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Experiences and Challenges of Video Assisted Thoracic Surgery (VATS) in Infants and Children: From Maximal to Minimal Access

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Healthcare Senaka William Bibile was born to a family in Uva-Wellassa on the 13th of February 1920. He was the eldest of the six children of Sylvia Augusta Jayawardane (daughter of Mudaliyar Harry Jayawardane of Kataluwa, Galle) and Charles William Bibile.

Senaka received his primary and secondary education at Trinity College, Kandy.

After successfully completing his school education, he entered the Faculty of Medicine, University of Ceylon, and graduated in 1945 with first-class honours.

After completing his internship at the General Hospital, Colombo, he was appointed as the medical officer of Health (MOH) Bingiriya, in Kurunegala district. After winning a scholarship, Senaka proceeded to the University of Edinburgh, Scotland, UK, to continue his academic career. Obtaining a Ph.D. in Pharmacology, Senaka returned to his motherland in 1951 and resumed his lectureship, becoming the first professor and head of the Department of Pharmacology in 1954.

Prof Senaka Bibile was chosen as the Founder Dean of the newly formed Faculty of Medicine at the Peradeniya University in 1967.

In 1970, the government entrusted Dr. S. A. Wickramasinghe and Prof. Senaka Bibile with the task of formulating a state pharmaceutical policy. This report was the turning point in establishing the State Pharmaceutical Corporation (SPC) in September 1971. In 1977, he was entrusted with the responsibility of working on the pharmaceutical policies of 13 developing countries.

On an official visit to Georgetown, Guyana, he suddenly became ill, and on September 29, 1977, Professor Senaka Bibile passed away.

In 1993, Dr. Hart, the pioneer of the Australian Pharmaceutical Policy, remarked;

"Sri Lanka is the summit of a mountain, Senaka Bibile is a glittering lamp on that top. By the glow of that light, we, the other countries, formulated the drugs policies".

History and evolution of paediatric thoracoscopic surgery

The history of thoracoscopy goes back to 1865 when Francis Richard Cruise looked into the thoracic cavity in an 11-year-old girl with a cystoscope. He was a 19th-century Irish surgeon and urologist best known for inventing an endoscope and using it successfully in surgery in 1865. It was not until 1910 that thoracoscopic interventions were largely practised, but with the revolutionary work done by Hans Cristian Jacobaeus, when he treated patients with tuberculosis (TB) with so-called surgical collapse therapy. It soon became a widely practised intervention for the treatment of TB.

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Nearly 4 decades down the line, a revolutionary milestone was laid with the invention of the first anti-TB drug, Streptomycin, in the 1950s. Since then, surgical collapse therapy has become largely obsolete. But in the 1970s, thoracoscopy was again performed by medical pulmonologists for diagnostic purposes.

Surgical thoracoscopy made a landmark turning point after the first laparoscopic cholecystectomy performed by Dr Erich Muhe in 1985. With the availability of advanced instrumentation and innovative surgical techniques, advanced thoracoscopic interventions have been performed since then.

The paediatric surgeon's role in thoracoscopy started with Dr Brad Rodgers, who was a paediatric surgeon in the University of Virginia Children's Hospital, who performed VATS in children as early as the 1970s, and published the first series of thoracoscopic decortication in paediatric empyema in 1993.

In the current era, Dr Steven Rothenberg has made a big impact on thoracoscopic surgery, introducing novel surgical techniques and procedures. He is the chief of paediatric surgery at Rocky Mountain Hospital for Children. He has pioneered many thoracoscopic interventions on children over the last 3 decades, including thoracoscopic lung lobectomies and PDA Ligations. He pioneered in developing miniature instruments in paediatric laparoscopic surgery.

Technology in Minimal Access Surgery

Technology in minimal access plays a pivotal role in accomplishing a safe laparoscopic procedure in children. Even though we are not exhaustive with optimum technological advancements in our set-up, we could procure miniature 3mm instruments and telescopes for the use of neonatal laparoscopic surgery. Technological advancements in anaesthesia have made a big impact, especially on neonatal laparoscopic and thoracoscopic surgery. This was well exemplified in thoracoscopic surgery when we could deliver precise tidal volumes in neonates and small children in our setup, with the availability of newer generation anaesthetic machines.

Landmarks

The following landmarks in paediatric thoracoscopic surgery signify the evolution of advanced thoracic interventions in children. The first paediatric lung lobectomy was performed in the 94-95 period by Steve Rothenberg, followed by more complicated tracheo-oesophageal fistula repairs in the years to come. With more experience and availability of advanced technology, all these procedures were standardised by many paediatric surgeons all over the world.

