



## Primary tracheobronchial tumors in children



Patricio Varela, MD<sup>a,\*</sup>, Luca Pio, MD<sup>b,c</sup>, Michele Torre, MD<sup>c</sup>

<sup>a</sup> Department of Pediatric Surgery, Clinica Las Condes Medical Center, Hospital de Niños Calvo Mackenna, University of Chile, Camino el tucuguere 4080, Santiago, Chile

<sup>b</sup> DINOGMI, University of Genoa, Genova, Italy

<sup>c</sup> Airway Team and Pediatric Surgery Unit, Istituto Giannina Gaslini, Genova, Italy

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### ABSTRACT

Primary tracheobronchial tumors are rare lesions that can be benign or malignant, with different location along the airway tree. Symptoms may include wheezing, chronic pneumonia, asthma, chest pain, recurrent cough, atelectasis, haemoptysis, and weight loss. Due to the heterogeneity of symptoms, diagnosis can be difficult and the airway involvement can lead progressively to a bronchial or tracheal obstruction. Due to the rarity of primary tracheobronchial tumors in children, there are not any oncological guidelines on pre-operative work-up, treatment, and follow-up. Only few reports and multicentric studies are reported. In most cases, surgical resection seems to be the treatment of choice. Brachytherapy, endoscopic treatment, and chemotherapy are rarely described. In this article we present an overview on these rare tumors, including pathological aspects, clinical presentation, imaging assessment, and endoscopic or open surgical treatments. We discuss different surgical approaches, according with tumor location.

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### Introduction

The most common airway tumor in children is papillomatosis, a well known viral infection disease, described in many reports, especially from otorynolaryngologist groups, both in pediatric and adult age. Another relatively frequent and well known airway tumor is infantile hemangioma. Conversely, the group of the other primary airway tumors in children includes very rare diseases whose treatment often requires a multidisciplinary approach and major surgery. Over the years, some clinical case series were published<sup>1–4</sup> in which the patients were treated heterogeneously (by endoscopic or surgical approach). In other few larger studies published,<sup>5–7</sup> details on type of surgical procedure, exact tumor location, and other data were lacking.<sup>5–7</sup> Primary airway tumors have a wide range of histopathologic types and their long-term outcomes remain still unknown (Figure 1).

Non-specific symptoms as haemoptysis, chronic pneumonia, asthma, chest pain, wheezing, recurrent cough, and weight loss can delay the diagnosis and children may develop tracheal or bronchial obstruction.

Neville et al.<sup>8</sup> reported an overall incidence of 0.049 per 100.000 children, but the exact incidence of every single primary tracheobronchial tumor (PTT) type in pediatric population is not

provided, due to the rarity of the singular entities. Epidemiology and End Results (SEER) registry, due to the rarity of the PTT, justified the absence of prospective studies comparing different treatments as well as the absence of guidelines for diagnosis and treatment.<sup>8</sup>

The aim of our article is to present an overview of rare pediatric airway tumors (excluding metastasis, papillomatosis, and vascular tumors), including pathological aspects, clinical presentation, imaging assessment, and endoscopic or open surgical treatment.

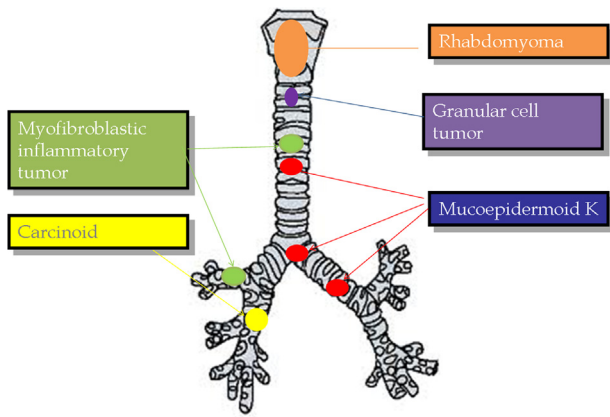
### Pathology

Tumor histology is the main factor determining the survival rate as reported by Rojas et al.,<sup>7</sup> with a better survival reported for carcinoids and mucoepidermoid carcinoma. The better prognosis of these tumors was also related to the intraoperative findings of negative lymph nodes and survival is higher when lymphadenectomy and a lesser extensive surgery were performed.<sup>7</sup>

Carcinoid tumors (CaT) are the most frequent PTT in children with an overall incidence of 3–5 cases per million people per year<sup>8</sup> and represent among the 80% of PTT.<sup>9,10</sup> CaT have an endodermal origin from Kulshitzky cells, generally located in the basal layer of bronchial epithelium. CaT are classified as typical (10%) and atypical (90%), according to mitotic index and presence or absence of necrosis.<sup>11</sup>

\* Corresponding author.

