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Paediatric One Lung Anaesthesia by Selective Bronchial Intubation

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ABSTRACT

One lung anaesthesia in paediatric patients may not always be achievable by bronchial blockade or double lumen tube intubation due to inadequate experiences or facilities. We attempted to isolate right lung by selectively intubating the left bronchus with single lumen tube on a 10 kg child. Optimal surgical condition and satisfactory oxygenation achieved but complicated with severe respiratory acidosis. The possible causes for hypercapnea in this child were discussed.

Keywords: paediatric, one lung anaesthesia, respiratory acidosis

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INTRODUCTION

The indications for one lung anaesthesia include isolation of an infected lung, pulmonary haemorrhage, bronchopleural fistula and resection of emphysematous bullae. One lung ventilation in adults is usually achieved by the use of double lumen tube. Marraro paediatric double lumen tube[1] is available but is not yet widely used. Fogarty embolectomy catheter or balloon atrioseptostomy catheter has been used successfully as a bronchial blocker in most reported cases. However correct placements of these balloon catheters require advanced skill with bronchoscope[2]. Selective one lung ventilation by endobronchial single lumen tube was documented as an alternative method[3] but report is lacking. We report a paediatric case where one lung anaesthesia achieved by selective left bronchial intubation in which optimal surgical condition and adequate oxygenation achieved but was complicated with severe carbon dioxide (CO_2) retention.

CASE REPORT

A 2 years 2 months old girl with the body weight of 10 kg was scheduled for a right thoracotomy and resection of infected lung cyst. This girl's illness started with empyema of right thorax at 1 year of age, which resolved with chest tube drainage and antibiotics. At the age of 2 years, she had recurrence of empyema at the same site that again drained by chest-tube insertion (Fig. 1). Subsequent Chest x-ray (Fig. 2) and C-T thorax revealed a large cyst within the right lower lobe, compressing on the trachea.

One lung anaesthesia by left endobronchial intubation using single lumen endotracheal tube was planned for the patient. Induction of anaesthesia was done with Halothane in 100% oxygen. After the establishment of a good intravenous access, a dose of atropine was given to the child and intubation done without paralysis. Olympus LF-P fibrescope (diameter 1.8 mm) was then introduced to the left main bronchus through the endotracheal tube (size 4.5). Subsequently the endotracheal tube was turned 180º to enable the tube bevel facing towards the right. It was then pushed down to the left main bronchus with the guidance of the fibrescope. Left radial artery was cannulated for direct blood pressure monitoring and thoracic epidural catheter inserted after the child was positioned at left lateral position. The child was breathing spontaneously with oxygen air mixture throughout this period of time. Good tidal volume was indicated by the reservoir bag and no desaturation noted.

She was then paralysed and supported with manual control hand ventilation when the right thorax was opened. Although the right lung was not able to collapse completely due to presence of inflammatory adhesions, it was not ventilated and well isolated with left endobronchial intubation. Brief desaturation down to arterial saturation (SpO_2) of 85% noted for 1 minute that corrected by giving 100% oxygen. Subsequent SpO_2 were maintained at 93% and above. However arterial blood gas (ABG) results revealed significant respiratory acidosis with marked carbon dioxide (CO_2) retention (Table I).

The respiratory acidosis persisted despite ventilating the child with significant higher minute volume. The surgical team was informed and the plan of resuming two lungs ventilation was contemplated. However lung compliance improved after the surgical team stopped dissecting and when all the packs were removed from the thoracic cavity. ABG results (Table I) at this time

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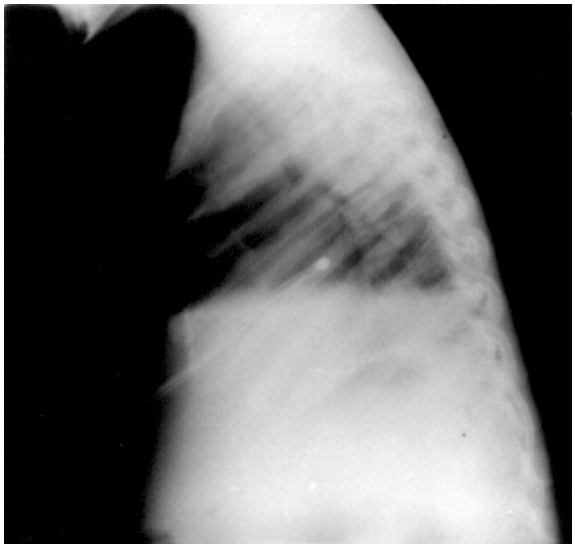

Fig. 1 Lateral chest x-ray showing empyema of the right thorax with chest tube drainage.