Transition from open thoracotomy to thoracoscopy at SBSCH

There are many congenital and acquired surgical conditions of the thorax in children that were intervened on by open surgical techniques. Other than frequently performed tracheo-oesophageal fistula repairs, we had to intervene for certain congenital lung malformations like congenital lobar emphysema and cystic lung disease by open surgical techniques. Additionally, we had to perform more complex interventions like pneumonectomy and lung lobectomies for neoplastic conditions. All these open interventions in children flourished in many ways before embarking on thoracoscopic interventions, especially given anaesthetic and critical care aspects.

In one of those instances, we had to perform a taxing task of removing a giant thoracic ganglioneuroma filling the whole hemithorax in a 3-year-old girl. And not to mention the labour-intensive post-operative period for the critical care, which was optimally handled by the anaesthesia team, leading to full recovery of the child.

Open thoracotomy approaches

Out of all the open surgical techniques, as paediatric surgeons, we perform postero-lateral thoracotomy for most of the paediatric thoracic conditions. Due to the morbidity of muscle muscle-cutting thoracotomy approach in a child with a developing thorax, we have changed our practice to perform muscle-sparing thoracotomy whenever

possible, even for commonly performed neonatal oesophageal atresia repairs.

However, even with muscle sparing approaches, the musculoskeletal deformity accounts for up to 20-30% risk of permanent disability in children compared to a lesser extent in adults due to the developing nature of the paediatric structure.

Disadvantages

Thoracoscopic surgery in children emerged as a comprehensive alternative to the open surgery counterpart, which has obviated the undesirable complications. Despite the well-described advantages of minimal access surgery, there are specific disadvantages pertaining to certain operative interventions.

These advantages and disadvantages have been studied extensively in many studies and evaluations. One of the most notable disadvantages of paediatric thoracoscopy is a significant difference in operative time, which we also experienced in our setup.

Directly related to operative time, there are 4 other limitations in thoracoscopic surgery in children. These are Hypothermia, effects of lateral decubitous position, one lung ventilation and CO2 insufflation. These could create many hemodynamic and acid-base disturbances in children, particularly in neonates, during and after the intervention.

It's of utmost importance to collaborate with the anaesthetist during the procedure to prevent any detrimental effects, especially during prolonged interventions.

Advantages

Despite the aforementioned disadvantages, one of the most striking advantages in thoracoscopic surgery is excellent cosmetic appearance. Additionally, it has been shown to improve pulmonary mechanics and to prevent the detrimental metabolic response of the thoracotomy approach in children.

Indications for thoracoscopic surgery in children

Over the decades, the indications for paediatric VATS have exponentially expanded. Out of these many indications, there are well-established indications which has stood the test of time, and the interventions are standardised with good post-operative outcomes. Lung biopsy, lung lobectomy, cystic lesions like duplication cysts, empyemas needing decortications, diaphragmatic hernia and eventration, PDA ligation, thoracic duct ligation, oesophageal atresia repair, and mediastinal masses requiring resection are all accepted as definitive indications for thoracoscopic interventions in children.

Spectrum of thoracoscopic procedures in SBSCH

Since the inception of thoracoscopic interventions at SBSCH Peradeniya, we have performed nearly 60 advanced thoracoscopic procedures over the last 5 years. Most neonatal thoracoscopic procedures were done on babies with congenital diaphragmatic hernia and eventration. In addition, children with infective pathologies like empyemas, tumours, and cystic mediastinal masses and congenital cystic lesions of the lung were subjected to thoracoscopic interventions.

Table 1: Spectrum of thoracoscopic interventions at SBSCH – Peradeniya

Intervention	Number
Congenital Diaphragmatic Hernia repair	15
Congenital Diaphragmatic Eventration repair	9
Empyema – Decortication	13
Lung abscess drainage	3
Thoracic neuroblastoma resection	3
Neurofibroma resection	1
Ewing's sarcoma resection	1
Pleuro Pulmonary Blastoma resection	1
Thoracic cystic lesions	4
VATS Biopsy	5
Pleurodesis for Chylothorax – bilateral	1
Repair of H Type fistula – converted	1
Repair of esophageal atresia	1
Total	57

Challenges

At the outset, we carried out thoracoscopic procedures case by case, but progressing through different procedures consistently was an epic task due to the hurdle of the learning curve. Retrospectively, four factors significantly contributed to the difficult learning curve in our setup: smaller working fields, difficult hemostasis, lack of tactile feedback, and anaesthetic considerations.

The restricted working field is a difficult challenge in neonates, and we adjusted ourselves with a variety of technical modifications to ease out the procedure in neonates.