E-mail address: [pvarelachile@yahoo.com](mailto:pvarelachile@yahoo.com) (P. Varela).



**Fig. 1.** The most representative primary tracheobronchial tumors are described with their more frequent location.

In association with airway symptoms, clinical presentation of CaT may include carcinoid syndrome (hypotension, diarrhea, and vasomotor flushing) in 10–30% of cases.<sup>12</sup>

As CaT can be characterized by lymph nodes metastases, lymph node sampling is recommended<sup>13</sup> during surgery. A complete surgical resection remains the treatment of choice—despite CaT can present as intraluminal or pedunculated, in case of a bronchial wall infiltration an endoscopic approach does not allow a complete resection.<sup>14</sup> The overall survival of CaT is good (95%) in the largest reported series of PTT.<sup>7</sup>

Mucoepidermoid carcinomas (MC) are the second commonest PTT in children. They take origin from salivary gland and are characterized by mucinous, intermediate, and squamous cells.<sup>15</sup> MC represent 10% of PTT and are classified in low, intermediate, and high grade, based on the mitotic index.<sup>16</sup> MC usually present as an airway (trachea or main bronchus) slow-growing vascular polypoid mass. Despite some endoscopic resections were attempted,<sup>17</sup> the possibility of recurrence, as reported by Romão et al.,<sup>2</sup> confirms that open surgical resection and lymph node sampling remain the treatment of choice.<sup>18</sup>

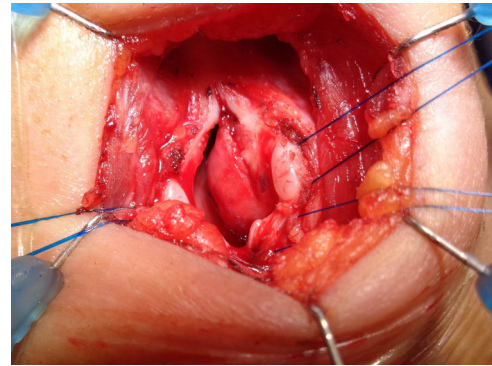
Similar to CaT, the overall survival for MC is excellent (87–100%).<sup>9</sup>

Granular cell tumors (GCT) take origin from Schwann cells and are frequently located in tracheobronchial lumen, only the 10% occurring in the larynx.<sup>3,19</sup> Whereas malignancy transformation was never documented in pediatric population, surgical resection must be considered, based on the morbidity risk.

Inflammatory myofibroblastic tumors (IMT), also named pseudotumors, are characterized by myofibroblastic spindle-shaped cells, lymphocytes, plasma cells, and eosinophils. They represent around 1% of PTT,<sup>20</sup> and are commonly located in upper trachea (Figure 2). Despite being considered as low-grade benign-tumor, IMT may give occasionally metastatic spread.<sup>21</sup> Corticosteroid treatment could favor proliferation of the tumor.<sup>22</sup> After the recent identification of ALK gene mutations in myofibroblasts on 50% of IMT patients, the utilization of ALK inhibitor as crizotinib was introduced in selected cases as complementary treatment and founded to be useful in preliminary studies.<sup>23–25</sup> Complete surgical resection actually remains the treatment of choice and endoscopic treatment must be reserved to those cases at high risk of surgical morbidity.<sup>20,21</sup>

Rhabdomyosarcoma (RMS) is a rare entity in children. In pediatric patients, RMS can be located in the larynx as an embryonal botryoid variant. A previous radiation therapy for a pre-existing papillomatosis is the main recognized risk factors for larynx RMS, but there are also implications between genetic predisposition and immunological factors.<sup>26</sup>

Mutilating surgery is not indicated, as multiagent chemotherapy associated with radiotherapy allows an excellent overall



**Fig. 2.** Miofibroblastyc tumor: upper airway localization.

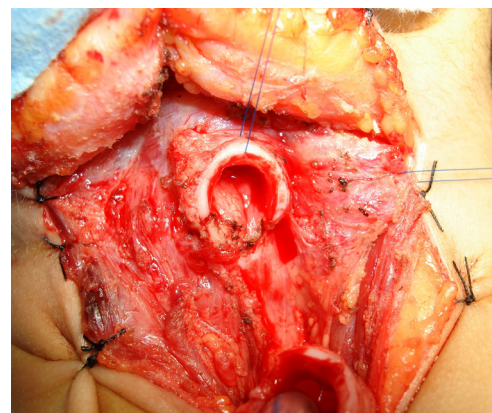
survival even in cases of lymph nodes metastasis with survival of all cases after a follow-up between 13 and 17 years in the largest reported series.<sup>27,28</sup> Surgery must be reserved to the purpose of diagnostic biopsy or debulking for emergency condition.

