving endotracheal and endobronchial tumors in the pediatric population and to describe the presenting symptoms and treatment modalities for endotracheal and endobronchial tumors.

Design: Retrospective chart review.

Setting: Tertiary care children’s hospital.

Patients: The study included 14 patients with endotracheal and endobronchial tumors.

Main Outcome Measures: Patients were selected if bronchoscopy was performed to obtain biopsy specimens from the trachea or bronchus.

Results: There were 14 cases that met the inclusion criteria between 1993 and 2009. The patients ranged in age from 4 to 18 years. The most common presenting symptom was recurrent pneumonia (n=6), followed by wheezing or asthma that was unresponsive to treatment (n=4). Nine lesions (64%) were malignant and 5 (36%) were benign. Of the malignant tumors, 5 (55%) were carcinoid, 3 (33%) were mucoepidermoid carcinoma, and 1 was adenoid cystic carcinoma. There were 1 or 2 cases of each of the following benign to intermediate malignant potential lesions: histoplasmosis nodules, chondroid hamartoma, pulmonary chondroma, and inflammatory myofibroblastic tumor. In 12 cases, definitive treatment included surgical resection. Three of these cases required postoperative chemotherapy and radiotherapy.

Conclusions: The results of this series suggest that in the pediatric population tracheal and endobronchial tumors are most likely to be carcinoid tumors or mucoepidermoid carcinomas, both malignant processes. For patients with recurrent pneumonias or chronic wheezing, an occult tumor is a diagnostic consideration that may require additional studies.


METHODS

ENDOTRACHEAL AND ENDOBRONCHIAL tumors in the pediatric population are rare, but pathologic findings of these tumors can represent a wide array of processes. Most of the literature describing the pathologic characteristics of these tumors exists as case reports or literature reviews rather than as single institution case series. Furthermore, literature reviews tend to group endobronchial and endotracheal tumors together with intraparenchymal lung tumors. The pathology results for endotracheal and endobronchial tumors are important in pediatric otolaryngology, because in the right clinical context these tumors should be in the list of differential diagnoses and can be diagnosed using direct laryngoscopy and bronchoscopy. The purpose of this study was to review the pathology results and presenting symptoms of the endotracheal and endobronchial tumors that were diagnosed with biopsies during bronchoscopy by pediatric otolaryngologists at a single institution. The modalities used for definitive treatment are also reviewed.

RESULTS

There were 14 patients from 1993 through 2009 that fit the criteria mentioned above. The Table includes the age, sex, pathology results, imaging findings, and treatment modalities of the patients included in this study. The patients (11 boys and 3 girls) ranged in age from 4 to 18 years, with a mean age of 13 years (median age, 14 years). The most common presenting symptom...
was recurrent pneumonia (n=6), followed by wheezing or asthma that was unresponsive to treatment (n=4). Of these cases, 5 (36%) were pulmonary carcinoid tumors (Figure 1) and 3 (21%) were mucoepidermoid carcinomas (Figure 2). There were 1 or 2 cases of each of the following: histoplasmosis nodules, chondroid hamartoma, pulmonary chondroma, inflammatory myofibroblastic tumor, and adenoid cystic carcinoma. Nine lesions (64%) were considered malignant, 4 (28%) were considered benign, and 1, the inflammatory myofibroblastic tumor, was considered intermediate rather than benign. There were no complications during the bronchoscopy and biopsy of the lesions. However, in 1 case, the lesion had a “bluish” tint, and alveolar wash was per-