In children, due to the restricted working space, proper positioning contributed immensely to optimum port placement and ergonomical maneuvering of instruments. As a principle, we adopted 3 positions in all of our procedures depending on the pathology. The true lateral position was mostly adopted on neonates with congenital diaphragmatic hernia (CDH) and for lung lobectomies, but with the risk of contralateral lung compression.

For anterior mediastinal masses, a semi-lateral position was adopted, and for posterior mediastinal masses, semi semi-prone position was adopted.

According to our series, post-operative contralateral lung collapse was mostly seen with true lateral position, of which the risk is higher with prolonged duration of surgery.

Positioning and anaesthetic considerations

Except for a few cases, all our patients had endotracheal intubation, with preparation for manually controlled ventilation. This preparation was necessary at the beginning of the surgery once lung collapse was achieved, since it takes a variable time duration for the contralateral lung adaptation to occur.

We used 1l/min low-flow air insufflation with 4 mmHg low-pressure pneumothorax for lung collapse to increase the working space.

In addition, lung collapse could be achieved by pulmonary isolation, which is accomplished by bronchial blocker, a double lumen endotracheal (ET) tube, or main stem intubation.

But in children, bronchial blocker or double lumen ET tubes are technically very difficult to insert except for older children, but a main stem intubation is technically feasible even in young children. In our series, main stem intubation was accomplished in one child for a thoracic neuroblastoma resection and in another child for thymic biopsy, but in all other children, lung collapse was achieved by pneumothorax.

Collaboration and negotiation with the anaesthetic team are of overriding importance in thoracoscopic surgery to prevent barotrauma in children during the procedure.

This was facilitated by keeping higher respiratory rates with smaller tidal volumes and low peak pressures.

In children, pneumothorax to achieve lung collapse during thoracoscopy is a universally well-established technique, with minimal hemodynamic and ventilatory disturbances to the child.

Personnel experience

I consider myself very fortunate to be inspired by a few teachers who were pioneers in the field of surgery. When I was the first-year surgical registrar under Prof Galketiya, out of the multifaceted surgical caliber he had, minimal access surgery inspired many of us, having inculcated a dream of becoming well-versed with minimal access surgery.

During the same period, he performed the first-ever thoracoscopic esophagectomy in SL, which is a landmark in the history of minimal access surgery. That was the first description of thoracoscopic surgery in SL, and later, he performed many advanced thoracoscopic interventions, which have contributed immensely to the literature on minimal access surgery.

It's with great gratitude that I recall the guidance and inspiration from two eminent paediatric surgeons, Prof Ranjan Dias and Prof Malik Samarasinghe, during my local training in paediatric surgery at Lady Ridgeway Hospital.

In 2012, I started the first half of my overseas training in Waikato Hospital, NZ. Mrs Udaya Samarakkody and Mr Cama were the two paediatric surgeons involved in thoracoscopic interventions in Waikato Hospital. This was the first ever hands-on experience I had with VATS in children when they performed decortication for empyema. In NZ, there was a very high incidence of empyema during the Winter, for which they performed VATS and thrombolytic treatment. And also, it was a fascinating experience to get exposure on neonatal PDA ligations in NZ.

For the second half of my overseas training, I got the opportunity to work in Great Ormond Street Hospital for Children, London, UK, under two eminent world authorities, Mr Edward Kiely and Mr Joe Curry. Mr Kiely innovated the subadventitial vascular dissection technique in Neuroblastoma in children, which is widely practised today, and they performed VATS for paediatric thoracic neurogenic tumours, which I was fortunate enough to get direct exposure during my stay.

Inception of Thoracoscopic Surgery at SBSCH Peradeniya

In 2020, we started doing thoracoscopic interventions at SBSCH Peradeniya. Initially, it was isolated index cases, but later on, we developed into a program with increasing experience in surgical and anaesthetic techniques. Not to mention the invaluable support extended by consultant paediatric surgeons, Dr KSU Kiriwattuduwa and Dr P Jayawardena since I started work in SBSCH.

VATS Decortication for Paediatric Empyema

At the outset, we started doing thoracoscopic decortications for empyema, which is a serious complication of pneumonia in children, expected to affect 1 in 150 children. Its mortality is recorded at a staggering value of up to 24%.

Clinically, there are 3 stages of empyema. Stage one is called parapneumonic stage, which is medically treatable with antibiotics and drainage, but when it progresses to stage 2, the pleural cavity becomes septated with fibrinous material, which loculates the infection, rendering it beyond salvage only by drainage. This is the stage at which children develop critical illness with unrelenting sepsis and respiratory distress.

If not adequately treated by either thrombolysis or VATS, it progresses to the organising stage, which causes trapped lung and its consequences.

Thrombolytic treatment with Recombinant TPA is a well-established treatment modality for paediatric empyema. In our setting, we have used it depending on the availability of the drug, but on a few occasions, we have reverted back to VATS due to failure of resolution.

