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Original research

Experiences and challenges of thorcoscopic lung surgery in the pediatric age group

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HIGHLIGHTS

- Technical considerations of thoracoscopic surgery in pediatric patients were analyzed.
- Anatomical lung resections are appear safe and effective in infants and children.
- Limitations exist due to the small thorax and in cases with infectious adhesions.
- Non-anatomical lung resections are technically easier and should remain standard.
- Limitations exsist in cases of metastases deeply within the parenchyma.

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ABSTRACT

Background: We report a single-center study of minimally invasive thoracoscopic lung surgery with pediatric patients.
Methods: We performed a retrospective analysis of patients who underwent thoracoscopic lung surgery between 2004 and 2013. The procedures were divided into anatomic and non-anatomical lung resections.
Results: Seventy-six patients with a mean age of 6.5 years (range: 7 days–17 years) and a mean weight of 11 kg (range: 2.6–56.0 kg) received thoracoscopic lung surgery for tumor metastases (n = 20), sequestration/congenital adenomatoid malformation (19), cysts (12), aspergillomas (7), bullae (5), middle lobe syndrome (3), bronchiectasis (3), emphysema (2), and other reasons (5). Twenty-nine anatomical lung resections (Group I: lobectomies, segmentectomies) and 47 non-anatomical lung resections (Group II: wedge resections, lung tissue-sparing surgery) were performed. In 6 cases, preoperative CT-guided coiling was used to localize the lung lesions. Specimen removal was achieved using a widened (2 cm) trocar site. The operating times of Group I patients were longer compared than those of Group II patients (means: 154 and 68 min, respectively); conversion rates (8 versus 2), chest tube insertion rates (100% versus 51%), and postoperative ventilation (48% versus 13%) also differed.
Conclusion: Thoracoscopic anatomical lung resections appear to be safe and effective in infants and children. In congenital lung diseases, the key to success is the intraoperative destruction of space-occupying lesions. Limitations exist in cases with infectious adhesions. Non-anatomical lung resections are technically easier and should remain standard in pediatric surgery. Limitations exist in cases of metastases, which are deep within the parenchyma and are not visible on the lung surface.

1. Introduction

Over the past, thoracoscopic lung surgery in pediatric patients has become routine at many institutions thanks to continuous advances in technology and techniques [1]. Minimally invasive

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procedures have gained acceptance and are associated with shorter hospital stays, faster recoveries, superior cosmesis and the avoidance of short- and long-term morbidity compared with standard thoracotomies [2]. This includes congenital benign lung anomalies, which encompass a spectrum of rare but potentially life-threatening lung diseases resulting from perturbations in lung and airway embryogenesis [3]. Indications also cover small lung nodules, malignant metastases, and localized pulmonary infections, which require biopsy or resection from the viewpoint of pediatric cancer treatment to enable survival [4]. Technically, minimally invasive lung surgery reflects a broad spectrum ranging from diagnostic biopsies to demanding anatomical resections of lung lobes and segments. Nowadays, these operations are also applicable in pediatric patients weighing less than 3 kg. Success rates and safety issues are strongly correlated with the technical progress of devices, learning curves and anesthesiological strategies.

This report details a single-center experience with the evolution of thoracoscopic lung surgery for congenital and acquired lung diseases over one decade.

2. Methods

2.1. Study population

All patients with pulmonary pathologies undergoing minimal invasive thoracoscopic surgery at our institution between January 2004 and December 2013 were retrospectively analyzed. The study was approved by the Ethical Committee of Eberhard Karls University in Tübingen, Germany (number 739/2014R). Thoracoscopic procedures were divided into two groups: anatomical lung resections (Group I: lobectomies, segmentectomies) and non-anatomical lung resections (Group II: wedge resections, lung tissue-sparing surgery).

2.2. Operative approach

2.2.1. General settings

The procedures were performed with the patient in a lateral decubitus position. Single-lung ventilation was realized by blocking the ipsilateral bronchus using a fogarty catheter or endobronchial blocker (Cook Medical Europe Ltd., Limerick, Ireland) in newborns, infants and smaller children. A double-lumen endotracheal tube was used in larger patients (>25 kg or >8 years). The operative procedure consisted of an initial explorative thoracoscopy using a 5 mm scope. The chest was initially insufflated with low-pressure carbon dioxide to induce complete collapse of the lung. A flow of 1.5 L/min was maintained throughout the procedure, and a pressure of 3 mm Hg was installed initially and then slowly raised to 5–6 mm Hg depending on the age of the patient. Two or three working ports (3, 5 or 10 mm) were inserted depending on the procedure encountered. In cases with space occupying lesions, such as large CPAMs (congenital pulmonary adenomatoid malformation), decompression was performed using a tissue-sealing device until adequate space for visualization and safe manipulation had been gained.

