# Tips and Tricks in Thoracic Surgery

Dakshesh Parikh
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*Editors*

Springer

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*Our respective families for their dedication, love, patience and support throughout our career.*

*Our patients, colleagues and staff for their support and trust to allow us to perform to our best in the specialty.*

# Foreword

Every thoracic surgeon needs "Tips and Tricks"! You never have enough of them and any or all may come in handy someday.

The authors have run a very successful course for thoracic surgeons in Birmingham, England, for many years. This textbook in many respects is an extension of that course. That course is predominantly for trainees, but this book is for practitioners of every level. This book will become a resource for the everyday problems and the occasional unusual one. The authors have selected an outstanding group of "expert" contributors from around the world. This international group of surgeons offers unique perspectives on a variety of problems facing thoracic surgeons.

Lung failure is a challenging problem facing physicians and surgeons. There is still an important role for lung volume reduction surgery (LVRS) in carefully selected patients. LVRS is an important stand-alone procedure or as a "bridge" to transplant. Both areas are ably covered by Drs. Wood and Mulligan who have extensive experience with both.

In many parts of the world, lung infections and the management of complications pose major challenges for thoracic surgeons. In some countries, these problems are infrequent, but in other countries quite common. Drawing on the experience of surgeons who regularly deal with empyema, tuberculosis, and hydatid disease will be invaluable to all. This is true of trauma management as well.

Mediastinal tumors are uncommon for most surgeons. However, they do occur on a regular basis. Understanding the principles of management of tumors and associated conditions is valuable.

Esophageal surgery is the most challenging area of commonly practiced thoracic surgery. This book deals with benign and malignant disease. The authors are acclaimed experts. Their chapters deal with technical aspects and important management issues.

I hope the thoracic surgery community looks forward to this important text as much as I do. There is something in it for everyone: trainee or practicing surgeon. ENJOY!

Boston, MA, USA — Douglas J. Mathisen

# Preface

A number of textbooks and atlases of adult and Pediatric thoracic surgery have been published. These are either textbooks for reference or descriptive atlases of operative techniques. Information relating to surgical results and outcomes is scattered in the literature. Outcomes and complications in thoracic surgery are dependent on the competence of the surgeon and the team. Surgical practice and operative technique are transferred by competence-based training to the new generation of surgeons. These surgeons require mentoring and support in their initial years of independent practice. This is especially true for those carrying out occasional procedures or as a sub-specialty interest in Pediatrics. The experts have acquired these skills by experience over the years, the knowledge gained is key to the outcome and reduction in the complications associated with the surgery. We believe that this book will be a useful resource to the trainee and the newly appointed thoracic surgeon.

This book includes 37 chapters that are aimed at the higher surgical trainees and serve as a useful adjunct to all newly appointed adult and Pediatric thoracic surgeons. We believe the expert contributors have discussed pathology in their chapters that may be useful to senior consultants undertaking surgery outside their comfort zone. Thoracic surgery is a high-risk specialty and requires attention to detail. Tips and tricks from experienced surgeons will contribute to improving outcomes and reduce complications.

In spite of our objective to allow contributors freedom to share their experience, tips and tricks of their surgical practice, we made every effort to achieve a uniform style. The authors were carefully chosen for their recognized expertise from around the world. The effort involved in making this textbook a reality has been exhausting and exhilarating. We sincerely hope the final result does justice to the original aim.

We would like to express our gratitude for the time and expertise provided by all the contributing authors. We express our sincere thanks to Melissa Morton, Senior Editor, at Springer and her editorial assistants and project managers especially Andre Tournois, Suganya Selvaraj and Georgette who have encouraged and helped us throughout this project.

Birmingham, UK — Dakshesh Parikh
Birmingham, UK — Pala B. Rajesh

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# Part I

# Lung

# Congenital Lung Malformations

1

Jörg Fuchs

**Abstract**

Congenital lung lesions are mostly diagnosed by a routine antenatal ultrasound scanning. Many remain asymptomatic immediately after birth but are likely to present later in life with symptoms of pneumonic infection or a persistent lesion in adults can be confused with malignancy. Controversy amongst the surgeons is to resect these asymptomatic lesions electively or to resect only if presented with infection on follow-up. With the advent of thoracoscopic resections and reduced morbidity with minimally invasive resections, elective resection has become more attractive. There is definitely increased morbidity once the lesion becomes infected with need for blood transfusion, wider resection, post-operative air leaks and risk of conversion to open thoracotomy. The subspecialization in Pediatric thoracic surgery may improve overall outcome of this and many other Pediatric thoracic surgical conditions.