Across many randomised studies, it has been found to have up to 16% failure of resolution of empyema with thrombolysis alone.

In the organising stage of empyema, we have used thrombolysis as a salvage therapy, in which case VATS has a higher risk of lung parenchymal injury.

In contrast, thoracoscopic decortication is very effective when it's performed at the fibrinopurulent stage. In most occasions, these children are septic, with respiratory distress and not amenable to usual high-grade antibiotic therapy.

During VATS, upon entry to the thoracic cavity, the visualisation is very poor due to obliterated pleural space, but gradually it's cleared and the fibrinous material is taken out, which forms a peel around the lung. The objective of the VATS is to free the lung for adequate expansion, which helps to improve the parenchymal infection. We reported the outcome of decortications initially in 2021 and subsequently as a comprehensive review.

Outcome of decortication

13 children underwent VATS decortication, out of which 2 had pre-operative TPA therapy.

Three were in the organising stage of empyema who had suboptimal outcomes with VATS, and it took an extended period for them to recover following the procedure.

Out of 13 children, five were in critical condition on the ventilator prior to VATS, but all of them were extubated within 3 days following the procedure.

Despite being in a critical condition prior to VATS, with a high risk of anaesthesia, being subjected to high-risk intervention, it's with great gratitude that I recall our anaesthesia team who accepted the challenge of anaesthetising these children, which has saved their lives.

This was well exemplified in this particular instance, where an 8-month-old baby presented with severe necrotising pneumonia complicated with empyema. At the initial operation, there were necrotic areas in the parenchyma. Unusually, he developed severe recurrent empyema with persistent left lung collapse.

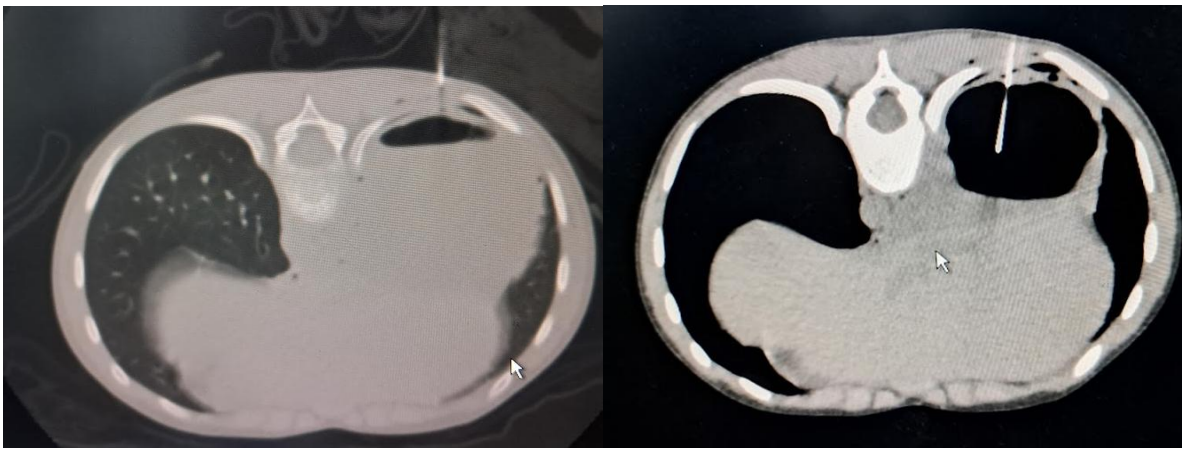
We had to perform VATS 3 times altogether to control the sepsis, and he spent nearly 3 months in the Intensive Care Unit. In the meantime, it was noted that he had large mediastinal lymph node masses and was finally diagnosed to have T-cell lymphoblastic leukaemia. He got completely recovered with chemotherapy.

Lung abscess in children is another complicated entity that is not commonly treated by VATS. The primary modality of treatment is image-guided aspiration of the lung abscess.

All these children developed persistent air leak following VATS, which settled without additional intervention.

Considering the complications of VATS for infective pathologies, one child had bilateral Acinetobacter Pneumonia and had to be ventilated for an extended period following VATS.

One child developed a persistent air leak after VATS for empyema, which settled with intercostal drainage. 2 Children with organising empyema had suboptimal outcomes.



Figue 1 : CT chest of a 3-year-old child who presented with an infected congenital pulmonary airway malformation, which progressed to a large lung abscess (Left). He had CT-guided aspiration, which completely settled the infection (Right)

Three children who had failed guided aspiration had thoracoscopic drainage. One had a large fungal abscess, and the other two had pyogenic abscesses. The child with a fungal infection was not amenable to guided drainage due to the presence of thick pus with debris, so we performed thoracoscopic drainage followed by antifungal treatment, which settled the sepsis completely.

