e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2022; 14(12); 1359-1363

Original Research Article

A Prospective Observational Evaluation of One-Lung Ventilation Strategies for Infants and Children Undergoing VATS

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Received: 08-09-2022 / Revised: 20-10-2022 / Accepted: 30-11-2022
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Conflict of interest: Nil

Aim: This article aims to evaluate on one-lung ventilation strategies for infants and children undergoing VATS.

Methods: The present study was conducted at Department of Anesthesia and critical care, Patna Medical college and hospital, Patna, Bihar, India for 10 months and children with cystic hygroma with one-lung ventilation strategies for infants and children undergoing VATS were included in the study.

Results: In the present study, we measured right and left bronchus according to Tan and Tan-Kendrick, aged 2 days to 16 years old using computed tomograms (CT) of the thorax and correlated it with the patient's age and weight, in order to create a guide to size selection of the Fogarty catheter. For children, the Arndt Endobronchial Blocker® is only suitable if the ETT to be used is greater than 4.5 mm internal diameter, as the available 5 Fr catheter has a diameter of 2.5 mm and requires a small bronchoscope of at least 2.2 mm for positioning.

Conclusion: General anaesthesia with one lung ventilation can be safely performed in infants undergoing VATS with through preparation of difficult airway cart and under expert anaesthetist guidance.

Keywords: CH (Cystic Hygroma), VATS (Video-assisted Thoracoscopic Surgery), One Lung Ventilation.

Introduction

Single lung ventilation, also known as 'One Lung' ventilation, is a method of ventilation which was first conceptualized by physiologists Eduard Pflüger and Claude Bernard who studied gas exchange in dogs using a lung isolation catheter. [1] Single lung ventilation involves ventilating one lung and letting the other collapse for providing surgical exposure in the thoracic cavity or isolating ventilation to one lung. The protective role of the single lung ventilation involves protecting one lung from the ill effects of fluid from the other lung - which may be blood, lavage fluid, malignant or purulent secretions. Thus it is prudent to ensure perfect placement of the tube as a misplaced tube defeats the goals of lung isolation or differential ventilation. This is ensured by bronchoscopy done after tube placement and after any position changes thereafter. One lung ventilation is used to facilitate a wide variety of

procedures on ipsilateral thoracic or mediastinal structures as well as to provide lung isolation; this is made possible by the use of double lumen tubes, bronchial blockers, and endobronchial tubes. [2]

Cystic hygroma, also known as cavernous lymphangioma, is a benign congenital malformation of the lymphatic system. It results from obstruction between the lymphatic and venous pathways, commonly, in the fetal neck, which leads to lymph accumulation in the jugular lymphatic sacs in the nuchal region. In the first trimester of pregnancy, the overall prevalence of cystic hygroma is about 1 in 100. [3-5] Possible etiologies implicated in the occurrence of CH are: [6]

- Altered dermal collagen composition (e.g., Down syndrome).
- Abnormal nuchal lymphogenesis (e.g., Turner syndrome).
- Hemodynamic alterations and cardiac dysfunction (e.g., heart defects)
- Abnormal endothelial cell differentiation.

Treatment is surgical excision under general anesthesia either one or multistage resections. Anesthesia related problems are frequently encountered during the management of CH. These complex problems are posed by virtue of the lymphangiomas the more severe anaesthesia extension into the pharynx or thorax, hemorrhage during resection, involvement of pretracheal region, post-operative respiratory obstruction and concurrent congenital anomalies-(Down, Turner and Heart Defect). [7]

The recommended treatment is surgical excision which can be achieved with no mortality and little morbidity. The advantages of video assisted thoracoscopic surgery (VATS) in children have led to its increased usage over the years. VATS, however requires an efficient technique for one lung ventilation. Today there is an increasing interest in developing the technique for lung isolation to meet the anatomic and physiologic variations in infants and children. Significant differences exist between airways of the neonate and the adult. Anaesthetic management of the airway is challenging in neonates and young infants with large neck mass like huge cystic hygroma because these patients are at risk for sudden complete airway occlusion resulting in hypoventilation and hypoxemia. [8]

This article aims to evaluate on one‑lung ventilation strategies for infants and children undergoing VATS.

Materials and Methods

The present study was conducted at Department of Anesthesia and critical care, Patna Medical college and hospital, Patna, Bihar, India for 10 months and children with cystic hygroma with one‑lung ventilation strategies for infants and children undergoing VATS were included in the study.

The indications of single lung ventilation aim at facilitating surgical exposure by isolating the lung away from the field of surgery or preventing further lung trauma by providing selective ventilation as well as preventing infection or secretions from entering the healthy lung.

