

# Pediatric minimal invasive surgery-thoracoscopic lobectomy

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**Abstract:** Although the development of minimally invasive surgery in children initially lagged behind those in adults, we have now seen massive and significant catch up over the past 10 years. For thoracic diseases, thoracoscopy is the norm for many advanced centres in the world. In this review, we describe the evolution of thoracoscopic lobectomy in children.

Keywords: Video-assisted thoracoscopic surgery (VATS); thoracoscopy; lobectomy

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# Introduction

With the widespread use of minimal invasive surgery (MIS) in adult population, this surgical approach has become increasingly influential in the more challenging pediatric population (1). The thorax, being a well-known dangerous region to most, was the last area to be conquered by MIS pediatric surgeons. MIS thoracic surgery, what is now better known as thoracoscopic surgery, is regarded by many pediatric surgeons as the holy-grail in MIS training. In this article, we have focused on thoracoscopic lobectomy, which takes up a significant proportion of thoracic surgery in current practice.

### **Early days: the pioneers**

In 1910 Hans Christian Jacobaeus, a Swedish physician, first developed the concept of thoracoscopy. As the very first thoracoscopic procedure that was performed a century ago, what he did was only to insert a cystoscope into the thorax for diagnosing pleural adhesion in tuberculosis, which would be considered as a minor procedure using today's standard. Subsequently, the pioneers who put the technique into pediatric use were Rodgers and Talbert who performed a diagnostic thoracoscopy in 1976 (2). With time and experience, Rothenberg and other pioneers later managed to perform more complex thoracic surgery, advancing from lung biopsy, to decortication of empyema and subsequently to the challenges of lobectomy and even repair of oesophageal atresia in newborn (3). Thoracoscopic lobectomy has now become the standard approach in many advanced MIS centres and is becoming more popular worldwide (4-8).

# Anaesthesia: the prerequisite in successful thoracoscopic lobectomy

Thoracoscopic lobectomy can never be performed successfully in a child without a good anaesthetic support. This is because of the very limited space in the thorax of children, single lung ventilation is necessary to provide sufficient space for thoracoscopic surgery with good exposure. However, unlike in adults, double lumen endotracheal tube is usually too large to be used in small children. Therefore, isolation of one lung is usually done with the insertion of an endobronchial blocker to the bronchus of the operating side, or alternatively directly inserting the endotracheal into the bronchus of the contralateral, non-operating, side. Both of these methods have been shown to produce single lung ventilation with

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satisfactory result (9).

Endobronchial blocker is a catheter containing a stylet with an inflatable balloon at the tip. This can be inserted through the central passage of the endotracheal tube or on the outside along the space between the endotracheal tube and the trachea, depending on the body size. Fiberoptic bronchoscopy is usually required to aid in the initial placement and position confirmation of the blocker. Bronchial occlusion is then achieved with inflation of the balloon. Although the principle sounds easy, blocker dislodgement can be encountered during positioning and also in operation. On the other hand, contralateral bronchial intubation is usually performed by advancing an uncuffed endotracheal tube over the fiberoptic bronchoscope. However, this method sometimes proves to be difficult in providing adequate seal of the bronchus, as uncuffed tube is usually used. In addition, suctioning of the lung on the operating side is not possible with this method. Nonetheless, whichever method to be chosen depends on patients' condition and the anaesthetic expertise.

# Indication for lobectomy

Currently the majority of lobectomy is performed in patients with congenital lung malformations, which include congenital pulmonary airway malformations (CPAM), bronchopulmonary sequestration, bronchogenic cyst and congenital lobar emphysema. One major reason for the increase in caseload is because of the more popular use of antenatal ultrasound in the recent decade (10). Indeed, CPAM is the commonest diagnosis of all these detected lesions and among all the lobectomy performed. The other main indication for lobectomy in children is for malignant conditions such as pleuropulmonary blastoma and rhabdomyosarcoma, but these are very rare conditions when compared to CPAM.

Although CPAM is the most common indication of lobectomy in children nowadays, its management is not without controversies. In the past when antenatal ultrasound had not been a common practice, most CPAM patients were born undiagnosed. Patients usually remained asymptomatic until they presented with recurrent chest infection during their infancy. Therefore clinicians used to regard CPAM as a rare and self-limiting condition, with conservative management being offered as the mainstream (11). With more experience, we have now realized that the condition has much been underestimated. The traditional figure usually quoted in the textbooks for the incidence of CPAM to be between 1 in 11,000 and 1 in 35,000 births (12,13). But our recent study suggested a much higher incidence of 1 in 7,000 live births (14).