Table 2 : Thoracoscopic decortication for Empyema

Patient No	Age in Yrs.	Stage	Pre op TPA therapy	Post op TPA therapy
1	3	Fibrinopurulent	Given	Given
2	2	Fibrinopurulent	Given	Given
3	3 8/12	Fibrinopurulent	Not given	Given
4	1	Early organizing	Not given	Not given
5	2 5/12	Fibrinopurulent	Not given	Not given
6	6	Fibrinopurulent	Not given	Given
7	4	Organising	Not given	Not given
8	1 6/12	Fibrinopurulent	Not given	Not given
9	6	Fibrinopurulent	Not given	Not given
10	4	Organizing	Not given	Given
11	3 2/12	Fibrinopurulent	Not given	Not given
12	7	Fibrinopurulent	Not given	Not given
13	8/12	Fibrinopurulent	Not given	Given

Congenital Diaphragmatic Hernia and Eventration

Congenital Diaphragmatic Hernia (CDH) is a life-threatening congenital anomaly, estimated to occur between 1 in 2600 - 3700.

At present, the surgical intervention is the only curative treatment for CDH, but only with optimum critical care management following the surgery. We had been performing open CDH repair for decades, but for the last 3 decades, there has been an exponential development and interest in

performing thoracoscopic repair, even though there's no consensus as to the gold standard.

In contrast to diaphragmatic hernia, congenital eventration exhibits less severe hemodynamic consequences. The standard open repair is approached either abdominally or through the thorax.

For post-neonatal eventration repairs, initially, we performed laparoscopic repair, but due to the technical complexity of the repair, we shifted to the thoracoscopic technique for all of the congenital eventrations. The first reported thoracoscopic CDH repair came up in 1995 in an adult patient who had a delayed diagnosis of CDH. In 1996, the first paediatric thoracoscopic repair was undertaken in the Netherlands, followed by neonatal repair being undertaken in many centres worldwide.

Depending on the severity of anatomical defect, and the severity of hemodynamic parameters and pulmonary hypertension, we developed our criteria for selection of neonates for thoracoscopic repair.

Anaesthetic preparation is crucial in neonatal laparoscopic interventions, primarily the IV access and prevention of hypothermia.

These babies are mostly ventilated at birth, but provided they are stable in terms of hemodynamic and ventilatory parameters, we proceeded with surgery.

In our setup, prior to repair, we either do ultrasound-guided central line insertion or, if the baby is premature or has low birth weight, perform PICC line insertion.

With increasing experience in neonatal thoracoscopic surgery, we standardised our surgical technique and approach in thoracoscopic diaphragmatic hernia repair. On entry to the thoracic cavity, we could see the bowel entirely occupying the cavity, and with gradual reduction, more space will be available for the maneuvering of instruments.

One of the most crucial steps is reducing the spleen, which should be done with utmost care to avoid catastrophic bleeding. We always keep the baby fully muscle relaxed during this stage to facilitate the bowel occupying the abdominal compartment.

Once all contents are reduced, the lower lip of the diaphragm is mobilised and the repair is

accomplished either primarily or with a mesh repair.

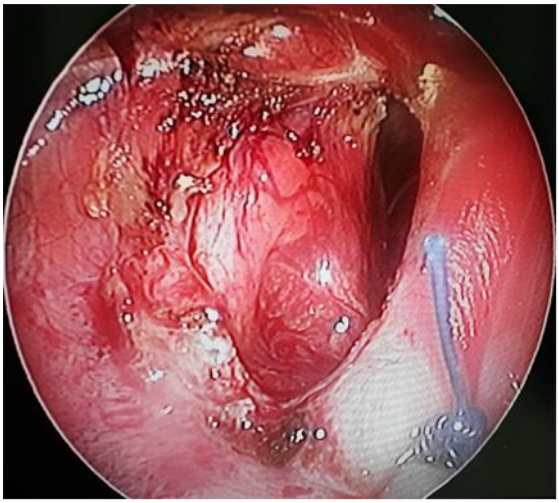


Figure 2 : Intrathoracic view of the diaphragmatic defect

developed recurrences. Four babies with CDH had conversion to open surgery due to poor tolerance of pneumothorax and technical difficulty in content reduction.

Out of all challenges, Postoperative recurrence is a major concern following thoracoscopic diaphragmatic hernia repair, primarily in babies who had patch repair. This is thought to be due to the long learning curve, limited effective space and visibility, and inappropriate suture tension during repair.