Other very rare tumors are the laryngotracheal chondromas (LTC). Surgical resection remains the treatment of choice and the rate of local recurrence seems to be low but still unclear, due to the slow growth of this PTT and the relatively short follow-up of reported cases in literature.<sup>29</sup>

In the literature, there is only 1 case of tracheal lipoblastoma (TL) in children, described by our group<sup>30</sup>—we described a posterior tracheal wall tumor with obstructive symptoms at presentation and a rapid growth with esophageal involvement (Figure 3). A partial cricoid tracheal resection was required, as well as a strict follow-up, due to the high local relapse risk in the early post-operative time.

### Sign and symptoms

Clinical presentation depends on the site and type of the tumor. Obstructive symptoms are frequent in case of severe (> 50% of the lumen) upper airway obstruction with stridor, wheezing, and dyspnea; cough is very common and is expression of mucosal irritation or poor clearance with accumulation of airway secretions distal to the stenosis; haemoptysis is not a frequent symptom and is observed in case of mucosal ulceration. Commonly, clinical presentations of PTT are misdiagnosed as bronchitis, pneumonia, or asthma episodes. Complete or partial lung atelectasis is another frequent occurrence in these patients with bronchial localization. Neuroendocrine tumors as CaT can present with carcinoid syndrome as described above.



**Fig. 3.** Tracheal lipoblastoma. A partial tracheal cricoid resection was necessary.

The diagnosis of PTT in children is usually delayed, due to the low suspicion level of the clinicians approaching patients with respiratory symptoms, because of their rarity, but also to the “functional reserve” of the trachea—obstructive symptoms usually do not appear until the lumen is occluded for 50% or more.<sup>31</sup>

### Radiology and endoscopic assessment

Conventional chest x-ray is often performed in patients with PTT, but in the majority of cases it is not diagnostic and can only detect not-specific indirect signs of airway obstruction, as pulmonary collapse, opacity, or hyperinflation.

The gold standard for radiological diagnosis of PTT remains computed tomography (CT) with intravenous contrast, that provides the exact location of PTT, the intra- and extra-luminal extension and the relation with the adjacent organs and vessels. CT also allows 3D reconstruction with the possibility of measurement of the tracheal and bronchial lumen. The different tumors present some of the following differences at CT scan: CaT and IMT are characterized by lobulated and defined contours on CT scan, with calcifications less present in cases of peripheral location; MC are lobulated or oval masses with calcifications in the 50% of cases; GCT present as ovoid soft-tissue masses.<sup>32</sup> However, CT cannot give us a definitive diagnosis on the histological type of the mass. This underscores the role of endoscopy with biopsy for studying the histological findings<sup>33</sup> (Figure 4).

If CT scan remains the gold standard for PTT assessment, magnetic resonance (MRI) represents a useful tool for staging of pediatric malignancies, whole-body scan allows detection of distant metastases as described by Siegel<sup>34</sup> (Figure 5).

The American College of Radiology Imaging Network demonstrated that MRI was not less accurate than other conventional techniques involving ionizing radiation as PET/TC or scintigraphy. In case of RMS, a metastatic work-up is indicated, including bone scan, bone marrow aspirate in addition to CT scan to identify cartilage invasion.

Fluoro-deoxy-glucose positron emission tomography (FDG PET) can be a complementary useful tool for diagnosis of CT because of the expression of somatostatin receptors. The main limitations of the application of FDG PET for CT diagnosis are the low metabolic activity of the typical form results and the size-relation with possible false negative.<sup>35</sup>

FDG PET utilization was also reported for MC, but due to the low metabolic activity of MC must be always associated with a CT scan.<sup>36,37</sup>

Airway endoscopy is essential in the study algorithm and commonly used to assess tumor location and obtain tissue sampling. Both flexible fiberoptic endoscopy and rigid bronchoscopy are useful and complementary techniques.<sup>1</sup> Flexible endoscopy is



Fig. 4. Computed tomography coronal section with the mass protruding in the left main bronchus.



Fig. 5. CT scan coronal view. Left subglottic space mass. Myofibroblastic tumor.

particularly useful to explore the distal airways, rigid bronchoscopy allows a better view and multiple biopsies or debulking of the tumor, while maintaining the patient ventilated.<sup>38</sup> In case of emergency during endoscopy some maneuvers can be performed such as hemostasis, tumor debulking, and stenting.<sup>39</sup>

### Endoscopic treatment

Despite several institutional experience on endoscopic resection of PTT were reported, its use remains controversial.<sup>1,2,39</sup>