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Sex/Age, y</th>
<th>Presenting Symptom</th>
<th>Pathology Results</th>
<th>Imaging</th>
<th>Surgical Treatment</th>
<th>Other Treatment Modalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/M/9</td>
<td>Recurrent pneumonia</td>
<td>Mucoepidermoid carcinoma</td>
<td>CT with contrast showed right upper lobe collapse</td>
<td>Right upper lobectomy</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>2/M/16</td>
<td>Recurrent pneumonia</td>
<td>Mucoepidermoid carcinoma</td>
<td>CT showed endobronchial mass of the left mainstem</td>
<td>Left lobectomy and pneumonectomy</td>
<td>Postoperative radiotherapy and chemotherapy</td>
<td></td>
</tr>
<tr>
<td>3/M/14</td>
<td>Recurrent pneumonia</td>
<td>Mucoepidermoid carcinoma</td>
<td>None</td>
<td>Left upper lobe lobectomy</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>4/F/16</td>
<td>Recurrent pneumonia</td>
<td>Chondroid hamartoma</td>
<td>None</td>
<td>Thoroscopic wedge resection of left lower lobe</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>5/F/14</td>
<td>Recurrent pneumonia</td>
<td>Pulmonary chondroma</td>
<td>None</td>
<td>Right middle lobectomy</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>6/M/11</td>
<td>Incidental finding</td>
<td>Inflammatory myofibroblastic tumor</td>
<td>Chest x-ray film showed pneumonia</td>
<td>Right lobectomy</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>7/M/8</td>
<td>Wheezing</td>
<td>Pulmonary carcinoid</td>
<td>None</td>
<td>Biopsy</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>8/M/18</td>
<td>Wheezing</td>
<td>Histoplasmosis nodule</td>
<td>None</td>
<td>Resection of right lower lobe</td>
<td>Itraconazole</td>
<td></td>
</tr>
<tr>
<td>9/M/16</td>
<td>Wheezing</td>
<td>Pulmonary carcinoid</td>
<td>CT showed mass in left mainstem</td>
<td>Left lobectomy and pneumonectomy</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>10/M/14</td>
<td>Cough, pneumothorax</td>
<td>Pulmonary carcinoid</td>
<td>None</td>
<td>Left mainstem sleeve resection with reanastamosis</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>11/M/16</td>
<td>Acute respiratory infection</td>
<td>Pulmonary carcinoid</td>
<td>None</td>
<td>Thoracotomy with left lower lobe resection</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>12/M/13</td>
<td>Persistent cough</td>
<td>Pulmonary carcinoid</td>
<td>Chest x-ray film showed air trapping</td>
<td>Bronchoscopy with partial laser ablation</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>13/M/4</td>
<td>Wilms tumor, incidental tumor</td>
<td>Histoplasmosis nodule</td>
<td>Chest x-ray film showed incidental mass</td>
<td>Surgical resection</td>
<td>Antifungal agents, although the tumor was mostly removed through resection; chemotherapy and radiotherapy for Wilm tumor</td>
<td></td>
</tr>
<tr>
<td>14/F/18</td>
<td>Chronic wheezing</td>
<td>Adenoid cystic carcinoma</td>
<td>CT showed endobronchial mass of the right mainstem</td>
<td>Right lobectomy and pneumonectomy</td>
<td>Postoperative radiotherapy and chemotherapy</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: CT, computed tomogram.

Figure 1. Histologic findings. A, Pulmonary carcinoid tumor nests inside respiratory epithelium. Vascular stroma surrounds the tumor nests (hematoxylin-eosin, original magnification ×200). B, Carcinoid tumor cells show small dark nuclei surrounded by clear cytoplasm (hematoxylin-eosin, original magnification ×100).
formed rather than actual biopsy. The carbon dioxide laser was used to achieve hemostasis during 1 biopsy case, while the potassium-titanyl-phosphate laser was used in another. In the 3 cases in which hemostasis required either laser or in which the biopsy was deferred, the resulting diagnosis was pulmonary carcinoid.

Imaging studies were performed before rigid bronchoscopy in 6 of the 14 cases, with computed tomograms (CT) obtained in 4 cases and chest x-rays films obtained in 2 cases. The Table shows the imaging studies that were performed, while Figure 3 shows a CT with an endobronchial mass in the left mainstem that was eventually diagnosed as mucoepidermoid carcinoma.

In 12 cases, definitive treatment included surgical resection of the tumors, with 3 of these cases also requiring chemotherapy and radiotherapy. The extent of the surgery for tumor resection varied from lobectomy to sleeve resection to pneumonectomy and was based on the location and size of the tumor. While the diagnosis in each case was made by a pediatric otolaryngologist, the definitive surgical resection was performed by a pediatric general surgeon. One case of pulmonary carcinoid was treated with laser ablation, which was performed by a pediatric otolaryngologist. Both cases of histoplasmosis nodules were treated with high-dose antifungal medications, although 1 of the 2 cases was treated primarily with surgical resection of the histoplasmosis nodule, and the antifungal agent was administered in addition to surgical resection because the patient was undergoing chemotherapy and radiotherapy for Wilms tumor.

In terms of outcomes of the study patients, follow-up could only be determined based on clinical visits to the institution where this study was conducted. The time for follow-up ranged anywhere from a few weeks to many years. When the patients either completed follow-up or were unavailable for follow-up, including transfer of care to an adult hospital, all of them were still alive.

