Obstetrical and Pediatric Anesthesia

Single-lung ventilation in a pediatric patient using a pediatric fibreoptically-directed wire-guided endobronchial blocker

[La ventilation unilatérale chez un patient pédiatrique à l'aide d'un bloqueur endobronchique muni d'une tige métallique pour guidage fibroscopique]

Elizabeth S. Yun MD, Asta Saulys MD, Peter M. Popic MD, George A. Arndt MD

Purpose: The pediatric wire-guided endobronchial blocker is a new device for single-lung ventilation through small diameter endotracheal tubes. In this case report we will discuss the use of this blocker in a pediatric patient.

Clinical features: We successfully placed the pediatric wire-guided endobronchial blocker in a 14-yr-old patient who underwent an aortic coarctation repair. The blocker is a 5-French 70 cm double-lumen catheter. One lumen contains an adjustable wire loop. The other lumen inflates a spherical low pressure, high volume balloon. Through a special bronchoscopy port, the blocker and bronchoscope were placed into a 7.0 cuffed endotracheal tube, the bronchoscope passed through the wire loop of the blocker and advanced towards the left mainstem bronchus. Then the blocker was advanced over the bronchoscope and positioned in the left mainstem bronchus. The balloon was slowly inflated under direct vision and the bronchoscope removed. During the case, single lung ventilation was achieved by inflating the balloon, thus collapsing the lung. At the end of the case, the lung was reinflated by deflating the balloon and the blocker was removed without difficulty. The patient tolerated the procedure well and had an uneventful postoperative course.

Conclusion: Because of the endobronchial blocker's small diameter, this device can be used in a small endotracheal tube without sacrificing the inner diameter (ID) cross sectional area. Therefore, the patient is ventilated through a conventional endotracheal tube with a larger ID compared to the ID of a double-lumen endotracheal tube.

Objectif : Le bloqueur endobronchique avec guide métallique est un nouveau dispositif de ventilation unilatérale au travers d'un tube endotrachéal de petit diamètre. Nous discutons de l'usage de ce bloqueur chez un enfant.

Éléments cliniques : Nous avons réussi à insérer un bloqueur endobronchique pédiatrique avec guide métallique chez un patient de 14 ans qui devait subir la réparation d'une coarctation de l'aorte. Le bloqueur est un cathéter 5-French, de 70 cm, à double lumière dont l'une contient la boucle métallique ajustable et l'autre permet de gonfler un ballonnet de haut volume et basse pression. Par un connecteur bronchoscopique spécial, le bloqueur et le bronchoscope ont été placés dans un tube endotrachéal à ballonnet no 7,0, le bronchoscope passant au travers de la boucle métallique du bloqueur et s'avançant dans la bronche principale gauche. Puis, le bloqueur a été glissé par-dessus le bronchoscope et mis en place dans la bronche principale gauche. Le ballonnet est alors gonflé lentement sous vision directe et le bronchoscope enlevé. Pendant l'opération, la ventilation unilatérale est assurée en gonflant le ballonnet et en affaissant le poumon. À la fin de l'intervention, le poumon est gonflé de nouveau par le dégonflement du ballonnet et le bloqueur est enlevé sans difficulté. Le patient a bien toléré l'intervention et aucun incident postopératoire n'est survenu.

Conclusion : Étant donné le petit diamètre du bloqueur endobronchique, ce dispositif peut être utilisé dans un petit tube endotrachéal sans sacrifier la surface de la section transversale du diamètre interne (DI). Ainsi, le patient reçoit une ventilation traditionnelle par le tube endotrachéal à large DI comparé au DI du tube endotrachéal à double lumière.

From the Department of Anesthesiology, University of Wisconsin Hospital and Clinics, Madison, Wisconsin, USA.

Address correspondence to: Dr. Elizabeth S. Yun, Department of Anesthesiology, U.W., Clinical Sciences Center B6/319 Clinical Sciences Center, 600 Highland Avenue, Madison, WI 53792-3272, USA. Phone: 608-263-5447; Fax: 608-263-0575; E-mail: esyun@facstaff.wisc.edu

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WE wish to report the use of a new pediatric 5-French fibreoptically directed wire-guided endobronchial blocker (PWEB; Cook Inc., Bloomington, IN, USA), developed by one of the authors, in a pediatric patient undergoing aortic coarctation repair. The technique allows precise and timely placement of an endobronchial blocker through a small diameter conventional endotracheal tube, using a pediatric fibreoptic bronchoscope and a special bronchoscopy port. This method allows single-lung ventilation in the pediatric patient population.