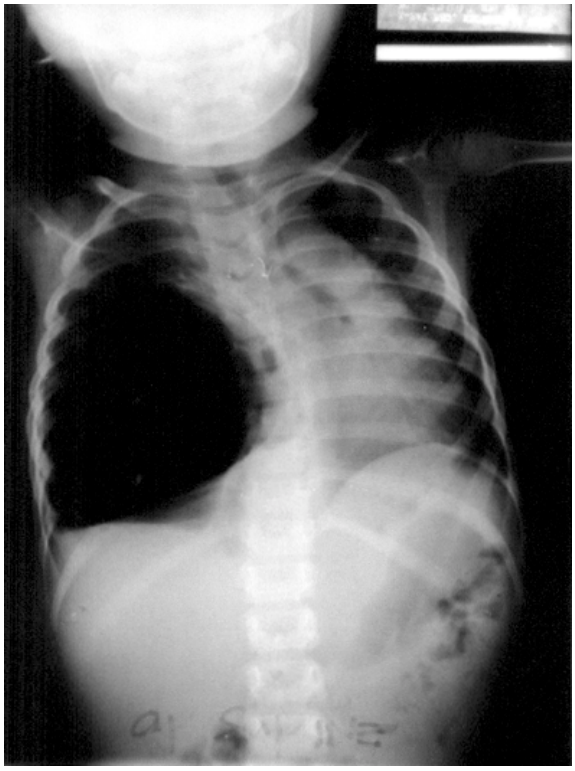

Fig. 2 Chest x-ray showing large cystic lesion at the right lower lobe.

show significant improvement. The operation was resumed with the care avoiding compression of the other hemithorax. One lung ventilation continued. When the right lower lobe lobectomy was successfully completed, the endotracheal tube was pulled up to the tracheal and bronchial stump leakage testing was done.

The child was extubated well at 12 hours post surgery in the intensive care unit and discharged home 1 week later. Histopathology of the lesion was consistent with Congenital Cystic Adenamatoid Malformation (CCAM) type 1.

DISCUSSION

Anaesthetic considerations in this child include the possibility of the presence of residual infected material and bronchopleural fistula. There was also a risk of progressive enlargement of the lung cyst during assist ventilation or pneumothorax that may subsequently result in mediastinal shift. Thus it was almost mandatory to have isolation of the pathological lung.

Our previous experiences for pulmonary resection that were done without lung isolation often resulted in tube blockade by blood clots. This required frequent endotracheal suction or even change of endotracheal tube intraoperatively. Soiling of the dependent lung with blood or infected material can also occur.

The standard bronchial blockers are unsuitable for small children or infants because of size limitations[4]. Fogarty embolectomy catheter and atrioseptostomy balloon catheter has been used successfully by many authors to isolate the pathological lung. These balloon catheters were introduced through a rigid bronchoscope and fited st the selected bronchus or manipulated into the selected bronchus under vision with the aid of a flexible fibrescope.

Table I. Arterial blood gas results.

Events sequence	Initial one-lung anaesthesia when the thorax opened	One-lung anaesthesia with higher minute volume	One-lung anaesthesia when surgical packs removed from thorax cavity	Two-lung anaesthesia (post lobectomy)
Fi O_2*	100%	100%	100%	100%
pH	7.132	7.144	7.188	7.243
PCO_2 (mmHg)	66.9	73.9	62.5	52.3
PO_2 (mmHg)	66.9	88.0	140.5	325.3
HCO_3 a(mmol/L)	22.3	25.4	23.7	22.5
HCO_3 -s(mmol/L)	27.5	29.7	29.7	20.2
T CO_2 (mmol/L)	24.4	27.6	25.7	24.2
BE(vt) (mmol/L)	-8.5	-5.8	-5.9	-5.4
BE(VV) (mmol/L)	-5.8	-2.5	-3.2	-3.5
pH** at PCO_2 40 mmHg	7.347	7.415	7.368	7.341