2.2.2. Upper-lobe resections

Anatomical lung resection was defined as the excision of one bronchopulmonary lung lobe or segment with individual division and transection of the corresponding bronchovascular structures. For upper-lobe resections, a 5 mm port/camera was placed on the mid-axillary line (Fig. 1A). A working port was inserted in the posterior and anterior axillary line cranially to the camera position. The interlobar fissure was identified followed by identification of the segmental artery (A2), which was either clipped using 5 mm Ethicon Titan clips (Ethicon, Norderstedt, Germany) or divided using 5 mm LigaSure (Valleylap, Boulder, CO, USA). In the next step, arteries A1 and A3 were identified. However, this identification was sometimes difficult due to the overlying segmental veins (V1–V3), which occasionally had to be divided beforehand (Fig. 1B). For this step, V4 and V5 were also exposed to ensure orientation. Finally, the main bronchus and segmental bronchi were visualized. To avoid accidental injury, flexible bronchoscopy was carried out during this step. The segmental bronchi were transsected using intracorporal knotting technique (PDS 4-0, Ethicon, Norderstedt, Germany) in neonates and infants or a 10 mm Endo-GIA (Tyco Healthcare, Neustadt/Donau, Germany) in school-aged children. Separation between lobes was carried out using an Olympus SonoSurg harmonic scalpel (Olympus, Munich, Germany). The specimens were retrieved through a slightly enlarged trocar site (2 cm) (Fig. 2D).

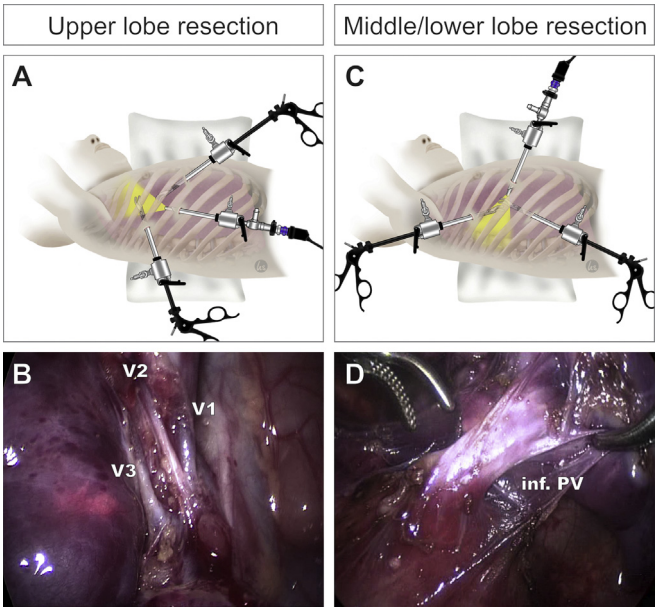

Fig. 1. Trocar positioning for anatomical resections. For upper-lobe resections, camera positioning on the mid-axillary line (A) enables initial identification of the segmental veins (B). In middle/lower lobe resections, the sequence of dissection/ligation of bronchopulmonary structures starts with the arteries and bronchi, which requires a camera position on the anterior axillary line (C). This positioning also enables good access to the inferior pulmonary vein (inf PV) as the final step of the procedure (D).

2.2.3. Lower/middle-lobe resections

For lower/middle-lobe resections, the camera trocar was positioned in the anterior axillary line (Fig. 1C). The working ports were inserted in the cranial and caudal mid-axillary line, respectively. Identification and division of the bronchopulmonary structures was carried out in a different chronological order compared with the upper-lobe resections: The segmental arteries were exposed initially (Fig. 2C), followed by the bronchial structures under bronchoscopic control. Next, the pulmonary ligament was divided, and the inferior pulmonary vein (Fig. 1D) was approached and divided in a final step.

2.2.4. Lung tissue-sparing surgery

A lung tissue-sparing surgery was defined as the complete resection of lung lesions with subsequent parenchymal sealing and suturing. Lung tissue-sparing surgery was necessary in the case of multiple lung pathologies allocated in different lobes and segments