

Use of Fogarty catheter as bronchial blocker for lung isolation in children undergoing thoracic surgery: A single centre experience of 15 cases

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ABSTRACT

Background and Aim: Various devices such as single lumen tubes, balloon-tipped bronchial blockers, and double-lumen tubes can be used for lung isolation in children, but no particular device is ideal. As such, there is a wide variation in lung isolation techniques employed by anaesthesiologists in this cohort of patients. This study aims to describe our experience with Fogarty catheters for lung isolation in children.

Methods: This was a single centre, retrospective review of 15 children, below the age of 8 years, undergoing thoracic surgeries and requiring lung isolation. Demographic details, clinical parameters, complications during Fogarty catheter placement, number of attempts for placement, time taken for satisfactory lung isolation, and intraoperative complications were collected.

Results: Successful lung isolation was achieved in all 15 children with Fogarty catheters of various sizes with the help of flexible bronchoscopy. Desaturation and bradycardia were the commonest complications seen during placement of the catheters but resolved with bag-mask ventilation. On average, 2 attempts were required for successful Fogarty placement. The mean time for successful lung isolation was 6.9 ± 1.3 minutes. The commonest intraoperative complication noted was desaturation, which resolved with an increase in FiO_2 and positive end expiratory pressure. 2 children had migration of the device proximally to the trachea causing airway obstruction. The devices were successfully repositioned in both cases.

Conclusion: Fogarty catheters can be used for successful lung isolation in children less than 8 years of age, undergoing thoracic surgery.

Keywords: Fogarty catheter, lung isolation, paediatric patients, thoracic surgery.

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INTRODUCTION

One lung ventilation (OLV) in children is indicated for various intrathoracic procedures. The common indications are decortication in suppurative lung disease, diaphragmatic hernia repair, resection of tumour, and congenital lung malformations. The American Thoracic Society has suggested the use of video-assisted thoracoscopic surgery (VATS) in this group of patients as there is less pain, better postoperative mobilization, and fewer complications.^[1] This has led to an increased request for

lung isolation in children and infants.^[2] A double-lumen tube (DLT) is the gold standard for OLV in adults.^[3] However, no such gold standard exists in children for lung isolation.^[4] Balloon tipped bronchial blockers (BB) are used for OLV in children younger than 6 years of age, and various devices like Arndt's BB are commercially available for use in children.^[5] But, they may not be available at all centres. Though not designed for use primarily as BB, Fogarty embolectomy catheters can be used for lung

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isolation and OLV even in very small children.^{16,71} We present our institutional experience in children undergoing various thoracic procedures with lung isolation performed by Fogarty catheters.

METHODS

This retrospective analysis was carried out after institutional review board approval (I/IM-NF/Anaesth/20/82) with waiver for informed patient consent. Date:06/08/2020. Children less than 8 years who underwent thoracic procedures for various indications over the last 4 years at our institute with a Fogarty catheter used as BB and had complete records were included in this analysis.

In all cases, Fogarty catheters were placed under flexible bronchoscopy guidance following which the trachea was intubated with appropriately sized tracheal tubes. The proximal end of the Fogarty catheters was fixed with adhesive tape at the angle of the mouth to prevent migration. Extubation was attempted after the reversal of neuromuscular blockade was carried out with inj. Neostigmine (50 microgram/kg) and inj. Glycopyrrolate (10 microgram/kg) at the end of surgery.

The following parameters were noted; failure to place Fogarty catheter into desired bronchus, sizes of the Fogarty catheter, number of attempts and time taken for lung isolation, incidence of complications (desaturation, hypoxia, bradycardia) during lung isolation, as well as incidence of intraoperative complications (hypoxia, migration of the Fogarty catheter, inability to ventilate the dependent lung).

RESULTS

A total of 15 children, below 8 years, who underwent lung isolation with a Fogarty catheter and had complete records were included in this analysis [Table 1]. Most of the children underwent VATS decortication for empyema thoracis. Satisfactory lung isolation for surgical access and conduct of surgery was achieved in all patients. Fogarty catheters were placed by same two anaesthesiologists in all cases. Fogarty catheters of sizes 3, 4, and 5 French (Fr)

Table 1: Demographic and Clinical Characteristics

Characteristics	Values
Age (years)	2.42 (5)
Weight (kg)	12.6 (10)
Gender (M:F)	10:5
VATS: Open thoracotomy	11:4
OLV (Right:Left)	4:11
Fogarty size (3 Fr./4 Fr./5 Fr.)	6/2/7

Values are Median (IQR) or number of patients; VATS (video assisted thoracoscopic surgery); OLV (one lung ventilation); Fr (French)

were used for children up to 2 years, 2-4 years, and 5-8 years, respectively. Fogarty catheters were placed into the desired bronchus under a flexible bronchoscopy guidance. 9 patients had desaturation (SpO₂ <90%) during the placement of the Fogarty catheter accompanied by bradycardia, which responded to bag-mask ventilation with 100% O₂, and both saturation and heart rate returned back to baseline values in all patients. It took 2 attempts per child on an average to place the Fogarty catheter. The average time taken for successful Fogarty insertion and lung isolation was 6.9 ± 1.3 minutes.

