Forgarty Catheter for Lung Isolation and One-Lung Ventilation in Infants with Multiloculated Empyema with Bronchopleural Fistula Undergoing Exploratory Thoracotomy

An Alternative of Double Lumen Tube

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Abstract. Lung isolation and one-lung ventilation are generally facilitated using a Double lumen tube (DLT) to achieve a good operating field, prevent contamination, maintain adequate ventilation and oxygenation. No suitable size of DLT on the current market for the infant and pediatric population remains a problem. In this article, we report a 2.5-month old infant with multiloculated empyema with bronchopleural fistula in the right lung who underwent a thoracotomy for decortication and closure of the fistula. Here, we used the Forgarty Catheter, commonly used in vascular surgery for thrombectomy, as an alternative to DLT. We made this Forgarty Catheter a bronchial blocker to isolate the patient's right lung, we inserted it into a modified endotracheal tube (ETT) with a Y connector. Intraoperatively, the Forgarty Catheter can properly act as a bronchial blocker to prevent contamination of healthy lungs, to facilitate one-lung ventilation and oxygenation can be provided adequately. Postoperatively, the Forgarty catheter was removed and both of the patient's lungs were re-expanded. Later, the patient was transferred to the PICU for further observation. In conclusion, Forgarty Catheter can be an alternative to DLT in infants and pediatrics undergoing thoracic surgery.

Keywords: Forgarty Catheter · Lung isolation · One lung ventilation · Thoracic surgery · Pediatric · empyema · Bronchopleural fistula

1 Introduction

Multiloculated empyema accompanied by a bronchopleural fistula requires surgery for complete evacuation of the empyema and closure of the bronchopleural fistula. This aims as a follow-up treatment after antibiotic therapy to control the infection and the patient's septic condition [1].

Intraoperative anesthetic management for decortication and closure of bronchopleural fistulas in infants has its difficulties and challenges, especially in managing the airway.

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Anatomically and physiologically, infants have differences with adults that cause a higher risk for desaturation compared to adult patients [2]. For this reason, the anesthesiologist must be able to overcome the desaturation that may occur while instrumentation during the procedure or other manipulations of the patient's lungs. The anesthesiologist must also ensure adequate ventilation and oxygenation throughout the procedure [3].

One-lung ventilation (OLV) is common airway management in thoracic surgery where ventilation is carried out in one lung and leaves the other lung unexpanded or collapsed. The indications for OLV itself are to provide good access or operating field during the procedure, to provide lung protection from pus or blood contamination, and to ensure adequate ventilation and oxygenation of healthy lungs [2, 3].

It requires a special tool that could facilitate separation between the left lung and right lung to perform the OLV. In adult patients, OLV is achieved by using a double-lumen tube (DLT) which has 2 lumens where the first lumen ends above the carina and the second one can be inserted into the main bronchus so that separate ventilation can be performed [4, 5].

In the infant and pediatric population, the use of DLT is still very limited due to the availability of an appropriate size. The smallest DLT size available in the market is only up to number 26 F which can only be used for children aged 8 years and over. This makes one-lung ventilation and lung isolation in infants still becoming a problem for some anesthesiologists [6].

Alternatively, a Forgarty Catheter may be an option to facilitate one-lung ventilation and pulmonary isolation in the infant. The Forgarty Catheter has an inflatable balloon at its end distal commonly used for thrombectomy in vascular surgery, It comprises various sizes with the smallest size 2 fr and the largest 7 fr [7].

In this case report, we present the anesthetic management of the infant's airway with multiloculated empyema accompanied by a bronchopleural fistula in the right lung which underwent thoracotomy for decortication and closure of the bronchopleural fistula.

2 Case Report

A baby aged 5 months, weighing 6.7 kg, was admitted to the hospital with complaints of shortness of breath, accompanied by a persistent high fever. History of fever and cough since 14 days before hospital admission was noted. Previously, the patient had been treated and received antibiotics.

The patient was born by cesarean section at the 40th week of gestation, cried immediately with a birth weight of 3600 g. No history of bluish skin or other congenital abnormalities.

Clinically, the patient was seriously ill, has shortness of breath, compos mentis, actively crying, has a fast breathing rate of 70x/minute, 91% saturation with free air, 96% with O2 0.5 L per minute by nasal cannula, accompanied by a fever of 38.1 °C with a pulse rate of 154 beats per minute. Physical examination of the chest revealed heavy work of breathing, retraction of the respiratory muscles, and lagging right chest movement. On auscultation, the vesicular breath sound in the right lung decreased to the 5th intercostal level.