Furthermore, it is now recognized that the risk of CPAM to cause recurrent chest infection can be up to 30% (15,16). With increase in episodes of chest infection, the intrapleural adhesion will become much more intense and hence making subsequent surgery much more difficult and risky. The better understanding of CPAM pathology also provide evidence for early prophylactic lobectomy. The formal pathological classification of CPAM was first described by Stocker in 1977 (17). It had long been regarded as a hamartoma with distorted architecture of normal lung parenchyma. However, the risk and significance of the malignant potential of CPAM was supported by some previously published reports. The precursor of rhabdomyosarcoma or pleuropulmonary blastoma, which is the dysplastic striated muscle cells, can be found in 15% to 20% of resected specimens (18). Foci of bronchioloalveolar carcinoma was noted to present in large proportion of patients in another study (19). For many surgeons, the concept has thus to consider CPAM as a pre-malignant condition, with lobectomy considered as the gold standard to eliminate the risk of malignant change.

# Advantages of thoracoscopic lobectomy

Needless to say, better cosmetic outcome can be one of the most important reasons to drive our patients towards MIS. Most operation can now be performed with 3 and 5 mm ports, resulting in only tiny, almost invisible scars. Other than the superficial advantage about wound size, what has attracted surgeons to perform thoracoscopic operation is another equally important factor, the wound tension. As wound tension is well proven to be directly proportional to the square of wound length, an incision with half the length will only experience a quarter of the tension (20). This concept has huge implication in the practice of MIS, as most of the postoperative wound complication is associated with wound tension per se. Much reduced tension means the risk of wound dehiscence and infection is greatly diminished, but it also means that patient will experience significantly less postoperative pain. The reduced pain eventually allowed patient to have faster mobilization and recovery, therefore other hospitalization related complication can be reduced as well. In the past patients who underwent thoracotomy required longer analgesic usage and vigorous chest physiotherapy before they can be fully mobilized.

But now some centres have pushed to the extreme that they are performing minor thoracoscopic procedures on an outpatient basis (21). Shorter hospital stays and reduced complication all ultimately translate to greatly reduced total healthcare cost. This is currently the most recognized short-term advantage of thoracoscopic lobectomy (22).

In the past healthcare professionals always associated thoracotomy with some sort of rib cage deformity, be it scoliosis, rib fusion or even shoulder girdle weakness, which happened in 30% of patients (23,24). This is because during thoracotomy, it is inevitable to divide certain amount of muscle such as intercostal muscle, even for a so-called muscle sparing thoracotomy. The problem may not be that obvious for adults who have completed their growth and development. But for children, a slight difference in tensile strength over the two sides of thoracic cavity because of a surgical wound can easily be exaggerated into a severe scoliosis when the chest double in length and size. In the contrary, major thoracoscopic lobectomy series do not find this a problem (3,4,6-8,25-27).

Chest wall deformity can compromise pulmonary function and not just disfigurement. 10% of patients developed restrictive pattern impairment even without obvious chest wall deformity (28,29). Our data has shown better long-term pulmonary function after thoracoscopic lobectomy when compared to the thoracotomy group (30). Indeed the result of pulmonary function test for MIS group of patients showed no difference when compared to agematched healthy individuals (31).

With the improvement of technology, high definition image can now be provided by different types of telescope. When compared to conventional bare-eye view, thoracoscopy can magnify the smallest structures to be dissected. Bronchus and blood vessels can be visualized more clearly and dissected with better precision. On the other end, surgical exposure in thoracotomy depends a lot on retraction and the experience of the assistants. With thoracoscopy the whole thorax including the deep corners can be clearly seen, so an evaluation of the whole condition is made possible.

# Limitations

Having adequate space has been a long-standing problem in pediatric MIS surgery, and thoracoscopic lobectomy is no exception. Unlike the abdomen, the rib cage is like a rigid box being restricted by the skeleton, so the space can only be provided by collapsing the lung with single lung ventilation as aforementioned. But what makes it even more difficult is due to the body size of pediatric patients. Any child with half the length of an adult only have one-eighth the space inside the thorax. This is not hard to imagine the space limitation in an infant, which is the most common age group for thoracoscopic lobectomy. Surgeons have to adapt to work in such a confined space before lobectomy can be safely and smoothly performed. Another reason for such a long and steep learning curve is because of the large variation in body size of patients. As pediatric surgeons have to operate from neonates to adolescents, another way of adaptation to different ergonomic positions and sense of depth have to be developed you can confidently claim that the technique has been completely mastered.

Limitation of instrumentation is another problem that need to be faced by pediatric surgeon. As the intrathoracic space is so small, many instruments are too big to be used in infants. Stapling devices, which are used extensively in adult thoracic surgery, are just too large to be used in children, as they require insertion of much larger ports and space (32). New energy devices which allow sealing of major vessels up to 7 mm have partially solved the problem. These are invaluable tools when incomplete fissures were encountered (33). There is a new 5 mm stapling device joining the market which should help (34).

# Conclusions

Thoracoscopic lobectomy has come its long way to become a well-established surgical technique in pediatric patients. Its benefits and safety profile have been verified with various studies. With increasing frequency of antenatally detected lung lesions, this procedure will certainly become more common. Learning curve and other difficulties remained challenging to pediatric surgeons.

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