There was airway obstruction in 2 children, denoted by a sudden increase in peak airway pressures, after assuming lateral decubitus position, due to proximal migration of the inflated balloon into the trachea. The catheters were repositioned successfully into the main stem bronchus with the help of flexible bronchoscopy without having to change the position of the children.

Intraoperative desaturation (SpO₂ <90%) occurred in 3 patients, which responded to increase in FiO₂ and positive end expiratory pressure (PEEP) to the ventilated lung. There were no other serious adverse events during surgery, and all the children tolerated OLV fairly. 7 patients were electively ventilated for various indications and extubated in the ICU. None of the patients developed any respiratory or neurological complications during their stay in ICU. Satisfactory postoperative analgesia was achieved in all children with either caudal epidural or intercostal nerve blocks.

DISCUSSION

In children, lateral decubitus position causes greater ventilation and perfusion mismatch as compared to adults. This is because the effects of the hydrostatic pressure gradient between the non-dependent and dependent lung on perfusion and ventilation in the lateral decubitus position are considerably less in children.¹⁵¹ Furthermore, residual volume is closer to the functional residual capacity and thus, airway closure and atelectasis can occur even with appropriate tidal ventilation.¹⁵¹ Thus, hypoxia during OLV is much more common in children than adults. In addition, thoracic surgery in children necessitating use of OLV is usually required for suppurative lung disease and there is a potential for contamination of the healthy lung during surgery.¹⁵¹ Thus, the twin challenges in paediatric OLV are troubleshooting intraoperative hypoxemia and minimizing contamination of the non-operative lung. In addition, provision of a quiet surgical field with a well deflated lung remains the 3rd major challenge.

The use of single-lumen tracheal tubes endobronchially is the easiest and quickest method for lung isolation and OLV and is practiced at many centres.^[8] However, lung isolation by single-lumen tracheal tubes may not be always adequate when uncuffed smaller size tubes are used endo-bronchially. They also fail to prevent aspiration into the dependent and ventilated lung. Ventilation may not be adequate in the right upper lobe when the right main bronchus is intubated, and hypoxemia may occur. A specific endobronchial tube, the Marraro Paediatric Endobronchial Bilumen Tube®, was developed for OLV but is currently available only as a special product and is not widely used.^[9] Although DLTs are ideal for OLV in adults, the smallest size DLT available is 26 Fr left DLT and can only be used for children greater than 8 years.^[10]

BB is the technique of choice for lung isolation in children 6-8 years of age.^[5] An ideal BB should have low volume balloon, stabilize in the bronchus, be flexible, have a channel for deflation and suction distal to the blocker, adaptable for use internally and externally to a standard tracheal tube, and should be available in a variety of sizes. No such ideal blocker exists for use in the paediatric population.^[4]

Wire-guided endobronchial Arndt blocker® and Univent™ tubes are used as BB in children.^[11-13] However, Arndt blockers can only be used in children if the tracheal tube is >4.5 mm internal diameter.^[5] Cohen® Flexitip Endobronchial Blocker, Coopdech™ endobronchial blocker tube, EZ-blocker™, and Papworth BiVent ETT are available for adults, but their use in paediatric age has not been demonstrated.^[14-17]

Fogarty catheters have been used as BB in children.^[6,7,18,19] The Fogarty catheters provide adequate lung isolation and protect the dependent lung from contamination from the operative non-dependent lung. However, they have significant limitations. Suctioning of the operative lung is not possible with the Fogarty catheter in-situ with the balloon inflated. The balloon must be deflated for intermittent suctioning and ventilation of the operative lung when required during which may lead to the soiling of the dependent lung.^[20] The lung collapse after lung isolation is not always complete and is generally achieved due to the absorption atelectasis of the blocked lung. The balloon at the tip of Fogarty is of high-pressure type, and there is always a risk bronchial rupture if the balloon is inflated with a higher volume of air.^[21] Finally the balloon can also migrate to the trachea and may lead to complete airway obstruction. Despite this, various workers have used it for lung isolation in children.