**Keywords**

Antenatal diagnosis · Congenital cystic lung lesions · Congenital pulmonary airway malformations · Congenital cystic adenomatoid malformations · Pulmonary sequestrations · Lung agenesis · Bronchopulmonary foregut cysts · Congenital lobar emphysema · Hydrops fetalis · VATS · Lobectomy · Segmental resection Partial lobectomy

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## 1.1 Introduction

This chapter describes congenital malformations of the lung such as lung agenesis and hypoplasia, congenital pulmonary adenomatoid malformation, lung sequestration, bronchopulmonary cysts and congenital lobar emphysema. All these entities are rare and their incidences difficult to determine. Despite different hypotheses, the aetiology of congenital lung malformations is not yet finally clear. Many of these malformations can be detected antenatally. Clinical symptoms are vary from asymptomatic course to life-threatening conditions [1].

Surgical treatment plays a key role for the successful treatment of all these entities with relatively low mortality and morbidity rates [2–4].

## 1.2 Lung Agenesis/Aplasia

Lung agenesis is very rare and includes absence of the bronchus, lung parenchyma and pulmonary vessels. There are approximately 200 cases described in the literature. More than 50% of the patients may die within the first years of life. However, some children with unilateral disease survived with a normal expectation of life (Fig. 1.1). Relevant prognostic factors for survival are associated anomalies of the heart, intestinal and urinary tract. Leading symptoms are dyspnoea, thoracic asymmetry and a secondary scoliosis [5]. Clinical symptoms depend on the existence of a uni- or bilateral affection. A respiratory distress syndrome is frequent; survival is minimal in bilateral constellations. Pulmonary hypertension is the leading criterion for the severity of the disease.

Lung hypoplasia implies a reduced number of alveoli and a hypoplasia of the pulmonary artery. Lung hypoplasia is associated with several syndromes or

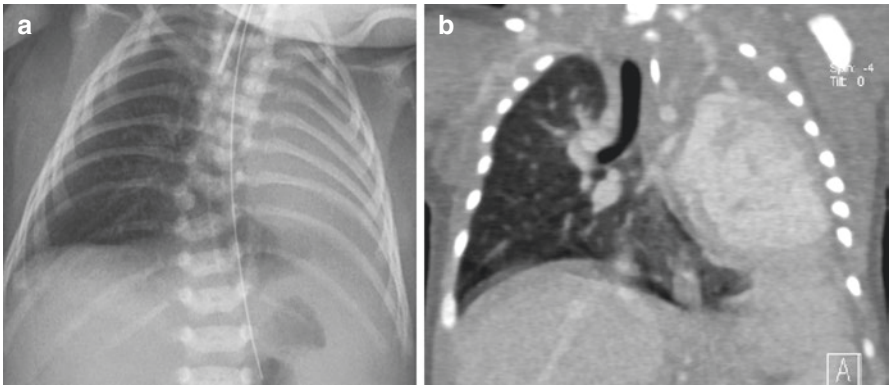


**Fig. 1.1** Newborn with congenital unilateral lung agenenis on the left side. X-ray with complete shifting of the mediastinum to the right side (**a**). Corresponding CT scan with complete absence of the left lung (**b**)

associations such as Potter syndrome, bilateral renal dysplasia, congenital diaphragmatic hernia, Scimitar syndrome, trisomy 13/15/18 or a severe scoliosis [6].

The diagnosis is established through chest X-ray, CT scan, echocardiography and bronchoscopy. The initial treatment includes a wide spectrum of measures ranging from supportive care such as a simple oxygen application to ECMO therapy. The further therapeutic approach depends on the underlying disease and has to take the surgical correction of associated congenital malformations into account [7, 8].

## 1.3 Cystic Lung Lesion

Isolated lung cysts are malformations of the terminal respiratory tract and histologically include cartilage, smooth muscles and glandular structures. They occur as singular or multiple cysts (Fig. 1.2). Incidence rates are notably higher in patients with Down syndrome in combination with congenital heart disease.

Clinical symptoms during the newborn period are varying depending on the size of the lesions and ranging from nearly asymptomatic clinical conditions to a severe respiratory distress syndrome. A pneumothorax with mediastinal shift caused by a cyst rupture can occur as emergency situation in every age group. Later, infections (pneumonia or lung abscess) are the leading symptom.

The treatment depends on the clinical symptoms and the size of the cyst. Spontaneous regression is possible. However, in symptomatic cases, the treatment of choice is the surgical resection. Whenever possible a lung sparing surgery should be performed (enucleation or wedge resection) [9]. Multiple cysts localized in one lobe can be managed by lobectomy. The best surgical approach is VATS. However, conventional thoracotomy should be preferred in cases of severe respiratory compromise or infection because of intolerance of the intrathoracic pressure during thoracoscopy or adhesions after an inflammation with difficulties to identify the anatomical structures [10, 11].