The second challenge of serious concern is intraoperative hypercapnia, which could lead to metabolic acidosis during or after the operation. This has been extensively investigated in many studies and confirmed to have a direct impact on the postoperative outcome of the baby. In our series, we studied the end tidal CO2 concentration,

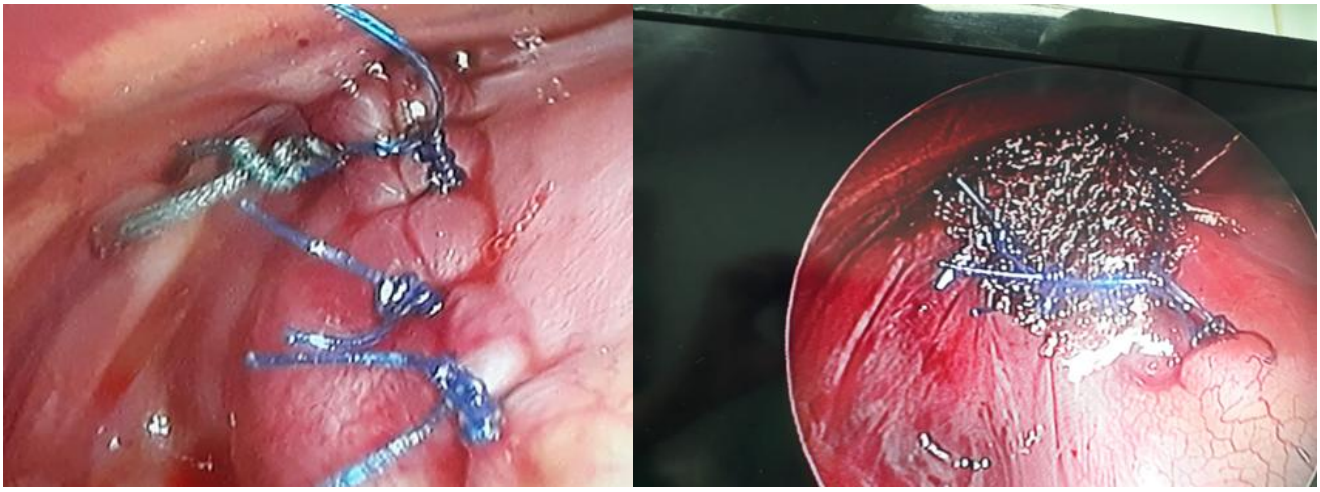


Figure 3: Primary repair of the diaphragmatic defect (Left). Patch repair of the defect (Right)

In our series, we performed primary repair only in one baby, and all others had patch repair. Even larger defects can be repaired, like in this instance, provided the abdominal domain allows content reduction with full relaxation. For all the repairs, we have withheld the pneumothorax once the contents are reduced back to the peritoneal cavity. There was a total of 15 babies who underwent thoracoscopic repair of neonatal CDH and eventration without conversion. One baby following CDH repair died due to sepsis and multiorgan failure. One baby had a recurrence of the hernia at the age of 1 year, which was repaired.

In our series, neonatal thoracoscopic eventration repair was done in 4 babies, but out of that, 3

which is a crude indicator of hypercapnia, and the mean value was at an acceptable level of 34.6, with a range of 26.8 up to 38.14. None of the babies had acidosis in the immediate post op gas analysis.

One strategy we used during the repair was to withdraw the CO2 insufflation once the contents were reduced. We used the same approach when we performed the post-neonatal eventration repair thoracoscopically.

The third challenge we identified is the operative time, which is significantly higher according to many other studies, primarily during the learning curve. The first thoracoscopic repair in our series took 330 minutes of operative time, but to our surprise, the baby tolerated the surgery

remarkably well, without major complications postoperatively. Because it has direct implications on hypothermia and acidosis, it's of utmost importance to prevent hypothermia during thoracoscopic CDH repair.

Congenital diaphragmatic eventration could present either during the neonatal period or post-neonatally. As we have observed with babies who had eventration repair during the neonatal period, the recurrence was unacceptably high. But post-neonatal repair has shown promising results in our setting. Initially, for those children who presented after the neonatal period, we performed laparoscopic repair, but it was a technically difficult operation due to tenting of the diaphragm with pneumoperitoneum.

To counteract this difficulty, we switched to thoracoscopic repair later on, which is a more complaisant operation with excellent results. We did not perform laparoscopic eventration repair in neonates due to restricted abdominal domain, but it was done on children, preferably more than 10kg. Even though there were no recurrences with this approach, we had to spend an unacceptably long duration for repair. 7 children had laparoscopic eventration repair, and out of those, 5 had right eventration and 2 had left eventration.

