Section: Paediatric Surgery

Original Research Article

LUNG RETRACTION FOR THORACOSCOPY IN NEONATES: A MODIFIED TECHNIQUE

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Abstract

Background: Advancements in minimal access surgery have enabled thoracoscopic surgeries in neonates. Thoracoscopy enables excellent vision and detailed tissue images allowing for accurate surgery. Conventional thoracoscopy requires Carbon Dioxide which is not tolerated for prolonged periods in many cases. Here we present a modified thoracoscopic lung retractor for assistance in retraction. We present the advantages, indications and mode of use of this technique. **Materials and Methods**: Laparoscopic fan retractor of diameter 3.5 mm was modified to a shaft length of 6cm and blades of length 4cm. The retractor was of 3 blade type. The blade tips were covered with neoprene cover to prevent injury to fragile lung tissues. Insertion was done with direct puncture without a port. Retraction was by means of mechanical traction with chest wall acting as pivot. **Results**: In our experience of using this technique in 16 neonates, there were no instances of lung injury, vision of operating field was good. **Conclusion**: The technique of using a fan retractor modified for use in neonates gave substantial advantage in limiting use of carbon dioxide and quick and safe surgery.

INTRODUCTION

Thoracoscopic surgery is fast becoming the rapidly advancing modality of care in adults and children. Traditional open surgery though effective often involves surgical morbidity, longer operating times and large incisions1. In contrast to open, thoracoscopy provides a means to perform these complex conditions with small incisions, enhanced precision and reduced postoperative pain. In children thoracoscopy poses unique challenges owing to inherently small space, very small calibre intercostals, limited areas for instrumentation. Apart from these, physiological limiters like minute lung reserves, immature alveoli, poor tolerance to anaesthetic agents also cause surgery to be risky. Advantages of thoracoscopy like better accurate surgery under magnification of 12.5x, reduced anaesthetic drug requirements, less pain and faster recovery which are easily achievable in adults are not easily translated to children. Thoracic surgery In particular requires adequate retraction of the lung for visualising the structures such as aorta, subclavian vessels, ductus arteriosus, esophagus etc. Currently in neonates commonly performed procedures thoracoscopically are congenital diaphragmatic hernia, esophageal atresia and trachea esophageal fistula, congenital pulmonary malformations, patent ductus arteriosus etc.[1] The addition of thoracoscopy in armamentarium of neonatal surgical care has been facilitated by advances in imaging technology such as 4k resolution, 3d vision, miniaturised surgical instruments, and techniques specifically tailored for the neonate's anatomical and physiological requirements. This minimally invasive approach has shown promise in various neonatal surgical interventions, including esophageal anastomosis, Patent ductus arteriosus ligation, resection and repair of diaphragmatic defects.

Despite these advantages, the application of thoracoscopy in neonates poses distinct challenges. The small operating field, limited instrumentation, and the need for specialized expertise require careful consideration and training. Moreover, the risks of complications such as bleeding, injury to surrounding structures, and the technical demands of performing procedures in such a confined space necessitate a thorough understanding of neonatal thoracic anatomy and physiology.

This article aims to review the current role of thoracoscopy in neonatal surgery, highlight its benefits and challenges, and explore the use case experience of the modified instrument.

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MATERIALS AND METHODS

The study was conducted in the department of paediatric surgery at JSS Hospital, Mysuru, Karnataka, India. All the cases were managed by the same team of two surgeons. The study was conducted between April 2019 to August 2024.

The modified technique was utilised on case to case basis where lung retraction was required during thoracoscopy. In cases where visualisation of the field of interest was possible, a mechanical retraction was not done.

Inclusion Criteria

Neonates undergoing thoracoscopic surgery where mechanical lung retraction is required due to intolerance to carbon dioxide or site of surgical dissection,

Exclusion Criteria

Isolated used of carbon dioxide insufflation or one lung ventilation for thoracoscopy.

The instrument description is as follows

The use of a fan retractor in thoracoscopic procedures allows for improved visualization and better access to the neonatal thoracic cavity. However, the small anatomical space in neonates presents unique challenges in terms of instrument size, the ability to manipulate structures, and maintaining optimal working space during surgery. The modified fan retractor, a specialized instrument designed to address these challenges, facilitates safe and effective neonatal thoracoscopic surgery by providing improved exposure with minimal disruption to surrounding tissues. This section outlines the materials and methods used in the design and application of the modified fan retractor for neonatal thoracoscopy.