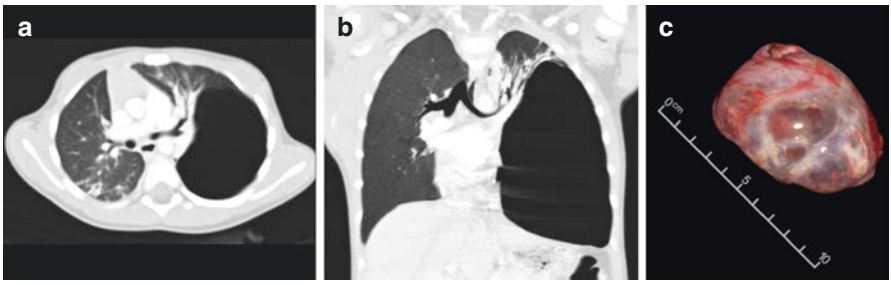


**Fig. 1.2** Congenital lung cyst in a 2-year-old girl, diagnosed after a simple respiratory infection. Extension of the isolated cyst on CT scan (**a**, **b**). Completely excised specimen after thoracoscopic resection (**c**)

## 1.4 Congenital Pulmonary Airway Malformation CPAM

The term "congenital pulmonary airway malformation" (CPAM) has been recently introduced in the nomenclature for the historical description of the former congenital cystic adenomatoid malformation (CCAM). The incidence is approximately 1:25,000–35,000. This malformation accounts for 25% of all congenital lung malformations and is mainly located on the left side (60%). Bilateral involvement is rare and occurs in approximately 6% of all cases. In up to 25%, a hybrid lesion (CCAM + lung sequestration) can be identified. There exist different clinical and histopathological classifications of CPAM (Table 1.1) [2].

Histologically, the CPAM has mainly four different appearances, which include polypoid changes of the mucosa, presence of mucous-secreting cells, absence of cartilage and inflammation.

The routine ultrasound examination in the second pregnancy trimester is reliable. The accuracy of the antenatal diagnostic workup in congenital lung lesions can be improved through MRI. Regarding the clinical risk stratification, prenatal ultrasound is able to distinguish between the macrocystic (single or multiple cysts with a diameter larger than 5 mm, good prognosis) and microcystic (solid mass with cysts smaller than 5 mm, poor prognosis) subtype. Meanwhile the CPAM volume-to-head circumference ratio (CVR) plays an additional key role for the risk stratification. CVR > 1.6 is predictive for a high risk of hydrops with poor prognosis. This parameter represents an indication for a possible prenatal intervention (laser ablation, thoraco-amniotic shunting) including lung resection as an EXIT (ex utero intrapartum therapy) procedure. However, the first step is the maternal steroid administration with a response in up to 90% of all cases. Therefore the maternal steroid administration can significantly improve the foetal survival [2, 3, 12].

Postnatal clinical symptoms include acute respiratory distress syndrome (approximately 60–80% of all cases), later recurrent pulmonary infections in the CPAM area, failure to thrive and reactive airway disease. Previously it has been postulated

**Table 1.1** Classification of CPAM [37, 38]

| | Anatomical classification (prenatal ultrasound) | Stocker classification (classical) |
|---|---|---|
| Size of the cysts | Macrocystic: >5 mm<br>Microcystic: <5 mm | I: >2 cm<br>II: <2 cm<br>III: solid |
| Associated malformation | Microcystic | II |
| Prognosis | | |
| • Favourable | Macrocystic | I |
| • Unfavourable | Microcystic | III |
| Echogenicity in ultrasound | | |
| • Solid | Microcystic | III |
| • Cystic | Macrocystic | I, II |

that the mesenchymal tissue of CPAM possesses a neoplastic potential. Malignant transformations (bronchoalveolar carcinoma, pulmoblastoma, rhabdomyosarcoma and myxosarcoma) have been described in 2–14% [13–15].

Most authors recommend contrast CT scan or MRI in older children as postnatal imaging for an exact description of the malformation and identification of a hybrid lesion or an atypical blood supply.

Respiratory compromises in neonates are almost always indication for an emergency lobectomy via conventional muscle-sparing thoracotomy or thoracoscopy (Fig. 1.3). In rare cases of multilobular involvement, a pneumonectomy or parenchyma preserving surgery might be indicated. Pneumonectomy performed in young infant is highly morbid condition and may result in mortality.

There exists a controversial debate in the literature regarding the role of surgical treatment in asymptomatic cases. Arguments for observation are the unknown natural history with the chance of spontaneous regression [12]. Reasons for the surgical treatment are the high risk of infection, which may render surgery more difficult, the malignant transformation without typical signs in imaging, the risk of