One of the largest series of endoscopic treatments for tracheobronchial lesions in children was reported in 2013 by Sjogren and Sidman<sup>40</sup> who used carbon dioxide laser. Despite their promising results of a total of 234 procedures in 17 patients, they concluded that endoscopic resection is burdened by several limitations: the high risk of transmural injury, the inability to coagulate vessels with caliber higher than 5 mm of diameter and the risk of rupture of laser fiber with dislocation in the airway tree. The high rate of endoscopic procedures for each patient expose to a high number of anesthesia procedures, with subsequent procedure-related complications. The others limitations are related to the tracheobronchial compression which represents a contraindication to endoscopic resection and the extratracheal involvement of the tumor. Several complications were reported after endoscopic resection as post-operative atelectasis and risk of local relapse.<sup>2,4</sup>

### Tracheotomy

It is recognized that surgical complete removal of the tumor is the treatment of choice, for most of PTT (CaT, IMT, and GCT). The role of pre-operative tracheotomy has not been studied, but in our opinion tracheotomy is usually unnecessary or not recommended. The patients who present with severe tracheal obstructive symptoms are those who potentially could benefit of a tracheotomy, however, primary resection of the tumor or biopsy with endoscopic debulking could allow a safe airway management avoiding the need of tracheotomy. Tracheotomy could be an option in a severely distressed patient in whom the surgeon needs a pre-operative precise definition of the tumor histology and endoscopic debulking could be technically impossible (e.g., for bleeding).<sup>22</sup> One of the disadvantages of the tracheotomy is that, depending on the site where it is performed, it could complicate the subsequent operation. If tracheotomy is really close to the tumor, it can be included later in the tracheal resection and anastomosis, without sacrificing a long segment of trachea; if tracheotomy is far from the tumor (at least 3–4 rings from the inferior margin of the tumor), a tracheal resection and anastomosis can be accomplished without the need of

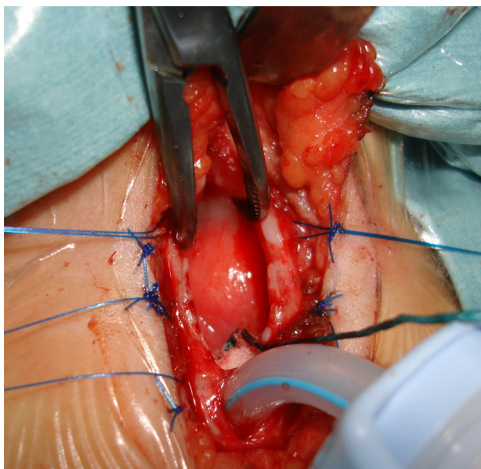
including the tracheotomy in the resection. If tracheotomy is performed at a middle distance (at around 2 rings) from the inferior margin of the tumor, it will probably complicate the subsequent tracheal resection. For these reasons, in our practice we tend to avoid the use of tracheotomy. We usually perform a biopsy during endoscopic pre-operative assessment and shortly after the histological diagnosis is achieved, we plan an open surgical resection.

### Surgical approaches. Technical aspects

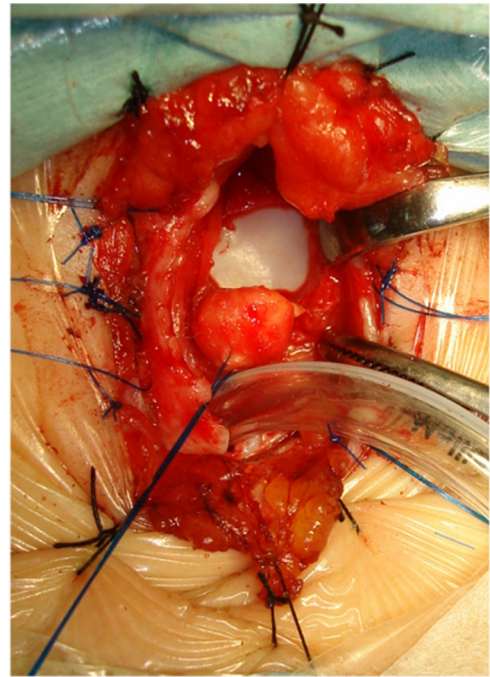
Despite several transverse neck incision were reported,<sup>41</sup> a conventional anterior transverse collar incision provides a good exposure for PTT located in the larynx tract.

After subcutis and platysma dissection, a modified Scott retractor (Lonestar<sup>®</sup> retractor) placement can help the surgeon to proceed to the larynx exposure (Figure 6).