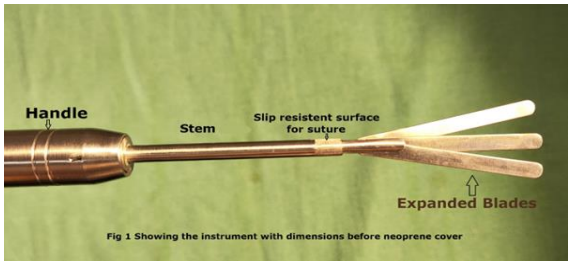

Fig 1 Showing the instrument with dimensions before neoprene cover

Materials

1. Modified Fan Retractor used by the authors

The modified fan retractor used in neonatal thoracoscopy is a smaller, shorter version of the traditional fan retractor, custom-designed to accommodate the dimensions of a neonatal chest. Key features of the retractor include:

- **Adjustable arms:** The retractor has 3 blades that can be adjusted for required width to provide optimal exposure of the surgical site.
- **Small and lightweight construction**: The retractor is designed to fit within the limited space of the neonatal thoracic cavity, with a reduced overall size and lightweight frame. The diameter is 3.5mm.
- **Slip resistant stem just proximal to the junction of blades and to tie neoprene** cover [Figure 1].
- **Articulating joints**: To provide greater flexibility, the arms of the retractor are connected to articulated joints, allowing for precise control over retraction without causing unnecessary stress on the surrounding tissue. [Figure 2]
- **Soft, non-abrasive cover**: To minimize tissue trauma and ensure safe retraction, the blades are covered with a soft material, such as silicone or neoprene rubber, to avoid direct contact with the delicate pleura and lung tissue. [Figure 3]

Fig 2 Showing anterior and Lateral views in collapsed state


Fig 3 Showing expanded retractor with neoprene glove cover with suture holding it over the non slip area

2. Thoracoscopic Surgical Instruments

- **30-degree video rod lens telescope:** A high-definition, miniature video thoracoscope is used to visualize the thoracic cavity during the procedure.
- **Minimally invasive instruments:** Specialized instruments designed for use in neonatal thoracoscopy, such as graspers, scissors, and coagulators, are employed to perform procedures under direct visualization.
- **Carbon dioxide insufflator:** To maintain appropriate pneumothorax (usually 4–6 mmHg) and create working space, a CO_2 insufflator is used. After initial insufflation to aid port insertion the flow and pressures are reduced after introduction of the retractor.

3. Endoscopic Monitoring Equipment

- **High-definition video monitor:** A monitor connected to the thoracoscope provides clear visualization of the thoracic cavity.

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- **Camera system:** A camera system that can be attached to the thoracoscope is essential for real-time visualization of the surgical field.

4. Anesthesia and Surgical Support Equipment

- **Neonatal anesthesia equipment:** General anesthesia and appropriate monitoring for neonates, including endotracheal intubation and continuous monitoring of vital signs, are essential.

Methods

1. Patient Preparation

- **Positioning:** Neonates are placed in a lateral decubitus position, with the affected side up, to optimize access to the thoracic cavity. Proper padding and support are essential to minimize pressure on the newborn's body.
- **Anesthesia:** General anesthesia is administered, and the neonate is intubated and ventilated appropriately. Continuous monitoring of oxygen saturation, heart rate, and blood pressure is essential.
- **Sterilization:** The instruments are sterilised by conventional plasma or autoclave

2. Insertion of Ports

- **Primary Trocar Insertion:** A small incision (3/5 mm) is made at the level of the mid-axillary line, through which the video thoracoscope is inserted. Additional small incisions are made to accommodate the insertion of surgical instruments.
- **Secondary Port Placement:** Two or more additional port sites are placed, typically along the anterior or posterior axillary line, to accommodate working instruments such as graspers or scissors.

3. Retractor Insertion and Adjustment

- The modified fan retractor is introduced through a direct puncture of the chest wall via a stab incision on the upper borders of the rib. A 3cm metal pivot can also be used. The retractor is carefully spread to provide optimal exposure of the thoracic cavity while minimizing tension on the surrounding tissues.
- The retractor may be repositioned as needed throughout the procedure to accommodate changes in the surgical approach.
- The retractor's soft coating prevents direct trauma to the delicate lung tissue and pleura, reducing the risk of postoperative complications such as atelectasis or pleural adhesions.