Surgical exposure

- Video-assisted thoracoscopic surgery including pneumonectomy, wedge resections
- Pulmonary resections including pneumectomies and lobectomies
- Mediastinal surgery
- Thoracic vascular surgery
- Esophageal surgery
- Spine surgery
- Lung Isolation

For protective isolation:

- Massive pulmonary hemorrhage
- Infection/purulent secretions

For control of ventilation:

- Tracheobronchial trauma
- Broncho-pleural/Broncho-cutaneous fistula

Exclusion criteria

- Patient unable to tolerate OLV/Dependence on bilateral ventilation
- Intraluminal airway masses (making DLT placement difficult)
- Hemodynamic instability
- Severe hypoxia
- Severe COPD
- Severe pulmonary hypertension
- Known or suspected difficult intubation

Results

Table 1: Fogarty catheter size for lung isolation in children by age according to Tan and Tan‑Kendrick

Age (y)	Size of Fogarty embolectomy catheter (Fr)	
	For boys	For girls
0-1	3	3
1-2	3	3
2-4	3	3
4-6	4 or 5	4 or 5
6-8	4 or 5	4 or 5
8-10	4 or 5	4 or 5
10-12	4 or 5	5
>12	5 or 6	6

In the present study, we measured right and left bronchus according to Tan and Tan‑Kendrick, aged 2 days to 16 years old using computed tomograms (CT) of the thorax and correlated it with the patient's age and weight, in order to create a guide to size selection of the Fogarty catheter.

Table 2: Arndt endobronchial blocker® sizing

Arndt size (Fr)	External diameter cuff (mm)	Best patient age (years)	Smallest ETT size (mm) for placement within ETT	Cuff inflation volumes (ml)	Fiberoptic bronchoscope (mm)
5.0	1.7	<8	4.5	0.5‑2	2.2 or 2.8
7.0	2.3	8‑12	6.5	2‑6	2.8
9.0	3.0	>12	8	Spherical:4‑8 Elliptical:6‑12	2.8

For children, the Arndt Endobronchial Blocker® is only suitable if the ETT to be used is greater than 4.5 mm internal diameter, as the available 5 Fr catheter has a diameter of 2.5 mm and requires a small bronchoscope of at least 2.2 mm for positioning.

Discussion

Cystic hygroma is a benign tumor of lymphatic origin. The anaesthetist should have knowledge of extension of cyst into thoracic cavity. One should access the size and extend of neck swelling in order to formulate an appropriate plan of airway management. Chest X ray is mandatory for all cases to exclude the presence of intrathoracic extension. Tumors in mediastinum require further investigations

like angiography, CT scan, fluoroscopy. [8]

In the clinical setting lymphatic pathways can be disrupted by many different causes including congenital anomalies, infection, malignancy, radiation, surgery, and trauma. These lymphatic tumors progressively enlarged without any pain or tenderness and are often noticed in the neck. They can present as symptomatic or asymptomatic mediastinal masses. They can result in upper and lower airway compression, [9-11] as well as superior vena caval obstruction.

Over the years various balloon‐tipped BB has been designed and used according to their purpose. As early as 1969, Vale and Lines already described the use of Fogarty® embolectomy catheter for lung isolation in small children and suggested appropriate size selection for this age group. [12,13] Tan and Tan‐Kendrick [14], measured right and left bronchus of 250 children aged 2 days to 16 years old using computed tomograms (CT) of the thorax and correlated it with the patient's age and weight, in order to create a guide to size selection of the Fogarty catheter. From this study, they found out that the age, but not the weight, of the patient is a good predictor of the main bronchial diameters. They recommended the use of a 3 Fr Fogarty catheter up to the age of 4 years and a 5 Fr catheter for 5-12 years old.

In the randomized trial of three bronchial blockers (Arndt, Cohen, and Fuji) versus double‐lumen tubes by Narayanaswamy, he concluded that among the bronchial blockers, the Arndt Endobronchial Blocker® needed to be repositioned more often. [15] The cuff of the blocker is deflated and advanced 1 cm deeper to avoid proximal dislodgement before turning the patient into lateral decubitus position. Direct visual check with FOB whether the bronchial blocker has achieved optimal position can allay uncertainties. With the patient in the lateral decubitus position, the outer surface of the blocker balloon should be at least 5 mm below the tracheal carina. Withdrawing the wire loop will convert this 1.4 mm channel into a suction port to expedite lung collapse. [16]

Different options available for intubation are blind nasal intubation but it can be traumatic and can cause bleeding, Fibre optic intubation but it requires considerable amount of skill, tracheostomy under local anaesthesia which only should be used as a last resort.

To avoid and manage the potential airway complications, adequate knowledge of the nature of tumor and communication between the anaesthesiologist, otolaryngologist and pediatric surgeon as well as presence of another expert anesthesiologist are required.

Conclusion

General anaesthesia with one lung ventilation can be safely performed in infants undergoing VATS with through preparation of difficult airway cart and under expert anaesthetist guidance. To overcome the challenges of rendering one lung ventilation technique in infants and children coming for video assisted thorascopic surgery, one must be mindful of the respiratory insult caused by OLV under general anaesthesia, and positioning during operation. Although it is prudent to use a device one is technically familiar with, the anaesthetists must also be aware whether if it is appropriate for the patients' age and weight. Furthermore, if the device is equipped with safety features such as ventilating both lungs in the event of hypoxia, and if it can provide efficient lung isolation intraoperatively.

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