There's a striking difference when eventration is repaired thoracoscopically because the pneumothorax causes a somewhat push-down effect on the diaphragm. Even though there's restricted space initially, once the diaphragm is pushed down by initial sutures, we could progress without pneumothorax due to the advantage of the space.

Because of this technical advantage, we could even repair severe eventration successfully with this approach. We evaluated the outcome of a series of thoracoscopic diaphragmatic hernia and eventration repairs in a retrospective analysis.

Intrathoracic solid lesions.

Thoracoscopy is an extremely useful adjunct in intrathoracic tumours in children, for diagnosis as well as for surgical treatment. Even though it's technically demanding when it's located in a restricted area, it gives excellent access and visualisation in a panoramic view.

In our series, we primarily used diagnostic thoracoscopy for mediastinal lymph node biopsy and thymic biopsy. Mediastinal neurogenic tumours account for the majority of solid tumours in the thorax, which were resected primarily or after neoadjuvant chemotherapy.

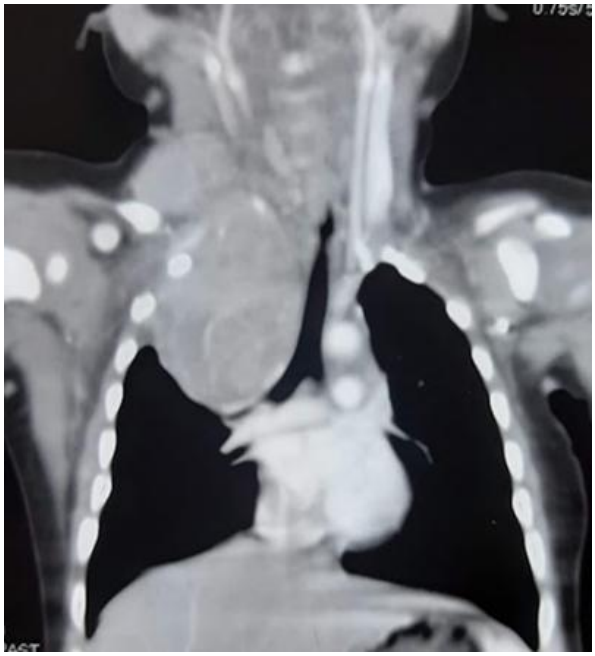


Figure 4: An 18-month-old baby who had a large neuroblastoma in the right upper zone, which was resected thoracoscopically after being downstaged by chemotherapy

In the technical aspect, positioning is crucial in tumour resections to have a convenient triangulation of instruments and the optical port. We used either modified supine or prone position, depending on the location of the tumour, with lung collapse achieved by pneumothorax. Due to the highly vascular nature of these tumours, especially after chemotherapy, we used specific energy devices for hemostatic control.

Ewing's Sarcoma of the chest wall - A 2-year-old child came with abdominal distension and was found to have a large tumour of the right thorax, initially thought to be a liver lesion. Biopsy of this tumour revealed an Ewing's Sarcoma of the thoracic wall. He had a remarkable response to chemotherapy, and we did a VATS-guided

resection of the lesion and total rib resection as the definitive surgical intervention.

During thoracoscopy, we found extensive lung adhesions to the tumour, which was separated and the limits of the tumour were marked under the guidance of thoracoscopy. With the support of the orthopaedic team, we did a total rib resection, and he made a remarkable recovery.

Out of all extracranial solid tumours, neuroblastoma is the commonest malignancy in children, and out of that, thoracic neuroblastoma accounts for 20% of all tumours. Overall, it has a very good prognosis due to the biologically less aggressive nature of the tumour.

Cervico-thoracic tumours constitute a very specific lesion due to very poor accessibility by open surgical intervention. Even with open thoracotomy, these tumours are beyond easy accessibility due to their apical location and continuity with the neck.

We resected a large cervico-thoracic neurofibroma of a 7-year-old boy who was diagnosed to have Neurofibromatosis. First, he had complete thoracoscopic mobilisation of the thoracic segment of the tumour and the cervical segment was subsequently mobilised, which enabled retrieval of the tumour through the root of the neck, without a thoracotomy.

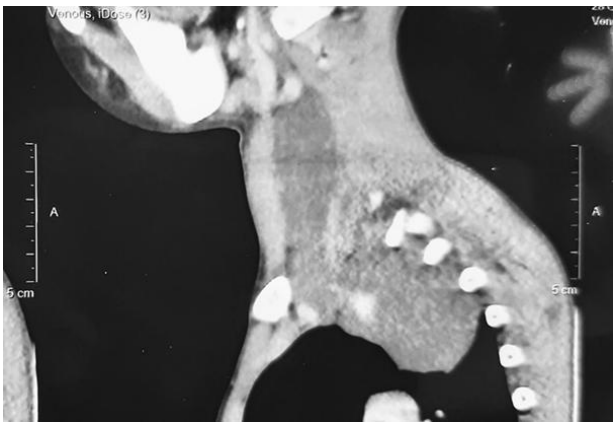


Figure 5: Cervico-thoracic neurofibroma of a 7-year-old boy

Intrathoracic Cystic Lesions

Cystic thoracic lesions in children mostly comprise of lymphangiomas and thoracic duplication cysts. 4 children had cystic mediastinal lesions, of which 2 were intrathoracic lymphangiomas and the other 2 were foregut duplication cysts.