RESULTS

The above said technique was employed in a variety of surgical procedures as outlined below.

Type of surgery	Number of cases
Patent ductus arteriosus	13
Esophageal atresia	2
Congenital diaphragmatic Hernia	1

The said instrumentation was used only in selected cases which require significant retraction of the lung. Also in those babies who did not tolerate carbon dioxide insufflation which led to drop in SPO2 levels, increase in end tidal CO2 more than 45 and drop in blood pressures. The technique yielded the maximum advantage in cases of patent ductus arteriosus where the procedure was done as an emergency in a sick neonate with significant lung congestion. In babies with esophageal atresia with trachea esophageal fistula the initial dissection up to ligation of distal pouch fistula is sometimes difficult due to loss of significant volume of ventilated air into the stomach leading to higher peep being used. A mechanical retractor until such time that an isolation of the lower pouch fistula is made and ligation transfixation is performed, retraction becomes important.

Operating times for patent ductus arteriosus varied from 12 minutes to 30 minutes from port insertion to port removal. Longer time was attributed to lower weight and fragile condition of the baby.

There was one phrenic nerve injury in a baby with PDA leading to development of eventration of diaphragm and required diaphragmatic plication after 20 days. There were no instances of chylothorax, broncho pleural fistula, air leak via chest tubes or injury to vascular structures.

DISCUSSION

Thoracoscopic procedures, including lung resections, biopsies, and congenital lung malformation repairs, esophageal reconstructions, require precise control and optimal exposure of the thoracic cavity. Lung retraction is a critical aspect of thoracoscopic surgery, particularly in neonates and pediatric patients, where anatomical spaces are small and delicate. Lung retractors designed for thoracoscopy help to maintain clear visual access and allow for the safe manipulation of tissues while minimizing trauma to the delicate structures in the thoracic cavity.

In a 10 year experience by Nicholas et al,[2] the authors noted the tolerance of laparoscopy and thoracoscopy in neonates. The pneumothorax caused due to carbon dioxide insufflation caused a 20% decrease in arterial blood pressure and increased end tidal co2 by 9mmHg.

The various types of thoracoscopic lung retractors used in clinical practice are

1. Fan-Shaped Retractors [Figure 4][3]

- **Design:** Fan-shaped retractors feature multiple adjustable arms that spread in a fan-like configuration to retract the lung and expand the surgical field. These retractors are typically made from lightweight, flexible materials such as titanium or stainless steel and are of lengths 36 to 42cm from the articulating joint to the handle

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- **Uses:** Fan-shaped retractors are commonly used in a variety of thoracoscopic & laparoscopic procedures. The adjustable nature of the fan retractor allows for optimal positioning within the thoracic cavity, offering stable and controlled lung retraction with minimal disruption to the surrounding structures.
- **Benefits:** These retractors provide good exposure of the lung, heart, and diaphragm, and allow the surgeon to work in a relatively confined space without risking injury to the ribs or major blood vessels. The fan-shaped design also reduces the need for multiple instruments, allowing for more efficient use of limited access ports.
- **Limitations:** The tips of the blades easily puncture the lung on even slight malposition, the long length causes loss of dexterity and makes handling the instrument with the pivot at the distal tip difficult.

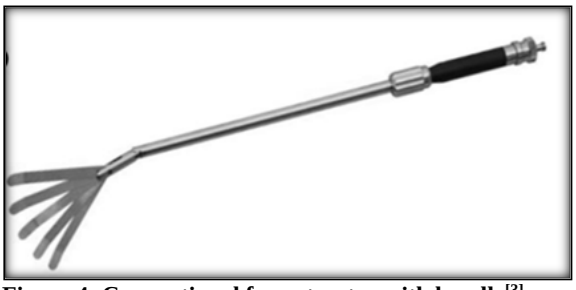

Figure 4: Conventional fan retractor with handle[3]

2. Pretzel retractor [Figure 5][4]

- **Design:** Consists of a series of metal articulating joints held together with a cable wire system which on tightening forms a ring like structure.
- **Uses:** Ring retractors are often used in laparoscopic & thoracoscopic surgeries. The platform though great in design, has a working stem length of 230mm and the platform width of 70mm for a 3mm diameter. The width of 70mm is achieved after inserting the entire length of the instrument and removal is also cumbersome.
- **Benefits:** These retractors provide excellent stabilization of the lung tissue, ensuring clear visualization and easy access to the surgical site. These are extremely gentle and comparatively less tissue damaging than fan retractors.