Camci *et al.*,^[19] reported their experience with Fogarty catheters in 15 children and recommended that these catheters should be used for OLV in children undergoing thoracotomy. However, the authors attempted bronchial blockade in all patients with a 7 Fr Fogarty catheter irrespective of the age of the patient. The median patient age in their series was 9.9 ± 3.2 years. The rationale was that a bigger catheter will be associated with successful lung blockade in the first attempt with less incidence of failure, since a lower volume of air will be required.

Furthermore, the authors introduced the Fogarty catheter blindly into the desired bronchus under direct laryngoscopy.^[19] This can cause tracheobronchial trauma and may even take a longer time to place the Fogarty catheter into the desired bronchus. The mean time taken for lung isolation in their series was 11.7 ± 12 minutes, which was considerably longer as compared to 6.9 ± 1.3 minutes in our series.

Additionally, instead of using the “one size fits all” approach, we individualized the selection of the catheters as per age of the patients. This has been previously recommended by Tan and Tankendrick who found that age and not the weight of patients correlated with bronchial diameters.^[7] They recommended use of 3 Fr Fogarty catheters up to 4 years and 5 Fr for 5-12 years.^[7] They did not use 4 Fr catheters stating that there was only a 1 mm difference between 4 and 5 Fr and that balloon pressure may be lower with 5 Fr catheters, thereby increasing the margin of safety against bronchial rupture.^[7]

In our series, we used 4 Fr catheters in children 2-4 years and balloon inflation was carried out under vision so as to prevent over inflation and bronchial rupture. 4 Fr catheters would additionally require less inflation as compared to 3 Fr catheters and thus, provide a greater margin of safety in children 2-4 years. 3 Fr catheters were used in our series in only children less than 2 years.

Kamra *et al.*,^[6] reported use of Fogarty catheter in 27 patients without any major complications. The authors, however used rigid bronchoscopes for placement of the Fogarty catheter. Anaesthesiologists have limited experience in using rigid bronchoscope. Furthermore, as compared to rigid bronchoscopy, a flexible bronchoscope provides better vision and ease of insertion with lesser hemodynamic perturbations. With expertise in the technique and good knowledge of tracheobronchial anatomy, flexible bronchoscopy is considered the best method to provide optimal confirmation of device placement.^[22] Moreover, rigid bronchoscopy cannot be performed once the child is

intubated, or when the need arises during the intraoperative period for repositioning of the Fogarty catheter.

In our series, 20% of children had hypoxemia intraoperatively. There are various options available for the treatment of hypoxemia in OLV. Application of continuous positive airway pressure and apneic oxygenation insufflation to the non-ventilated lung are recommended techniques, but are not possible with a Fogarty balloon catheter in-situ. Alveolar recruitment strategies and the use of PEEP to the ventilated lung improves oxygenation and lung mechanics.^[20] In our patients, intraoperative hypoxemic episodes were managed by increasing the FiO₂ and PEEP to the dependent lung.

The biggest disadvantage of a Fogarty catheter is the absence of a hollow lumen, which prevents suctioning of the non-dependent lung. To avoid the soiling of the ventilated lung, intermittent suctioning of the trachea should be done intraoperatively, and patients should be placed in supine 30° Trendelenburg position to aid gravity-dependent drainage of the secretions in an attempt to minimize contamination of the healthy lung. However tracheobronchial toileting can still remain a problem in this cohort of patients.

There are some limitations in our study. This was a small retrospective analysis which had only had 15 patients, but we included only those with complete intraoperative and postoperative records. However, all retrospective studies suffer from inherent biases of patient selection, non-randomization, data collection and outcome reporting which can be addressed only by well-designed prospective randomized trials. Only 2 anaesthesiologists were involved in all the cases and thus, operator experience may play a big role in the placement of the catheters which may not be replicated by other workers. We did not evaluate the impact of lung isolation with Fogarty catheters on the gas exchange and lung mechanics. However, Hale *et al.*,^[2] have shown that older age and duration of OLV but not the type of device were associated with decrease in lung compliance and a poorer gas exchange. Finally, we evaluated only Fogarty catheters and cannot comment on other types of devices that are used in this age group for OLV.

CONCLUSION

There is no “gold standard” method for lung isolation in children less than 8 years. Fogarty catheters are widely available and can be used as BB in this subset of patients for conduct of OLV with a low incidence of complications.

However, suitable experience and practice may be needed for using these catheters as BB.

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Conflicts of interest

There are no conflicts of interest.

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