**COMMENT**

Primary endobronchial and endotracheal tumors are uncommon in childhood. There is very little literature regarding endotracheal and endobronchial tumors in the pediatric population. Much of the literature consists of case reports or small case series. Some larger series also include all primary pulmonary nodules, not just endotracheal and endobronchial tumors. Our focus was limited to tumors diagnosed by endoscopic rigid bronchoscopy. Patients up to age 18 years were included in this study, as patients in their late teens still are routinely treated at pediatric hospitals and are often referred to pediatric otolaryngologists from pediatric pulmonologists who have been treating the patients for months to years for symptoms of recurrent pneumonia or asthma.

In 1983, a literature review consisting of 230 cases of primary pulmonary neoplasms in children showed that 65% of these lesions were malignant. Our finding of a 64% rate of malignancy is consistent with the results of this earlier review. The 2 most common malignant tumors identified in our series were carcinoid and mucoepidermoid carcinoma, and these results are also consistent with previous reports.

In reviewing the presenting symptoms in our series, carcinoid tumors tended to manifest as recurrent wheezing and cough, while the most common presenting symptom for mucoepidermoid carcinoma was recurrent pneu-
nia. Prior reports of carcinoid tumors of the trachea and bronchi in adults also describe the most common presenting symptom as wheezing. The wheezing is thought to be attributable in part to the effect of serotonin release by the tumor in the respiratory tract in addition to the obstruction. The treatment modality for endobronchial carcinoid tumors in our series was surgical resection, which is also consistent with previously reported studies.1,3

The results of this review differ from earlier studies in that mucoepidermoid carcinoma was found almost as frequently as carcinoid tumors (3 of 14 tumors were mucoepidermoid, while 5 were carcinoid). Bronchial adenoma and pulmonary adenoma are terms that are rarely used in the current literature but have been used in the past to include carcinoid tumors, mucoepidermoid carcinoma, adenocystic carcinoma, and mucous gland adenomas. The term pulmonary adenoma is rarely used today, because it grouped both malignant and benign neoplasms together. However, prior studies of pediatric primary pulmonary tumors that did use that classification have found that 80% to 90% of the pulmonary adenomas were carcinoid tumors.3,5 The results from this study suggest that in pediatric endobronchial tumors carcinoids may not outnumber mucoepidermoid carcinomas to the extent that was previously reported. The explanation of this difference is that mucoepidermoid tumors arise in the minor salivary glands of the trachea and bronchi but are unlikely to arise from the lung parenchyma, where there are fewer minor salivary glands. Therefore, a study focusing on endobronchial and endotracheal tumors will be more likely to have a greater percentage of the mucoepidermoid carcinomas compared with studies that look at all pulmonary neoplasms.

The remaining malignant histologic subtype identified in this study was a single case of adenoid cystic carcinoma, which gives a rate of roughly 7% (1 of 14) in this series. In the larger literature review results, roughly 1% of total pulmonary neoplasms in the pediatric population were adenoid cystic carcinoma.1,2 This study revealed no cases of small cell carcinoma, squamous cell carcinoma, or adenocarcinoma. There are cases in which the pulmonary adenomas were carcinoid tumors.3,5 The results from this study suggest that in pediatric endobronchial tumors carcinoids may not outnumber mucoepidermoid carcinomas to the extent that was previously reported. The explanation of this difference is that mucoepidermoid tumors arise in the minor salivary glands of the trachea and bronchi but are unlikely to arise from the lung parenchyma, where there are fewer minor salivary glands. Therefore, a study focusing on endobronchial and endotracheal tumors will be more likely to have a greater percentage of the mucoepidermoid carcinomas compared with studies that look at all pulmonary neoplasms.

Histoplasmosis nodules were the most common benign pulmonary adenoma.8,9 Diagnosis can be made at time of resection, although if diagnosis is made on bronchoscopy with biopsy, there are reports of surgical removal using the Nd: YAG laser rather than a pneumonectomy or a lobectomy. Pulmonary chondromas are often associated with Carney triad, which consists of gastrointestinal stromal tumors, extra-adrenal paragangliomas, and pulmonary chondromas.10,11 There are cases in which the pulmonary chondromas exist alone and not in association with other tumors, as in our single case. If the chondromas are causing respiratory symptoms, surgical resection is recommended. When the lesions are associated with Carney triad, asymptomatic chondromas may be followed up with watchful waiting.