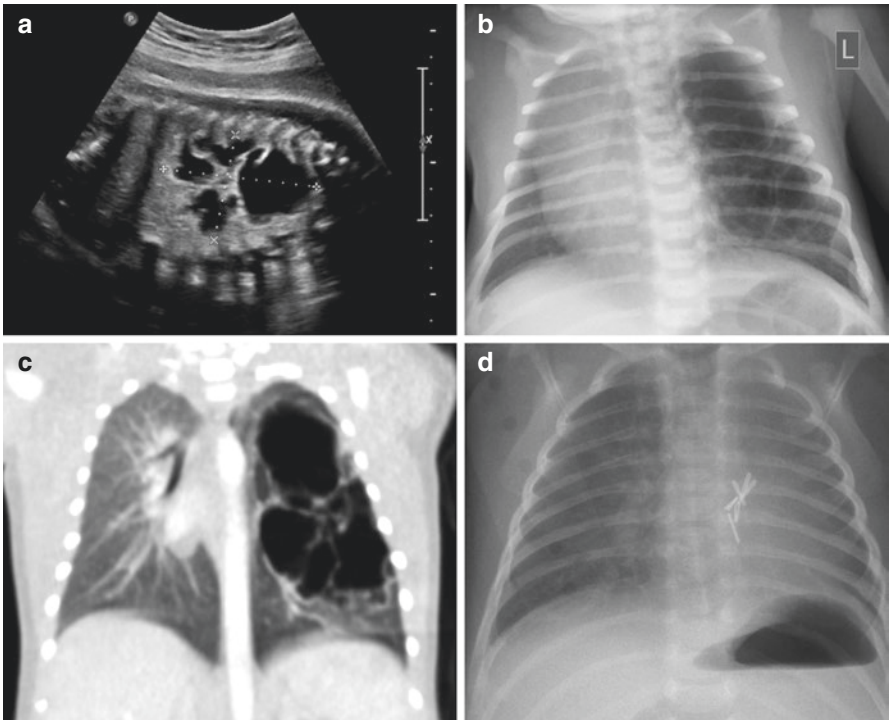


**Fig. 1.3** CPAM in a newborn, antenatally diagnosed in the 22nd Gestational week. Ultrasound scan during pregnancy (**a**). Postpartal chest X-ray (**b**). Postpartal CT scan with a mediastinal shift to the right side (**c**). Postoperative chest X-ray after thoracoscopic lower lobe resection on day 8 after birth (**d**)

pneumothorax because of a rupture of the cyst and the fast post-operative recovery in young asymptomatic children [16]. The optimal time point for an elective surgical treatment in asymptomatic children is the third to sixth month of life because of the compensatory lung growth up to 5 years of age [15, 17].

## 1.5 Congenital Lobar Emphysema

Congenital lobar emphysema (CLE) is characterized by a lobar overexpansion based on a bronchial pathology. In this condition the passage of air takes place into the lobe during inspiration, whereas there is only a limited expulsion of air during expiration (air trapping). There exist several reasons for the bronchial pathology (endobronchial obstruction through inspissated mucus, dysplasia of the cartilages and extrinsic obstruction caused by an aberrant vessel) [18]. The left upper lobe is involved in up to 50% of cases followed by the right middle lobe and right upper lobe. The pathology in the lower lobes is extremely uncommon.

Clinical symptoms vary widely ranging from very mild symptoms with a sporadic diagnosis to acute respiratory distress syndrome including a foetal hydrops.

The prenatal diagnosis is established through the classical ultrasound scan or MRI. In these examinations CLE can be distinguished from other congenital lung malformations. In approximately 25–50% of all cases, postnatal diagnoses are made directly after birth. Here, the diagnostic tools are chest X-ray and CT scan. An echocardiography is necessary to exclude cardiac malformations; a preoperative bronchoscopy is essential for delineation of an intrinsic cause for CLE.

In the constellation of mild clinical symptoms, a conservative treatment can be successful. If the child presents with respiratory distresses, an emergency thoracotomy is indicated [19]. The anaesthesiological management during surgery might be a challenge because of the air trapping with a massive overextension of the affected lobe. A selective intubation can prevent this problem, but this depends on the clinical tolerance of the child. The thoracoscopic resection may be difficult because of the small working space resulting from the rigid overextended lobe; it may be possible only in selected cases (Fig. 1.4).

## 1.6 Lung Sequestration

Lung sequestration is represented by a microcystic mass of non-functioning pulmonary tissue without communication to the main tracheobronchial tree. Two different forms of lung sequestrations: extrapulmonary and intrapulmonary sequestrations are described. An extrapulmonary lung sequestration is completely separated from the normal lung tissue and incorporated by separate covering visceral pleura. It can appear above, within and below the level of the diaphragm and has a separate arterial blood supply from the aorta (Fig. 1.5). Associated occurrence of other congenital malformations (CDH, congenital heart disease, skeletal abnormalities) is frequent. Extralobar sequestrations predominantly occur in males (3:1) [2]. In some