On thoracoscopic view, the first lymphangioma had typical features of a lymphangioma, and it was very closely related to the brachiocephalic vein and was totally resected.

The second lymphangioma was of a 2-year-old 7-month-old child who had an incidentally detected large right paracardiac lymphangioma, which had solid cystic areas in the imaging. Even though it's in a crucial location in the paracardiac area, thoracoscopic visualisation enabled an unparalleled panoramic view, much more than we could get by open thoracotomy. It appeared to be a well-defined lesion without any lung involvement, but on the pericardial aspect, the tissue plane was quite obscured due to inflammatory adhesions, likely due to previous subclinical infections. Due to the critical location of this lesion, it took nearly 3 hours for complete resection, but it was a worthwhile endeavour, having seen a swift post-operative recovery of the child.

One child with a duplication cyst was of a 5-month-old baby who was having a large posterior mediastinal cystic mass very closely related to the diaphragm. It was occupying almost all right hemithorax with a dimension of 10X12cm.

Because of the total cystic nature of this lesion, we ventured into thoracoscopic resection. Even though the space was very limited on entry to the thorax, with complete aspiration of the lesion, we could get enough space to dissect the lesion off the oesophagus and inferior vena cava.

Altogether, we resected 10 neoplastic lesions including cystic masses thoracoscopically, and none of them represented with a recurrence. One of the well-documented complications of thoracoscopic resection of malignant tumours is port site recurrence, which we did not encounter in our series. However, in the ideal setting, we should use endo bags for the retrieval of malignant lesions out of the thorax to prevent port site recurrence.

Table 3: Intrathoracic cystic and solid lesions

Tumour	Type	Age	Size	Location	Intubation	Duration
Neuroblastoma 1	Malignant	8M	3X3 cm	Right apical C2-C3	Left main stem	180M
Neuroblastoma 2	Malignant	1Y 6M	3X2 .5cM	Right T4-C5	Tracheal	90M
Ganglioneuro blastoma	Bord Erline	3 Y	3X2 cm	Right T3-T5	Tracheal	120M
Neurofibroma	Benign	7 Y	8X6 cm	Left cervicot horacic	Tracheal	240M
Ewings sarcoma	Malignant	2 Y	5X4 cm	Right 8-10 ribs	Tracheal	260M
Pleropulmonary blastoma	Malignant	2Y 9M	8X7 cm	Right middle lobe	Tracheal	190M
Lymphangioma 1	Benign	2Y 7M	7X5 cm	Right paracardiac	Tracheal	320 M
Lymphangioma 2	Benign	4 Y	3X4 cm	Right paratracheal	Tracheal	90M
Duplication cyst	Benign	2 Y	8X7 cm	Right T4-T7	Tracheal	180 M
Duplication Cyst	Benign	5M	6X7cm	Rigtht T4-T7	Tracheal	160M

Thoracoscopic Lobectomy

Thoracoscopic lung lobectomy is a technically demanding procedure performed in the paediatric population. It's primarily performed for congenital pulmonary airway malformations (CPAM), bronchopulmonary sequestrations, congenital emphysema and bronchogenic cysts.

Control of major vascular structures during lobectomy is a major hurdle, and it's accomplished by the use of energy devices and staplers during the dissection. We performed lung lobectomy in 2 children with congenital pulmonary airway malformation. The first child was a 12-year-old girl who presented with an infected CPAM of the right lower lobe. Once the infection was successfully treated, she underwent right lower lobectomy asan elective procedure. The second child presented with a cystic lung lesion of the right middle lobe and underwent right middle lobectomy, and it later turned out to be a Type 1 Pleuropulmonary blastoma. Out of all types of thoracoscopic lobectomies, right middle lobectomy is technically more straightforward in terms of vascular dissection.

In 2022, we presented a review of thoracoscopic interventions in children at the PeMSARC annual research conference, University of Peradeniya. We believe that there's a long way to go slowly but steadily in thoracoscopic interventions of children, and I hope with the availability of technological infrastructure like we see in world-leading centres, sick children in our country will certainly benefit from this novel paradigm change we encompassed as a developing nation.

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