Figure 5: Pretzel type retractor with dimensions on expansion (Surginno USA)[4]

3. Single-Arm Retractors (Langenbeck type) [Figure 6][5]

- **Design:** Single-arm retractors typically have a long, slender arm that is inserted through a small port and used to retract the lung or other structures in the thoracic cavity. Some of these retractors have a right angled tip that grabs onto the lung or pleura, providing gentle traction.
- **Uses:** These retractors are typically used for smaller, more focused thoracoscopic procedures, such as biopsy or small lung resections. They are also useful for specific tasks like holding the lung in place during thoracoscopic PDA ligation or congenital diaphragmatic hernia repair.
- Benefits: Hook retractors are versatile, easy to maneuver, but the small diameter tip limits the area of lung tissue that can be retracted.

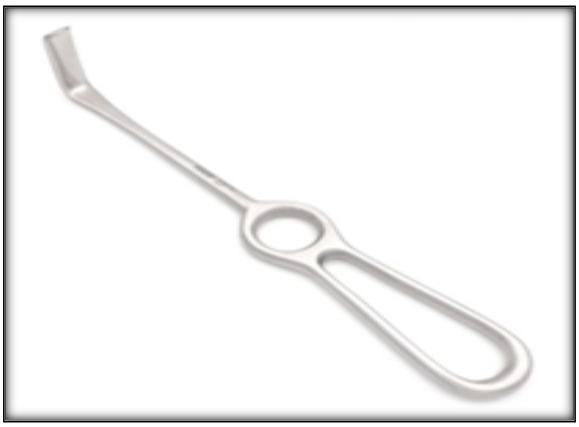

Figure 6: Simple langenbeck right angled rectractor with narrow tip.[5]

Irrespective of the design, all the instruments are prone to inherent hazard of breaking invitro, collateral damage to tissues, bleeding, and nerve injury to phrenic/vagus nerve.

Considering the maximum use case in the authors experience in cases of patent ductus, the technique of lung retraction with expandable lung retractors was published by Redmond P. Burke et al,[6] However the instrument is a traditional long one and the bare metal blades can easily injure the underlying lung. This technique was made safer and handling was made easier by the authors modification. Pretzel type retractors are used for lung and liver rectraction and is excellent in terms of tissue damage however limited by the width of the fully expanded platform.[7] A simple retraction system for uniportal surgery was described where cotton tipped straight metal stems connected by a string was used as a retraction technique.[8] In a large series of patent ductus arteriosus patients managed by coiling, thoracoscopy and open conversions, an expanding metal retractor was used for babies more than 2500grams and a cotton swab was used for less than 2500grams.[9] In a series of 59 thoracoscopic surgeries, the respective authors used expandable metal retractors in bigger babies > 3-4 kgs and cotton tipped swabs in smaller ones.[10] One

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lung ventilation in neonates has been achieved by selective bronchial intubation, occlusion of the selected bronchus/fistula in cases of tracheoesophageal fistula via fogarty catheter. This technique is helpful in stable neonates who can tolerate one lung ventilation and the weight is adequate enough to accept a bronchoscopy/fluoroscopy guided fogarty insertion. One lung ventilation reduces the need for higher insufflation pressures.[11]

CONCLUSION

Thoracoscopic lung retractors are vital instruments in the minimally invasive management of pediatric and neonatal thoracic conditions. They provide stable retraction and improved visualization, which are crucial for safe and effective surgical outcomes. Various types of lung retractors—such as fan-shaped, pretzel, hook, and suction-assisted retractors—offer different advantages depending on the specific needs of the procedure. As technology continues to advance, the design and application of these devices will evolve, with ongoing improvements in safety, precision, and ease of use. Patents related to thoracoscopic lung retractors reflect the innovation in this field, driving the development of more effective, efficient, and tailored tools for neonates and pediatric patients undergoing thoracic surgery. In the authors experience with the described instrument and technique, it was a safe and effective alternative which can be considered. Further experience and research in design of surgical instruments with improved dexterity specifically developed for neonates and infants will greatly aid in the safe surgical care of this group of patients.

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