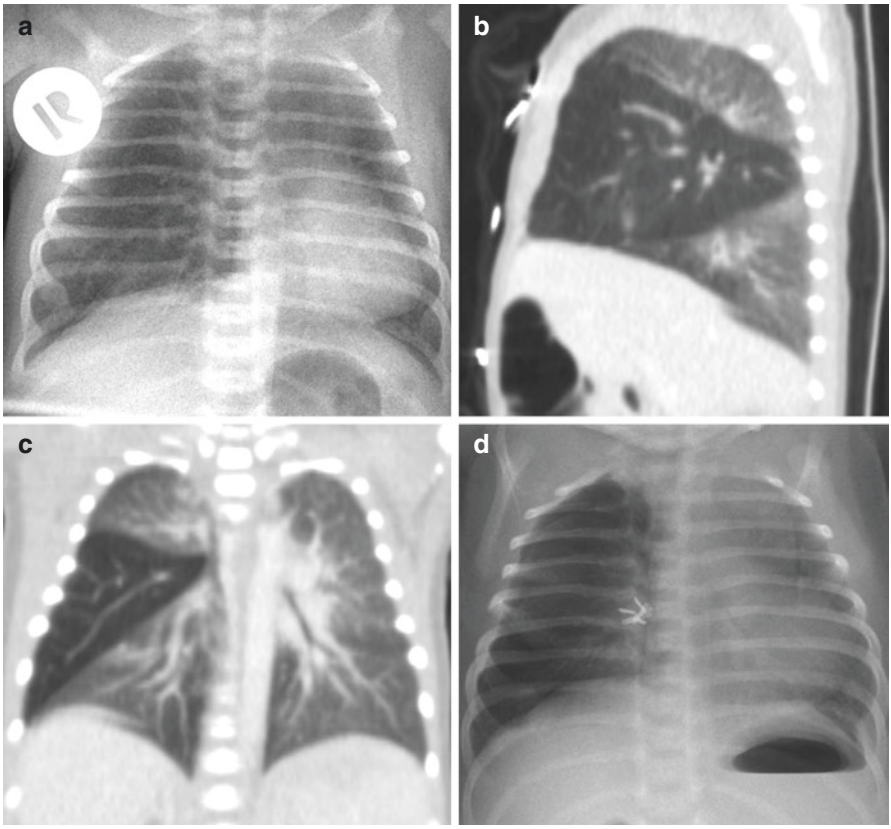


**Fig. 1.4** Congenital lobar emphysema in a 4-week-old newborn. Conventional X-ray with an overexpansion of the right lung (**a**). Corresponding CT scan with the pathology in the middle lobe (**b**, **c**). Postoperative X-ray after thoracoscopic middle lobe resection (**d**)

cases the atypical blood supply can lead to a high cardiac output failure. Under these circumstances an emergency treatment might become necessary (surgery or coiling). The venous drainage is systemic or through the portal vein.

In contrast, an intrapulmonary sequestration is usually refined to one single lung lobe (predominance of the left side). Communications with the oesophagus or stomach are possible in 10% of all cases. Bilateral cases and so-called hybrid lesions (combination of CPAM and intrapulmonary lung sequestration) are uncommon.

The venous drainage of the lung sequestration is mainly into the pulmonary vein but can be variable and from the diagnostic point of view a challenging aspect (Fig. 1.5) [20].

Clinical symptoms range from asymptomatic situations over recurrent infections with haemoptysis to emergency situations in cases of high cardiac output failure. In analogy to the CPAM, a foetal hydrops can occur in some cases resulting from the compression of the inferior cava vein compromising the cardiac output.

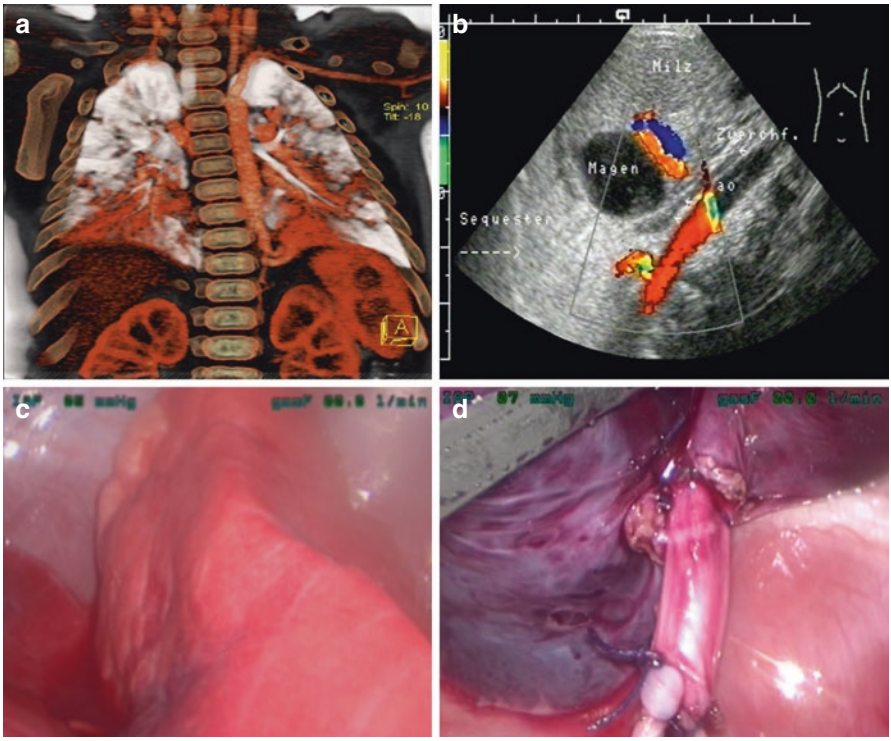


**Fig. 1.5** Extrapulmonary lung sequestration in a 6-month-old baby, diagnosed antenatally. CT scan (reconstruction) (**a**) and Doppler ultrasound (**b**) with an atypical arterial blood supply from the abdominal aorta. Intraoperative aspect before (**c**) and after (**d**) ligation of the vessels within the inferior pulmonary ligament

The prenatal diagnosis has an important significance in lung sequestration. The classical appearance on prenatal ultrasound is an echodense and homogeneous structure with an atypical blood supply detected on Doppler ultrasound. However, differentiation from CPAM, hybrid lesions or neuroblastoma can be challenging. Adzick et al. reported that 75% of antenatally diagnosed bronchopulmonary sequestrations can resolve spontaneously [21].

