Approach to one lung ventilation during the surgical resection of an intrathoracic ganglioneuroblastoma in a three-year-old child: A case report and review of the literature

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Abstract: One lung ventilation (OLV) in children is a challenge and requires creative solutions. A case of OLV with bronchial placement of a fibroscope inspection-guided vascular embolectomy catheter in a three-year-old girl, scheduled for the resection of an intrathoracic tumor through thoracotomy is described. The availability of a broad range of vascular catheters as well as of fibroscope inspection material was decisive in managing the airway intra-operatively.

Over the last 20 years, the need for OLV in children has increased, and various methods for performing it have been reported. Knowing all existing strategies in that domain is important to provide optimal perioperative care. In this paper, several methods of OLV in children will be discussed, such as selective endobronchial intubation, types of bronchial blockers, Univent tube, pediatric double lumen tubes, as well as the Marraro double lumen tube.

Key words: Anesthesia; Hospitals, pediatric; Airway management; One-lung ventilation; Thoracic surgery; Intraoperative care.

Introduction

We present a case of a three-year-old child scheduled for an extensive surgical resection of an intrathoracic ganglioneuroblastoma. Due to the localization and dimensions of the tumor, a thoracotomy was performed and resection required OLV. After envisaging several alternatives (1-4), one lung ventilation was achieved using the endobronchial placement of a vascular embolectomy catheter. The placement was guided by fibroscope examination.

Disease history

A three-year-old girl, with no prior medical history, presented with a swelling in the left scapular region. Sonographic evaluation of the tumor was difficult due to partial intrathoracic localization. The child was in good overall condition and had a normal physical examination, except for the palpable mass in the left scapular region.

MRI showed a large multilobular tumor (Fig. 1), extending from the scapular region to the left thoracic cavity (intrathoracic component 7.6 x 6 cm) and the spinal canal, hence compressing the spinal cord without causing any symptoms of compression. Further imaging and staging showed no macroscopic metastatic locations or nodal involvement.

A biopsy of the tumor revealed histological findings compatible with a neuroganglioma, a benign subtype of peripheral neuroblastic tumor (5-7). Insofar as the tumor had favorable histology,
and no nodal involvement or metastasis, a curative surgical resection through a thoracotomy was scheduled. Because of the large dimensions of the tumor, optimal surgical exposure was necessary. In order to avoid possible lung contusion with the use of retractors, OLV was favored.

Anesthesia was induced using sevoflurane inhalation. An 18G IV line was placed in the right arm. Fentanyl 50 µg and atracurium 7 mg were administered to facilitate intubation. The trachea was intubated using a cuffed 5.0 mm Mallinckrodt® endotracheal tube (ETT). The ETT passed the vocal cords without any resistance in this nearly four-year-old patient. Tube cuff pressure was monitored throughout the procedure, and never exceeded 25 cm H2O. A 4 French double lumen central venous catheter (Arrow®) was placed in the left internal jugular vein and a 22G arterial catheter was placed in the right radial artery.

The patient was initially positioned prone to allow resection of the perimedullar and dorsal extra-thoracic part of the tumor. Subsequently the child was installed in the right lateral decubitus for resection of the intrathoracic part through a left thoracotomy.

To allow intrathoracic resection, one lung ventilation was required. A left main stem bronchial block was achieved using an embolectomy catheter. In order to prevent catheter dislocation during positioning, we initially attempted to place the catheter while the patient was positioned in lateral decubitus for surgery. A 3 French Python® embolectomy catheter was guided using a fiberscope (Pentax® FI/7BS 2.4 mm) through the Mallinckrodt® 5.0 mm ID cuffed ETT. Despite a retractable guide wire inside the catheter, it wasn’t rigid enough for adequate placement into the non-dependent left main stem bronchus. Therefore, the patient was repositioned in the dorsal decubitus to allow for successful catheter placement (Fig. 2a). After placement, the patient was installed in the lateral decubitus for surgery. OLV was initiated by inflating the balloon in the left main stem bronchus, and correct placement was confirmed by fiberscope examination (Fig. 2b). Pressure in the embolectomy catheter was not monitored. However, the transparent balloon of the catheter allowed visualization of the respiratory mucosa, which showed a well perfused status after balloon insufflation. The embolectomy catheter had a lumen, through which oxygen could be administered in case of severe hypoxemia. No adaptor port was available for oxygen delivery connection, as well as no airtight seal between the ETT, the bronchial blocker, and the fiberscope. Therefore, the bronchial blocker was inserted through the fiberscope port, and sealed using adhesive tape (Fig. 2c). Nevertheless, air leakage was minor, and did not compromise capnography.