After sternohyoid and sternothyroid muscle lateral retraction, the isthmus of the thyroid is transected in the middle port to gain the access to the airway. A temporary intraoperative tracheotomy can help to assist the child during the surgery and give the possibility to remove the tracheal tube positioned at the beginning of the procedure. Depending on the localization of the tumor, a laryngofissure is performed to gain access to the tumor. If necessary, a full laryngofissure will give access to posterior glottis and inter-arytenoid space. If the tumor is covered by a normal mucosal layer, the mucosa can be open and the tumor dissected. If not infiltrating the cartilage, the tumor can be easily separated and removed (tumorectomy), leaving the laryngeal framework intact (Figure 7). After tumorectomy, the mucosa can be re-approximated and the laryngofissure closed. In case of infiltrated larynx, a partial resection is usually necessary and frozen sections are recommended to delineate tumor margins and then surgeon can proceed to the reconstruction. A posterior and/or the anterior larynx defect can be reconstructed with a cartilaginous rib graft (laryngotracheal reconstruction with cartilage graft). In this case, after measuring the cricoid defect, a rib graft is harvested from the anterior chest wall, designed on the cricoid defect leaving additional 1–2 mm for the postero-lateral margins<sup>42</sup> and leaving the perichondrium intact on 1 side. The graft is sutured to the laryngeal cartilage by using absorbable sutures, avoiding multiple punctures for the risk of cartilage rupture and necrosis. In addition, fibrin–thrombin glue can be used to facilitate the re-epithelization. The mucosa will progressively cover the graft proliferating from both sides of the graft onto the perichondrium.



**Fig. 6.** Larynx tumor with posterior cartilage exposure, tracheal tube is inserted below the tumor location.



**Fig. 7.** A granular cell tumor (GCT) is removed from the posterior cricoid plate (tumorectomy).

In case of PTT with larger extension, a cricotracheal resection with an end-to-end anastomosis is required. In this case, the anterior arch of the cricoid is removed, leaving the posterior arch intact to preserve the recurrent nerves. The resection completed, the distal tracheal stump is mobilized and moved cranially to join the thyroid cartilage, to which is anastomosed by using absorbable extra mucosal sutures. A full mucosal approximation is essential to avoid subsequent granulation tissue and stenosis.

In some children, extubation could be attempted at the end of the surgery. In infants or small children, the patient will be usually kept intubated for few days.

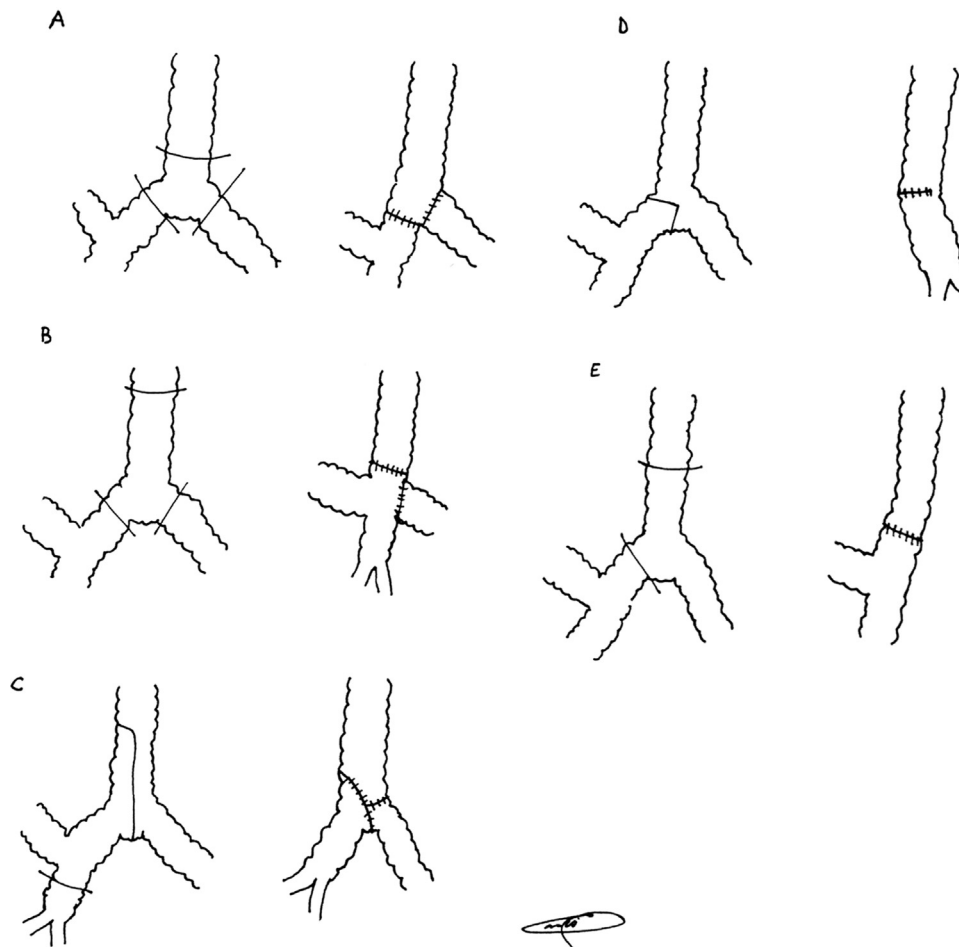
Complications of these types of surgeries include infection of the rib graft, granulation, malacia, vocal cord palsy for laryngeal nerve trauma, dehiscence of the airway, graft collapse, and laryngotracheal stenosis. All these complications are described with low incidence in main airway centers.