The postnatal diagnostic workup includes chest X-ray, Doppler ultrasound with identification of the blood supply, thoracic CT scan and in selected cases an angiography [22].

Lobectomy is the treatment of choice in intrapulmonary sequestrations, whereas simple resection (enucleation) is preferred in isolated extrapulmonary sequestrations. The thoracoscopic approach should be chosen in all cases of extrapulmonary sequestration. It is a safe and fast surgical procedure, which often makes a chest tube unnecessary. The feeding systemic arterial vessels are mostly located in the inferior pulmonary ligament and arise from the abdominal aorta. Therefore a careful dissection of the ligament is necessary through which a severe bleeding is prevented.

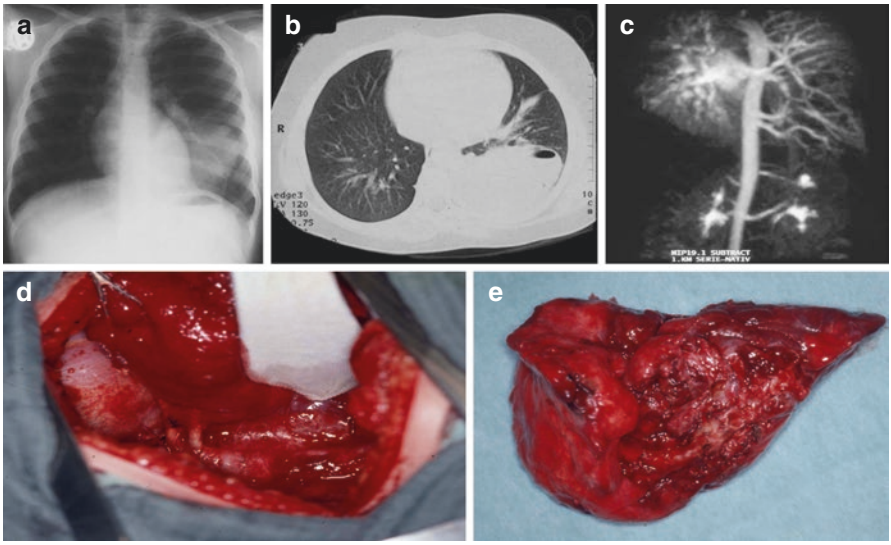


**Fig. 1.6** Intrapulmonary lung sequestration within the left lower lobe in a 5-year-old boy. Conventional chest X-ray (**a**). CT scan with compression of the healthy upper lobe (**b**). Vascular reconstruction showing an atypical blood supply with two arteries from the aorta (**c**). Intraoperative view on the two arteries within the inferior pulmonary ligament (**d**). Completely resected lower lobe (**e**)

Lobectomies can be performed as an open or thoracoscopic procedure. They are mainly depending on the expertise of the surgeon. In the literature there is a controversial discussion between promotion of lungs sparing procedures (wedge resection) and lobectomies (Fig. 1.6). Atypical or nonanatomic lung resections often lead to recurrent infections and should be avoided. The optimal time point for surgery is within the first 3–6 months of life [2, 17].

## 1.7 Bronchogenic Cyst

A bronchogenic cyst develops from an abnormal budding from the tracheobronchial tree. It is usually located along the trachea and bronchial structures. However, so-called ectopic location has been described within the lung parenchyma or in the tongue, the neck or below the diaphragm [23].

Histologically, the wall of the cysts is lined by ciliated columnar epithelium. Some cysts may contain cartilage, and they can have a communication with the tracheobronchial tree.

The clinical spectrum is wide and ranges from asymptomatic children over respiratory symptoms in the newborn period to complications such as infections including lung abscess, atelectasis or haemorrhage.