Left lung collapse was complete and persistent during the 1.5 hour duration of single lung ventilation. Upon application of OLV, inspiratory peak pressures went from 12 mbar to 18 mbar, arterial pCO2 was 43.6 mmHg, and arterial oxygen saturation remained between 93-96% with a FiO2 of 0.5. There was no need for additional oxygen supplementation in the non-ventilated lung. The tumor was completely resected without any complication. Re-expansion of the collapsed lung was complete. The tracheal tube was removed in the operating theater after the procedure. No signs of airway edema were present.

Postoperative radiographic control of the chest showed full expansion of the lung, and mild pulmonary edema. The patient was discharged from the Pediatric Intensive Care Unit on the second postoperative day, and discharged from the hospital on day 7. Six months after surgery, the child was fine, and MRI showed no tumor recurrence.

**Discussion**

In this particular case, the choice an embolectomy catheter for bronchial blockade was due to the unavailability of specialized pediatric lung iso-
ation equipment for the concerned age category. The tracheal diameter in a 14 Kg, three-year-old girl is expected to be around 6.5 mm. The smallest DLT (Rüscht®, 26 French) and Univent tubes available have an outer diameter of respectively 9.0 mm and 7.5 mm. Right main stem bronchus intubation using a classical ETT was also contemplated. However, this technique does not provide any reliable seal, and has a large incidence of right upper lobe obstruction. A Python® 3 French embolectomy catheter was available as well as fiberscope equipment (Pentax® Fl7BS 2.4 mm). These are the reasons why the use of selective bronchial blocking was favored. This technique was successfully achieved, and no intraoperative or postoperative complications occurred. An excellent alternative could have been the use of a 5 French Arndt endo-bronchial blocker (Cook®) for lung isolation. The Arndt Multiport Airway Adapter would have prevented airway leakage, and would have offered good practical conditions of use.

**Methods of one lung ventilation in pediatric thoracic surgery**

Traditionally, thoracic surgery in the pediatric population is performed through a thoracotomy. Anesthesiologists ventilate both lungs and retractors are used to expose the surgical field. During the 90’s, video-assisted thoracoscopy (VATS) became widely used, and single lung ventilation became as popular in pediatric thoracic surgery as in adult (9). These new techniques can also be useful during thoracotomy surgery. Different methods of lung isolation are available (10-13) and recommended equipment according to age is summarized in Table 1 (21).

One lumen endo-bronchial intubation

The easiest and quickest way to isolate the lungs is the advancement of a traditional ETT in the desired bronchus (1, 14). This is preferred in emergency situations. Technically speaking, and for anatomical reasons, it is less easy to insert the ETT into the left main stem bronchus. Right upper lobe obstruction is frequent after a right main stem bronchus intubation.

Smaller, uncuffed tubes do not provide reliable isolation of the lung. Contrarily, inflation of cuffs can cause injury to the bronchial tree. In addition, one lumen endo-bronchial intubation does not allow aspiration of the contralateral lung. Endo-bronchial intubation can be traumatic (15) and should be executed with caution.

Most manufacturers (Mallinckrodt®, Sheridan®) sell uncuffed ETT’s with internal diameters (ID) as small as 2.0 mm, which makes it suitable for children of all ages, including premature neonates. In older children, cuffed ETT’s can also be used. However, cuff pressure should be monitored to avoid mucosal ischemia.

Bronchial blocker

A balloon tipped catheter can be used as an endo-bronchial blocker. The isolation of the lung or lung lobe is reliable, and the catheter can be advanced through or beside a traditional ETT. However, dislodgement can cause total tracheal blockade or airway trauma and perforation (16).