* Inspired oxygen concentration ** pH at PCO_2 of 40 mmHg = measured PCO_2 - 40) mmHg x 0.008

R F Kaplan and L. Guzzi reported great difficulties and failures in the attempt to negotiate balloon catheter into the right bronchus by introducing the balloon catheter along the outside of the tracheal tube with the aid of fibrescope within the tracheal tube[2]. F S Robert subsequently suggested blind placement of balloon catheter through the endotracheal tube that intubated the selected bronchus intentionally with the aid of flexible fibrescope[5]. We had no experience in lung isolation using balloon catheter technique. We had also concluded that although F S Robert method was technically possible in this child but may subject her to severe hypoxia. This is because the large cystic lesion was occupying the great portion of right lung. Oxygenation would not be adequate if we intubate the right bronchus intentionally. Thus selective left endobronchial intubation was chosen.

It is always difficult to choose the appropriate size tube for endobronchial intubation. Smaller size tube is indicated in order to avoid trauma on the bronchus[3], however lung isolation will not be achieved if there was presence of leaks between the tube and the bronchus. Correct placement of endobronchial intubation again required confirmation by skilled bronchoscopy. The placement of the left bronchial tube in this child initially was found satisfactory as indicated by absent breath sound and expansion of the right thorax, good saturation and adequate tidal volume were maintained by the left lung even after positioning.

With the increment of inspired oxygen up to 100% and certain amount of positive end expiratory pressure exerted by the ventilating hand, oxygenation in this child during one-lung anaesthesia was just able to be maintained at satisfactory level (arterial PaO_2 of >60 mmHg). The mechanical compression on the left lung not only induced severe ventilation perfusion mismatch due to closure of the dependent airway, the resistance of pulmonary arterial vasculature in the dependent lung also increased and resulted in more pulmonary blood flow being shunted to the unventilated non-dependent lung. In normal physiological condition, shunting of pulmonary blood flow to the unventilated lung was minimised by hypoxic pulmonary vasoconstriction, a physiological response following the reduction in alveolar oxygen concentration. Ventilation perfusion mismatching and intrapulmonary shunting almost always causes poor oxygenation of patient and its effect on CO_2 excretion often negligible. In this child both oxygenation and CO_2 removal were severely affected. Carbon dioxide retention was probably due to inadequate tidal volume generated for the child, as the left lung expansion was extremely restricted. Small tidal volume further increased dead space (apparatus and anatomical) percentage for each tidal ventilation especially in small children. Attempts to increase minute volume by increasing the ventilation rate only ended up with reduction of expiratory time and the expiratory gas flow was impeded. Thus the repeated arterial blood gas results after the apparent increased minute volume show worsening of CO_2 retention (Table I). On the other hand, tube displacement may also have occurred and the tube bevel may partially impinge on the bronchial wall and resulted in limitation of ventilation.

The degree of asidosis in this child was alarming but this was purely respiratory in origin. By considering every increment of 1 mmHg PCO_2 will lead to drop in plasma pH by 0.008 in acute respiratory acidosis[6], the calculated pH at PCO_2 of 40 mmHg (Table I) were near normal. Although there was metabolic compensation at later stage of severe respiratory acidosis, it is definitely not advisable to allow this to be prolonged. The tube should be readjusted or pulled up to resume two-lung ventilation if no improvement noted. Metabolic causes of hypercapnia should also be suspected if the ventilatory problems of the child was excluded.

Lung isolation by selective bronchial intubation using single lumen tube in paediatric patient is obviously less optimal than bronchial occlusion by balloon catheters. The balloon catheter will not only ensure total isolation of one lung; it is also less likely to cause trauma on the bronchial epithelial. Although there are also chances for the balloon catheter to migrate, dislodge and occlude the trachea[4], their successes in various surgical procedures are widely reported[4,7,8]. Until there is more experience with the paediatric double lumen tube in the future, selective bronchial intubation using single lumen endotracheal tube is still an alternative for lung isolation in paediatric patients when bronchial occlusion has failed.

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