Laboratory examinations showed that the patient was anemic with Hb of 8.9 g/dl, a sign of infection with leukocytosis (37,030/mm^3), thrombocytosis (923,000/mm^3), increased CRP of 7.06 mg/dL, and hypoalbuminemia (2.43 g/dL). Arterial blood gas analysis with pH 7.523, pCO2 32.8, pO2 69.1, HCO3 29.7, BE 7.0, SaO2 93.5%, and pFRatio of 300.4.

A chest X-ray examination revealed multiple lucent cavities of various sizes from the upper right lung to the lower and suspected a Congenital Cystic Adenomatoid Malformation (CCAM) and right pleuropneumonia. Further, a chest CT scan was performed and showed multiple loculated empyemas in the right upper to lower right hemithorax accompanied by a bronchopleural fistula.

The patient was planned for thoracotomy for decortication and fistula closure where PRC transfusion and 20% albumin were given preoperatively. General anesthesia and one-lung ventilation were planned for pulmonary isolation and intensive room for postoperative.

Before induction, preoxygenation was performed and the anesthesia was induced with propofol, fentanyl, and atracurium. Intubation was done with ETT No. 3.5 which had been connected to a Y connector taken from used closed suction. After making sure the depth of anesthesia was reached, we inserted the Forgarty Catheter size number 3 french through the valve on the Y connector while the ETT inserted deeper to make sure that it would lead to the right lung. Then the Forgarty Catheter was inserted further and later the balloon was inflated as the ETT pulled back into the trachea (See Figs. 1, 2 and 3).

The position of the Forgarty Catheter was confirmed by vesicular breath sound in the left lung, no sound, and no chest movement in the right lung which indicated that the balloon Forgarty Catheter was appropriately placed in the right main bronchus branch. We fixated the ETT and positioned the patient on the left side.

Anesthesia was maintained with sevoflurane 2–3%, oxygen fraction 50%, and manual Jackson Reese bagging were performed during surgery. The patient was monitored by oximeter, etco2, heart rate, and rhythm. Intraoperatively, there was a desaturation phase during Forgarty Catheter insertion, early left tilt position, and operator instrumentation which caused excess pressure in the dependent lung but could be overcome by increasing the oxygen fraction and giving positive end-expiratory pressure during bagging. The operation lasted for 3 h, bleeding was noted and the patient received a

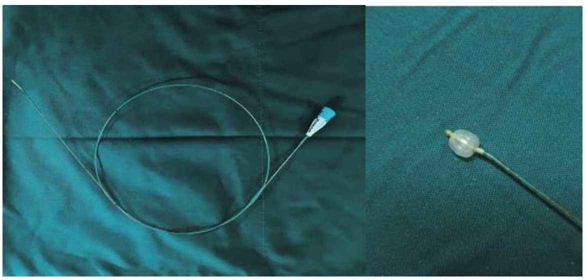

Fig. 1. Forgarty Catheter size 3 Fr, with an inflatable balloon, tipped at the end distal.

Fig. 2. Y Connector took from used closed suction.

Fig. 3. The use of Forgarty Catheter on ETT connected with Y Connector.

transfusion of 50cc packed red cell. The right lung underwent decortication and closure of the fistula was done.

At the end of the operation, the patient was repositioned supine, the Forgarty balloon was deflated and then released while active suction was carried out until it was clean and the two lungs were re-expanded. The patient was awakened with spontaneous breaths, an ETT retention was performed for further monitoring in the intensive care unit.

3 Discussion

Double lumen tube (DLT) is known for its use as selective bronchial intubation (SBI) to facilitate one-lung ventilation (OLV) and lung isolation. The smallest DLT size available in the market is only up to no 26 F which can only be used for children aged 8 years and over [2, 5].

The use of a Forgarty Catheter as a bronchial blocker is aimed as an alternative to the absence of a double-lumen tube for infants and pediatrics. Forgarty Catheters, although commonly used in vascular surgery for thrombectomy, can function as bronchial blockers by utilizing their inflatable distal balloon cuff [3, 4].