The diagnosis can be made antenatally using ultrasonography. In older children the pathology is possibly detected as an incidental finding during investigation for

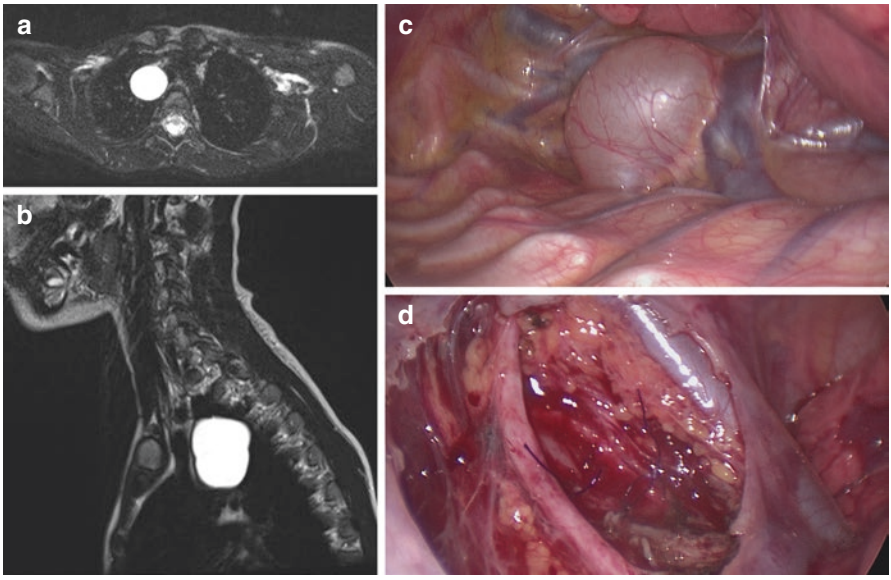


**Fig. 1.7** Bronchogenic cyst in a boy with recurrent pulmonary infection. MRI showing a cyst filled with fluid (**a**, **b**). Intraoperative aspect during thoracoscopy before (**c**) and after (**d**) resection. The main bronchus has been sutured because of a connection from the cyst to the bronchial tree

infections or on a chest X-ray. CT scan or MRI can confirm the diagnosis displaying a homogeneous mass with smooth margins.

Complete excision of the cysts is the treatment of choice (Fig. 1.7). Malignant transformations have been described. A lobectomy is necessary in cases of intrapulmonal cysts. The majority of affected patients can be managed using a thoracoscopic approach [2, 24].

## 1.8 Technical Tips and Tricks for Thoracic Surgery in Congenital Lung Malformation

### 1.8.1 Thoracoscopic Resection

One of the important aspects for a successful thoracoscopic lung resection is a good selection of the patients. Candidates for MI lung surgery should be in clinically stable conditions without additional major congenital malformations such as heart diseases. Previous pneumonia is a risk factor for conversion to open surgery [25, 26]. In small children MIS for thoracic pathologies is possibly limited because of the distension of the affected lobe or the rigidity of pulmonary structures (e.g. lobar emphysema). This results in a small working space within the chest. Also, mechanical ventilation during surgery can be relevantly hampered because of lung compression and increased intrathoracic pressure. Finally, the intraoperative carbon dioxide uptake might represent an anaesthesiological issue that needs further evaluation [27].

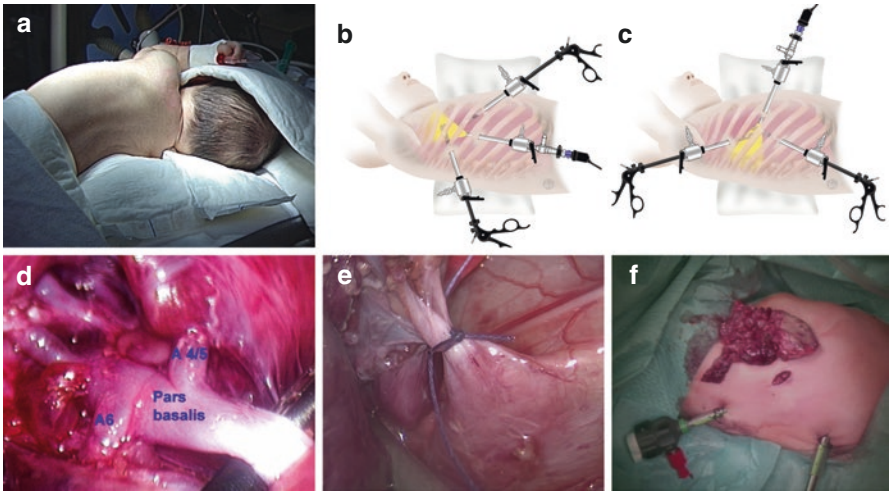


**Fig. 1.8** Technical aspects of thoracoscopic lung resection with demonstration of the position of the child (**a**). Trocar positioning for an upper lobe resection (**b**), and for a middle/lower lobe resection (**c**). Exploration of the pulmonary arteries within the fissura (**d**). Dissection and ligation of the pulmonary vein (**e**). Retrieval of a CPAM through a 2 cm trocar incision (**f**)

The procedures should be performed in a lateral decubitus position and if possible using single lung ventilation. Single-lung ventilation leads to a larger working space and can be realized in infants and children below 6 years of age by a main stem intubation or by blocking the ipsilateral bronchus using a Fogarty® catheter. In older children (above 25 kg), the anaesthesiologist can use a commercial double-lumen endotracheal tube [28]. In noninflammatory congenital lung malformations, destruction of the affected lobe with bipolar forceps or LigaSure® can improve the working space. This is nearly necessary in all cases of CPAM or CLE [29, 30].