Histioplasmosis nodules were the most common benign tumor in this study (2 of 14, or 14%). One of the patients with a histoplasmosis nodule was undergoing chemotherapy and radiotherapy for Wilm tumor. A prior report identified 61 cases of pulmonary histoplasmosis in pediatric patients undergoing cancer treatment, primarily for acute lymphocytic leukemia.6 Most of the cases in that study were diagnosed by cultures from lung biopsies, similar to this study. Histoplasmosis in general can be treated with antifungal medications, such as itraconazole. Surgical removal of the nodule is warranted if it is causing severe obstructive symptoms. Most of the literature concerning endobronchial and endotracheal tumors does not include histoplasmosis nodules, likely because histoplasmosis is an infection and not a neoplasm. However, it still produces a masslike lesion that is an important component of the differential diagnosis for a mass lesion in the trachea or bronchus.

A number of studies have shown inflammatory myofibroblastic tumor (also known as inflammatory pseudotumor) to be the most common nonmalignant pulmonary neoplasm in the pediatric population, at almost 20%.1,2 The World Health Organization has classified inflammatory myofibroblastic tumors as intermediate in terms of malignant behavior.7 The results of this study found an incidence of only 7% (1 of 14 cases). However, in these large reviews, most of the inflammatory myofibroblastic tumors were located within the parenchyma rather than presenting as endobronchial lesions,8 which may explain why our study had a lower incidence. Alternatively, the sample size may explain the difference in frequency. The literature has found that hamartomas, such as chondroid hamartomas, are the second most common benign pulmonary tumor. However, these data include the general population and are not limited to the pediatric population. The literature states that anywhere from approximately 1.5% to 20% of pulmonary hamartomas are endobronchial compared with the majority found in the parenchyma.6,9 Diagnosis can be made at time of resection, although if diagnosis is made on bronchoscopy with biopsy, there are reports of surgical removal using the Nd: YAG laser rather than a pneumonectomy or a lobectomy.

Pulmonary chondromas are often associated with Carney triad, which consists of gastrointestinal stromal tumors, extra-adrenal paragangliomas, and pulmonary chondromas.10,11 There are cases in which the pulmonary chondromas exist alone and not in association with other tumors, as in our single case. If the chondromas are causing respiratory symptoms, surgical resection is recommended. When the lesions are associated with Carney triad, asymptomatic chondromas may be followed up with watchful waiting.

It is important to note that the results of this study indicate that most patients did not undergo any recent imaging before going to the operating room for rigid bronchoscopy. While CT scans may not be routine before a rigid bronchoscopy, chest radiography is more routinely performed. According to an algorithm for recurrent pneumonia in pediatric populations, chest radiography is generally recommended, and, based on findings on the chest x-ray film, rigid bronchoscopy or CT imaging may be recommended.12 A number of our patients underwent radiography of the chest early in the workup for their pulmonary symptoms, and it is likely that as no abnormality was detected at that time, there were no new indications based on their symptoms to repeat radiography of the chest before the bronchoscopy. Pulmonary
function tests and analysis of immunodeficiency status may also play a role in the workup of patients with recurrent pneumonia or with wheezing that is unresponsive to standard asthma medications. While there is no conclusive evidence in the literature on the importance of imaging studies, CT scans may offer insight into whether a lesion is present, but only a biopsy can give definitive diagnosis.

The age range in this study was 4 to 18 years, with all the malignant lesions being found in children older than 8 years. This finding is consistent with other studies looking at tracheal lesions that observed that most malignant lesions were found in adolescents, while benign lesions, including hemangiomas, were much more common in infants and young children. However, it is important to remember that some malignant neoplasms, such as rhabdomyosarcomas, can be found in younger children.

In conclusion, the results of this study, in conjunction with an extensive literature review, indicate that endobronchial and endotracheal tumors in the pediatric population are more likely to be malignant rather than benign. These tumors most often present with symptoms of recurrent pneumonia or wheezing. When a child presents with respiratory symptoms that do not improve with standard treatment (antibiotics, bronchodilators), further workup is warranted to rule out an obstructive process. Bronchoscopy continues to play an important role in completing the pulmonary evaluation, with rigid bronchoscopy often performed by the pediatric otolaryngologist so that adequate biopsy specimens can be obtained. When an endobronchial lesion is identified, biopsy should be performed to obtain a tissue diagnosis and to assist in determining the optimal treatment plan.

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Author Contributions: Dr Roby had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Roby and Sidman. Acquisition of data: Roby and Drehner. Analysis and interpretation of data: Roby, Drehner, and Sidman. Drafting of the manuscript: Roby. Critical revision of the manuscript for important intellectual content: Roby and Drehner. Statistical analysis: Roby and Sidman. Administrative, technical, and material support: Roby and Drehner. Study supervision: Sidman.

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Additional Contributions: This study was conducted at Children’s Hospital of Minnesota, Minneapolis campus.