### Upper trachea

PTT of the upper trachea must be approached through an anterior access with an hyperextension of the neck. Sternotomy is usually not necessary. A careful attention must be paid on the dissection of the lateral aspects of the trachea not to damage the inferior laryngeal nerves and avoiding unnecessary devascularisation. A flexible intraoperative bronchoscopy can be useful for the correct identification of the tumor location. Based on histological frozen evaluation of tumor margins and extension of the mass, a cylindrical tracheal resection with end-to-end anastomosis or a window resection can be performed. Tracheal anastomosis is performed using interrupted absorbable extra mucosal sutures with the knots outside. The length of the trachea to be resected is usually not too long for a safe tracheal anastomosis. Lymph nodes evaluation and biopsy is recommended.<sup>7</sup>

### Inferior trachea

PTT of the inferior trachea usually required a full sternotomy. Based on tumor location an extracorporeal circulation (CEC) or



**Fig. 8.** Type of tracheobronchial resection according to the tumor location: (A) Carinal tumor with minor tracheal involvement; (B) Carinal tumor with major tracheal involvement; (C) Tracheobronchial right angle involvement including the upper lobe orifice and initial part of the right main bronchus; (D) tracheobronchial right angle involvement including the upper lobe orifice and long part of the right main bronchus; (E) tracheobronchial left angle involvement including the left main bronchus.

extracorporeal membrane oxygenation (ECMO) can be required. Each case requires an individualized surgical approach, as the technical solutions vary according to the site and extension of the tumor described by Grillo.<sup>43</sup>

### Lobar and segmental bronchi

If PTT is located in the main bronchus, with both proximal and distal margins free from disease, a sleeve resection is the gold standard surgical approach. Sleeve resection consists in the resection of the affected segment of the bronchus (checked with frozen sections) and re-anastomosis of the distal to the proximal stump. By this approach, the entire parenchyma of the lung is preserved. Intraoperative bronchoscopy is very useful to guide the bronchial resection. Single lung ventilation (contralateral to the tumor) is usually sufficient to manage these cases, but extracorporeal circulation must be ready to be installed (Figure 8).

In case of more peripheral location of PTT (lobar or segmental bronchi) a lobectomy or a segmentectomy are recommended with the saving of the greater amount of lung tissue especially in cases of diagnosis of benign tumor. Flexible intraoperative endoscopy is very useful again to guide the bronchial section.

Despite thoracoscopy is progressively accepted for lobectomy and segmentectomy of congenital cystic malformation,<sup>44,45</sup> minimally invasive approach for PTT has not been attempted in pediatric age, while it was used in adult and adolescent population.<sup>46,47</sup>

### Conclusions

PTT are rare in children and oncological guidelines are lacking in this group of population. Chemotherapy and radiotherapy are used only in cases of pediatric lung malignancies as adenocarcinoma, pleuroblastoma, or small cell carcinoma, following protocols. In children neither recommendations exist on medical treatment of CaT, MC, GCT, and IMT nor regarding radiological and endoscopic follow-up.

In the largest reported series, PTT were also associated with pulmonary malignancies as AC, PB, and SCC, but differ from primary pulmonary tumors for the better prognosis.<sup>7</sup> Though benign or with low grade of malignancy, the treatment is based on surgery, so the removal of the mass must be radical. The endoscopic treatment does not seem as efficacious as the open approach. The surgeon should reduce to the minimum lung demolitive surgery if possible, using technical tricks and preferring sleeve resections to multiple lobectomy or pneumonectomy. PTT must be managed in centers with airway reconstructive surgery facilities.

### References

1. Ayache D, Wagner I, Denoyelle F, et al. Use of the carbon dioxide laser for tracheobronchial pathology in children. *Eur Arch Otorhinolaryngol.* 2000;257:287–289.
2. Romão RL, de Barros F, Maksoud Filho JG, Gonçalves ME, Cardoso S, Tannuri AC, et al. Malignant tumour of the trachea in children: diagnostic pitfalls and surgical management. *J Pediatr Surg.* 2009;44:1–4.