For the surgical procedures 3 or 4 ports are necessary. Positioning of the trocars depends on the procedure and is different for the lower/middle and upper lobe resections (Fig. 1.8). However, different options for the trocar positions have been suggested. Finally, trocar positions depend on the personal experience of the surgeon and the access to the anatomical structure within the lobar fissure from anterior or posterior. Initially, the chest should be insufflated only with a low pressure in order to induce a collapse of the lung and to allow adaptation of the child. The initial pressure should not exceed 3 mmHg (flow 1.5 L/min) and should then slowly be raised to 5–6 mmHg. Dissection of the anatomical structures should be performed with the monopolar hook. This device gives a comparatively good tactile feedback to the surgeon. It allows an accurate visualization of the border between the different anatomical structures and sufficiently seals the vessels located around the bronchus wall or feeding the lymph nodes. However, other surgeons strictly promote LigaSure® for dissection.

In contrast to the open approach, the chronological order of dissection of anatomical structures is management of the lung arteries, then bronchus and finally pulmonary veins.

For the *upper lobe resections*, a 5 mm camera port should preferably be placed in the mid-axillary line. The two working trocars should be inserted in the posterior and anterior axillary line cranially to the camera port. After identification of the interlobar fissure, the segmental artery A2 has to be clipped or sealed. In the next step, A1 and A3 have to be identified. This can be difficult because of the overlying pulmonary veins V1–3, which must be divided beforehand. The preservation of V4 and V5 is mandatory to protect the venous drainage from the middle lobe or lingula. After this step the main bronchus and the segmental bronchus B1–3 are identified. The transection of the bronchus can be realized in infants with clips or suturing in older children with a meanwhile available 5 mm stapler or 10 mm stapler device. The separation of the lobes is facilitated using the LigaSure® [31].

For the *lower/middle lobe resections*, the camera port should be positioned in the anterior axillary line. The working ports are then located cranially and caudally from the camera trocar in the mid-axillary line. The first step is the dissection of the oblique fissure with identification of the pars basalis including the arteries A6, A4/5 and A2. After clipping or sealing the feeding arteries, identification of the lower bronchus with the branches B6, B4/5 and B7–10 is possible. The bronchus management should be realized in the same fashion as described above. An intraoperative bronchoscopy can be helpful to identify all these structures, especially in cases of anatomical variations. There exist several classical variations in the segmental arteries A4 and A5 [32]. However, the key for a successful thoracoscopic lung resection is the consequent dissection and identification of all anatomical structures, which allows the unambiguous assignment of vessels and bronchi to the specific lobes [33]. The final step is the dissection of the inferior pulmonary ligament with dissection of the lower branches of the pulmonary vein from V4/5. A transthoracic traction suture through the lower lobe allows an excellent exploration of the inferior pulmonary vein, and a safe ligation of this vein is possible (Fig. 1.8).

The removal of the resected lung specimen is usually possible through the extension of a port incision (2–3 cm). Certainly, a destruction of the resected lobe helps retrieving the specimen. This procedure has no negative impact for the histological investigation.

Minimally invasive lung segmentectomies have been described by several authors being applicable for segment 6, lingula segments and upper lobe segments. The thoracoscopic segmentectomy is a challenging procedure with higher complication rates compared to lobectomies [34]. The border between affected segments and healthy lung tissue is identifiable after dissection of the segmental bronchus following the ventilation of the lower lobe [25].

## 1.9 Muscle-Sparing Thoracotomy

Whenever possible a thoracotomy should be performed as muscle-sparing posterolateral procedure. Historically, the classical posterolateral approach has been the gold standard as access to the thoracic cavity. However, this is one of the most painful surgical incisions. The muscle-sparing thoracotomy (MST) means less acute and

chronic pain, a better function of lung and shoulder, faster recovery and superior cosmetic results [35]. MST is realized performing a skin incision of 5–10 cm length in line with the fourth or fifth intercostal space. The latissimus dorsi muscle and the trapezius muscle are exposed, and the triangle fascia is incised along the posterior border of the latissimus; the serratus fascia is incised in the same way. A small retractor is used to spread the ribs, while a second retractor is placed at a right angle to retract the latissimus anteriorly and the paraspinal muscles posteriorly. Generally, the incision through the fifth intercostal space is the optimal approach for an excellent visualization of nearly all congenital anomalies. In cases of intrapulmonary lung sequestration on the left lower lobe, the sixth intercostal space may permit a better overview and handling of the anomalous vessels. Management of the malformation starts with the dissection of lung arteries, followed by ligation of the pulmonary vein. Now the lung lobe is sufficiently mobile and the bronchial tree can easily be managed. Generally, surgeons should carefully close the bronchus without narrowing the neighbouring airways. This can be realized with a separate surgical supply of the subsegment bronchus (e.g. B6 and B7–10 on the lower lobe resection to prevent a stenosis on the remnant B4/5) [36].

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