**Table 1**

Overview of methods and equipment sizes in different age groups for OLV

<table>
<thead>
<tr>
<th>Age, yr</th>
<th>ETT ID, mm</th>
<th>Fogarty, Fr</th>
<th>Swan-Ganz, Fr</th>
<th>Arndt, Fr</th>
<th>Univent ID, mm</th>
<th>DLT, Fr</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5-1</td>
<td>3.5-4</td>
<td>2-3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-2</td>
<td>4-4.5</td>
<td>3</td>
<td>5</td>
<td>5?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-4</td>
<td>4.5-5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-6</td>
<td>5-5.5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-8</td>
<td>5.5-6</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>3.5</td>
<td>26</td>
</tr>
<tr>
<td>8-10</td>
<td>6 + cuff</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>3.5</td>
<td>26</td>
</tr>
<tr>
<td>10-12</td>
<td>6.5 + cuff</td>
<td>6</td>
<td>7</td>
<td>9</td>
<td>4.5</td>
<td>26-28</td>
</tr>
<tr>
<td>12-14</td>
<td>6.5+ cuff</td>
<td>6</td>
<td>7</td>
<td>9</td>
<td>4.5</td>
<td>32</td>
</tr>
<tr>
<td>14-16</td>
<td>7 + cuff</td>
<td>7</td>
<td>7</td>
<td>9</td>
<td>6</td>
<td>35</td>
</tr>
</tbody>
</table>

ETT : Single lumen endo-bronchial intubation with the use of an endotracheal tube. ID : internal diameter in millimeters ; Fogarty, Swan-Ganz, Arndt, Univent : Bronchial blockade using balloon tipped catheters ; Fr : External diameter in French ; ID : Internal diameter in millimeters ; DLT : Pediatric double lumen tube.

The Arndt endobronchial blocker (Cook®) is a 5 French open end and balloon tipped catheter, specifically designed for endo-bronchial blocking. The Arndt Multiport Airway Adapter permits simultaneous bronchoscopy, ventilation and blocker placement (17). The lumen of the catheter allows the administration of CPAP to the non-ventilated lung. The smallest size is 5 French, usable with a 4.5 mm ID ETT.

Embolectomy catheters (Fogarty®, Arrow®) or pulmonary artery catheters (Edwards Lifesciences®) can be used to seal the bronchus. A broad variety in cuff sizes exists, as well as in terms of shape and pressure/volume characteristics. In contrast to embolectomy catheters, open end wedge pressure catheters have small lumens that can be used to provide CPAP. However, aspiration of secretions through those lumens is not possible. A size 3 Fogarty catheter will provide effective bronchial blocking for children up to 4 years old, and a size 5 can be used for most children between 5 and 12 years old (18). The cost of these catheters is generally high.

Univent tube

The Univent tube (Fuji Systems®) is an ETT with separate integrated lumen for bronchial blocker insertion. The advantages of that device are easy placement, and the ability to administer CPAP. Dislodgement of the bronchial blocker is infrequent, insofar as the two lumens are part of a single tube. However, the bronchial blocker lumen diminishes the cross-sectional area of the main lumen, particularly in smaller ETT’s, which causes a high resistance to gas flow. Caution is advised when inflating the cuff, insofar as the balloon has low volume/high pressure characteristics. The smallest Univent tubes are 3.5 and 4.5 mm ID, but the outer diameter ranges between 7.5 and 8 mm. This allows using it in children of 6 years and older.

Double lumen tube

The use of a double lumen tube (DLT) has many advantages. First, placement is easy and rapid. Adequate placement is confirmed using bronchoscopy. Both lungs are isolated securely. The two lumens allow suction and bronchoscopy of both lungs. CPAP can also administered to the non-ventilated lung. Although airway trauma has been reported in adults (19), it occurs rarely. Indeed, cuffs have high volume/low pressure characteristics.

The main disadvantage of DLT is their size. They are available only for larger children. Mallinckrodt® and Sheridan® smallest DLT are 28 French in size, which can be used in children of 10 years and older. The smallest commercially available DLT is 26 French (6.0 mm ID). This Rüsch® DLT is suitable in children of 8 years and older. In children, right turning DLT’s are avoided whenever possible. Those tubes cause right upper lobe obstruction frequently.

Marraro tube

The Marraro Paediatric Endobronchial Bilumen tube (SIMS-Portex®) is a double lumen tube for neonates and small children up to 2 or 3 years of age. It consists of 2 uncuffed tubes that are molded together so as to function like conventional DLT’s. Although reports on the use of Marraro DLT are few, it seems to provide effective OLV in a wide spectrum of cases, and without serious intraoperative or postoperative complications (20). The smallest Marraro bulumen tube consists of two 2.0 mm ID tubes. Sizes go up to 3.0/3.5 mm ID for the 2 to 3 year-old children. Positioning is similar to the one of DLT in adults. Adequate placement is controlled using radioscopy. These tubes are not widely available.

Conclusions

The need for single lung ventilation in children is rather rare in pediatric anesthesia and not all centers have extensive experience. Therefore, it is important to be aware of the existing methods and strategies. According to the patient’s age, anatomy, lesion, and type of surgery, several strategies can be envisaged in order to provide optimal perioperative care.

References