3. Finck C, Moront M, Newton C, Timmapuri S, Lyons J, Rozans M. Pediatric granular cell tumor of the tracheobronchial tree. *J Pediatr Surg*. 2008;43:568–570.
4. Avanzini S, Pio L, Buffa P, Panigada S, Sacco O, Pini-Prato A, et al. Intraoperative bronchoscopy for bronchial carcinoid parenchymal-sparing resection: a pediatric case report. *Pediatr Surg Int*. 2012;28:75–78.
5. Yu DC, Grabowski MJ, Kozakewich HP, Perez-Atayde AR, Voss SD, Shamberger RC, et al. Primary lung tumours in children and adolescents: a 90-year experience. *J Pediatr Surg*. 2010;45:1090–1095.
6. Yu Y, Song Z, Chen Z, et al. Chinese pediatric and adolescent primary tracheobronchial tumors: a hospital-based study. *Pediatr Surg Int*. 2011;27:721–726.
7. Rojas Y, Shi YX, Zhang W, Beierle EA, Doski JJ, Goldfarb M, et al. Primary malignant pulmonary tumors in children: a review of the national cancer data base. *J Pediatr Surg*. 2015;50:1004–1008.
8. Neville HL, Hogan AR, Zhuge Y, Perez EA, Cheung MC, Koniaris LG, et al. Incidence and outcomes of malignant pediatric lung neoplasms. *J Surg Res*. 2009;156:224–230.
9. McMullan DM, Wood DE. Pulmonary carcinoid tumours. *Semin Thorac Cardiovasc Surg*. 2003;15:289–300.
10. Hancock BJ, Di Lorenzo M, Youssef S, Yazbeck S, Marcotte JE, Collin PP. Childhood primary pulmonary neoplasms. *J Pediatr Surg*. 1993;28:1133–1136.
11. Travis WD1, Rush W, Flieder DB, Falk R, Fleming MV, Gal AA, et al. Survival analysis of 200 pulmonary neuroendocrine tumours with clarification of criteria for atypical carcinoid and its separation from typical carcinoid. *Am J Surg Pathol*. 1998;22:934–944.
12. Wang LT, Wilkins EW Jr, Bode HH. Bronchial carcinoid tumours in pediatric patients. *Chest*. 1993;103:1426–1428.
13. Granberg D, Wilander E, Oberg K, Skogseid B. Prognostic markers in patients with typical bronchial carcinoid tumours. *J Clin Endocrinol Metab*. 2000;85:3425–3430.
14. El Jamal M, Nicholson AG, Goldstraw P. The feasibility of conservative resection for carcinoid tumours: is pneumonectomy ever necessary for uncomplicated cases? *Eur J Cardiothorac Surg*. 2000;18:301–306.
15. Techavichit P, Hicks MJ, López-Terrada DH, Quintanilla NM, Guillerman RP, Sarabia SF, et al. Mucoepidermoid carcinoma in children: a single institutional experience. *Pediatr Blood Cancer*. 2016;63:27–31.
16. Qian X, Sun Z, Pan W, Ye Q, Tang J, Cao Z. Childhood bronchial mucoepidermoid tumours: a case report and literature review. *Oncol Lett*. 2013;6:1409–1412.
17. Desai DP, Mahoney EM, Miller RP, Holinger LD. Mucoepidermoid carcinoma of the trachea in a child. *Int J Pediatr Otorhinolaryngol*. 1998;45:259–263.
18. Mullins JD, Barnes RP. Childhood bronchial mucoepidermoid tumours: a case report and review of the literature. *Cancer*. 1979;44:315–322.
19. Pernas FG, Younis RT, Lehman DA, Robinson PG. Management of pediatric airway granular cell tumour: role of laryngotracheal reconstruction. *Int J Pediatr Otorhinolaryngol*. 2006;70:957–963.
20. Jindal A, Bal A, Agarwal R. Inflammatory myofibroblastic tumor of the trachea in the pediatric age group: case report and systematic review of the literature. *J Bronchology Interv Pulmonol*. 2015;22:58–65.
21. Carillo C, Anile M, De Giacomo T, Venuta F. Bilateral simultaneous inflammatory myofibroblastic tumour of the lung with distant metastatic spread. *Interact Cardiovasc Thorac Surg*. 2011;13:246–247.
22. Panigada S, Sacco O, Girosi D, Magnano GM, Tuo P, Tarantino V, et al. Corticosteroids may favour proliferation of thoracic myofibroblastic inflammatory tumours. *Pediatr Pulmonol*. 2014;49:E109–E111.
23. Minoo P, Wang HY. ALK-immunoreactive neoplasms. *Int J Clin Exp Pathol*. 2012;5:397–410.
24. Butrynski JE, D'Adamo DR, Hornick JL, Dal Cin P, Antonescu CR, Jhanwar SC, et al. Crizotinib in ALK-rearranged inflammatory myofibroblastic tumour. *N Engl J Med*. 2010;363:1727–1733.