To our knowledge, there are currently no official guidelines for selecting the size of a Forgarty Catheter, but the study by Tan and Kendrick measured the right and left bronchi of 250 children aged 2 days to 16 years on thoracic computed tomograms (CT) and correlated them with age and weight. It was found that the patient's age was a good predictor for the determination of the diameter of the main bronchi. The study recommends the use of a Fogarty 3 Fr catheter up to 4 years of age and a 5 Fr catheter for ages 5–12 years [3, 5].

Anesthesia management in infant thoracic surgery poses significant challenges for anesthesia. The differing anatomy and physiology of infants make airway management more difficult than the general adult patient with a greater risk of desaturation [7].

OLV is well-tolerated in pediatrics with healthy heart and lung function. When OLV ventilation (V) and perfusion (Q) were highest in the dependent lung, where blood supply and perfusion were greater because of position and gravity than in the nondependent lung. Meanwhile, in the non-dependent lung during the large shunt phase, due to the absence of ventilation, the shunt that occurs will decrease because blood flow is decreased by the force of gravity and disappears in the presence of hypoxic pulmonary vasoconstriction (HPV) mechanism [4, 5, 7].

The mechanism of HPV is not fully understood but is considered to be a regional protective response that occurs due to alveolar hypoxia with the release of vasoactive substances resulting in vasoconstriction of pulmonary blood vessels so that blood flow can be more optimal to healthy alveoli. The HPV mechanism minimizes V/Q mismatch by increasing perfusion from the atelectasis lung to the dependent lung. The partial pressure of venous oxygen (PvO2), inhalation agents, anesthetic induction agents, and agents influences this mechanism [5, 7].

With reduced lung capacity in OLV, an adequate balance must be achieved between the tidal volume for gas exchange and the peak inspiratory pressure that is not too high to avoid barotrauma. Peak inspiratory pressure is maintained not to exceed 30 cmH20 and permissive hypercapnia may be tolerated. A mismatch can still occur due to changes in functional residual capacity, lung retraction during operator instrumentation, and lung collapse during one-lung isolation [4, 5].

The effect of the lateral decubitus position of the infant on the V/Q mismatch differs from that of the adult. Infants have a softer chest and are more easily compressed, resulting in decreased lung compliance, narrower airway closure so that the risk of dependent lung atelectasis increases so that the risk of intraoperative hypoxia increases [2, 3].

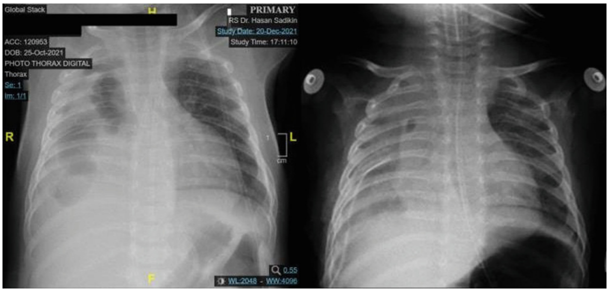

Fig. 4. Before surgery (left) and after (right) X-rays shows no contamination or pneumonia afterward at the left lung.

One-lung ventilation and lung isolation, in this case, were used to isolate healthy lungs from the risk of pus contamination by a bronchopleural fistula and also aspiration of blood due to surgery, so that ventilation and oxygenation can also be optimized properly. One ventilation can also facilitate the operator during the action with a better operating area.

There are several events of desaturation during surgery such as when lung reserve of residual capacity decreases during intubation and Forgarty Catheter insertion, also when the lung is compressed by left tilt position and manipulation. To overcome this we added ventilation with PEEP and a high fraction of oxygen. The lowest saturation is 83% when desaturation occurs and we monitored etCO2 to anticipate hypercarbia and it peaked at 47 mmHg throughout the surgery.

Good lung isolation is achieved with no abnormal sound from auscultation and no visible blood regurgitation on the ventilator circuit. The postoperative X-ray thorax examination portrayed no contamination to the left lung with normal pulmonary roentgenology (see Fig. 4).

4 Conclusion

The use of a Forgarty Catheter, in this case, provides satisfactory one-lung ventilation and isolation. Desaturation happened physiologically due to decreased functional lung reserved capacity and manipulation of the lung.

Oxygenation was optimized with PEEP, high fraction oxygen, and also good lung separation, there was no regurgitation and contamination proofed by no sign of pneumonia from X-rays photo afterward.

Forgarty Catheter is an excellent alternative to lung isolation devices whereas DLT in infants and pediatrics is still limited.

Conflict of Interest. The author has no conflict of interest in the scientific article written.

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