25. Chavez C, Hoffman MA. Complete remission of ALK-negative plasma cell granuloma (inflammatory myofibroblastic tumour) of the lung induced by celecoxib: a case report and review of the literature. *Oncol Lett*. 2013;5:1672–1676.
26. Ferlito A, Rinaldo A, Marioni G. Laryngeal malignant neoplasms in children and adolescents. *Int J Pediatr Otorhinolaryngol*. 1999;49:1–14.
27. Kato MA, Flamant F, Terrier-Lacombe MJ, Habrand JL, Schwaab G, Luboinski B, et al. Rhabdomyosarcoma of the larynx in children: a series of five patients treated in the Institute Gustave Roussy (Villejuif, France). *Med Pediatr Oncol*. 1991;19:110–114.
28. Fernandes P, Tandon DA, Tickoo SK, Rath GK. Embryonal rhabdomyosarcoma of the larynx in a child: report of a case and review of literature. *Indian J Cancer*. 1988;25:89–93.
29. Ozlugedik S, Tuncel U, Han U, Tezer MS, Unal A. Laryngeal chondroma: a rare neck tumour in pediatric age. *Int J Pediatr Otorhinolaryngol*. 2004;68:1551–1555.
30. Torre M, Borel C, Saitua F, Ossandon F, Latorre JJ, Varela P. Lipoblastoma with unique localization requiring tracheal and esophageal resection. *J Pediatr Surg*. 2010;45:21–23.
31. Macchiarini P. Primary tracheal tumours. *Lancet Oncol*. 2006;7:83–91.
32. Amini B, Huang SY, Tsai J, Benveniste MF, Robledo HH, Lee EY. Primary lung and large airway neoplasms in children: current imaging evaluation with multi-detector computed tomography. *Radiol Clin North Am*. 2013;51:637–657.
33. Colletti PM, Beck S, Boswell WD Jr, Radin DR, Yamauchi DM, Ralls PW, et al. Computed tomography in endobronchial neoplasms. *Comput Med Imaging Graph*. 1990;14:257–262.
34. Siegel MJ, Acharyya S, Hoffer FA, Wyly JB, Friedmann AM, Snyder BS, et al. Whole-body MR imaging for staging of malignant tumours in pediatric patients: results of the American College of Radiology Imaging Network 6660 Trial. *Radiology*. 2013;266:599–609.
35. Stefani A, Franceschetto A, Nesci J, Aramini B, Proli C, Kaleci S, et al. Integrated FDG-PET/CT imaging is useful in the approach to carcinoid tumours of the lung. *J Cardiothorac Surg*. 2013;8:223–230.
36. Lee EY, Vargas SO, Sawicki GS, Boyer D, Grant FD, Voss SD. Mucoepidermoid carcinoma of bronchus in a pediatric patient: (18)F-FDG PET findings. *Pediatr Radiol*. 2007;37:1278–1282.
37. Elnayal A, Moran CA, Fox PS, Mawlawi O, Swisher SG, Marom EM. Primary salivary gland-type lung cancer: imaging and clinical predictors of outcome. *Am J Roentgenol*. 2013;201:W57–W63.
38. Sittel C. Pathologies of the larynx and trachea in childhood. *Laryngorhinootologie*. 2014;93:S70–S83.
39. Roby BB, Drehner D, Sidman JD. Pediatric tracheal and endobronchial tumours: an institutional experience. *Arch Otolaryngol Head Neck Surg*. 2011;137:925–929.
40. Sjogren PP, Sidman JD. Use of the carbon dioxide laser for tracheobronchial lesions in children. *J Am Med Assoc Otolaryngol Head Neck Surg*. 2013;139:231–235.
41. Macfee WF. Transverse incisions for neck dissection. *Ann Surg*. 1960;151:279–284.
42. Monnier P. Laryngotracheoplasty and laryngotracheal reconstruction. In: Monnier P, editor. *Pediatric Airway Surgery*. Berlin, Germany: Springer-Verlag; 2011. p. 257–279.
43. Grillo HC. Tracheal tumours: surgical management. *Ann Thorac Surg*. 1978;26:112–125.
44. Kim MP, Ernst A, DeCamp MM, Gangadharan SP. Endobronchial ultrasound-facilitated video-assisted lobectomy with wedge bronchoplasty for typical carcinoid tumour of the right middle lobe. *Chest*. 2008;133:1474–1476.
45. Solaini L, Bagioni P, Prusciano F, Di Francesco F, Poddie DB. Video-assisted thoracic surgery (VATS) lobectomy for typical bronchopulmonary carcinoid tumours. *Surg Endosc*. 2000;14:1142–1145.
46. Seong YW, Kang CH, Kim JT, Moon HJ, Park IK, Kim YT. Video assisted thoracoscopic lobectomy in children: safety, efficacy, and risk factors for conversion to thoracotomy. *Ann Thorac Surg*. 2013;95:1236–1242.
47. Kaneko K, Ono Y, Tainaka T, Sumida W, Kawai Y, Ando H. Thoracoscopic lobectomy for congenital cystic lung diseases in neonates and small infants. *Pediatr Surg Int*. 2010;26:361–365.