Case report

A 14-yr-old, 45 kg, white male was scheduled to undergo a repair of coarctation of the aorta. His past medical history included coarctation balloon angioplasty at the age of 28 months. Important findings on his preoperative physical examination included an upper and lower extremity blood pressure differential, in the right arm being 140/80 mmHg and in the right leg being 98/60 mmHg. A grade 2/6 smooth systolic ejection murmur at the mid left and upper right side of the sternum was also present. An echocardiogram showed mild to moderate coarctation of aorta, a bicuspid aortic valve, mild aortic insufficiency, a small patent ductus arteriosus, an ejection fraction of 80%, and a peak gradient of 51.8 mmHg. Chest magnetic resonance imaging demonstrated mild bicuspid aortic stenosis and regurgitation, and a hypoplastic coarctated aortic arch with focal stenosis just distal to the left subclavian artery. Because of these findings, the patient was scheduled to undergo coarctectomy and end-to-end anastomosis through a left thoracotomy. Combined thoracic epidural anesthesia and general anesthesia was administered. The patient was monitored with capnography, temperature, pulse oximeter, electrocardiogram, and invasive blood pressure in the right radial and left femoral arteries. Central venous pressure was also monitored. Single-lung ventilation was requested for surgical exposure.

Single-lung ventilation was provided using a 5-French PWEB through a 7.0-mm inner diameter (ID) cuffed endotracheal tube. The PWEB was placed coaxially through a conventional endotracheal tube using a 2.0-mm Pentax pediatric bronchoscope (Pentax Inc., Tokyo, Japan) and special bronchoscopy port (SBP; Cook, Inc., Bloomington, IN, USA; Figure 1). The PWEB is a 5-French, 70-cm double-lumen catheter with a 0.3-mm diameter balloon inflation lumen and a 0.7-mm diameter guide-wire/gas lumen. At the PWEB distal end is a 1-cm long, elliptical, low pressure, high volume balloon inflated via the 0.3-mm lumen. The

FIGURE 1 The pediatric wire-guided endobronchial blocker (PWEB) is coupled to the fibreoptic bronchoscope in the special bronchoscopy port (SBP).

0.7-mm lumen contains a guide wire passing through the PWEB, where it exits as a small loop with approximately a 6-mm diameter. The loop size is varied by extending and retracting the wire within the PWEB. Following PWEB placement, the guide wire may be removed and the lumen used for suctioning or providing CPAP of the isolated lung segment. The PWEB is placed through a SBP. The SBP offers multiple access ports allowing simultaneous introduction of a pediatric bronchoscope and PWEB while maintaining mechanical ventilation. The bronchoscopy port has a standard plastic sealing cap. The PWEB port has a Tuohy-Borst type valve to lock the PWEB in place, maintain an airtight seal or allow free PWEB movement by loosening the valve. The PWEB port is oriented at a 30° angle to the bronchoscopy port to facilitate introduction of both devices into the endotracheal tube. Prior to PWEB placement, the PWEB shaft, guide wire loop and pedi-

FIGURE 2 The bronchoscope is advanced into the selected bronchus independent of the pediatric wire-guided endobronchial blocker (PWEB).

atric fibreoptic bronchoscope were all lubricated with a medical grade silicone lubricant. The wire loop was adjusted to loosely approximate the outer diameter (OD) of the 2.0-mm Pentax pediatric bronchoscope and the PWEB passed through its SBP port. The SBP was then connected to the 7.0-mm ID cuffed endotracheal tube and ventilation maintained with 100% oxygen. The bronchoscope was then advanced into the SBP and passed through the guide wire loop of the PWEB, effectively coupling the two together (Figure 1). The bronchoscope was advanced into the left main stem bronchus (Figure 2). The threaded blocker port

FIGURE 3 Once the position is visualized by the bronchoscope, the pediatric wire-guided endobronchial blocker (PWEB) is passed over the bronchoscope and into the bronchus.

was then loosened and the PWEB advanced over the bronchoscope (Figure 3) until the guide loop exited the bronchoscope end (Figure 4). The guide wire loop kept the PWEB in close approximation to the bronchoscope, guiding it into the left main stem bronchus. As the bronchoscope was withdrawn, the position of the PWEB was verified and the balloon slowly inflated under direct vision (Figure 5) until the entire bronchial lumen was occluded. This required approximately 3 mL

FIGURE 4 The pediatric wire-guided endobronchial blocker (PWEB) is uncoupled from the bronchoscope and the bronchoscope is pulled back into the trachea.

of air (Figure 6). The bronchoscope was then removed and the PWEB locked in place by tightening the SBP cap down. Following thoracotomy, the balloon was again inflated. The lung immediately began to collapse due to absorption atelectasis and continued to deflate for approximately two minutes. The PWEB functioned well with no lung reinflation or PWEB dislodgment. Following surgical repair the PWEB balloon was deflated. The left lung was reinflated, the chest was closed and the PWEB system removed, leaving the patient

FIGURE 5 The balloon is inflated under direct fibreoptic view.

intubated with a 7.0-mm ID endotracheal tube. The patient was extubated at the end of the case and transported to the pediatric intensive care unit. The patient's postoperative course was uneventful and the patient was discharged home on postoperative day two.

Discussion

Single-lung ventilation is required frequently in thoracic surgery. However, this technique is difficult to achieve in the pediatric population, as the suitable equipment is limited. Previous techniques have included selective endobronchial intubation, balloon tipped bronchial

FIGURE 6 An *in vivo* view of the pediatric wire-guided endobronchial blocker (PWEB). The picture on the right shows the PWEB in the left bronchus with the balloon deflated. The picture on the left shows the PWEB with the balloon inflated.

blockers or Fogarty catheters, pediatric size Univent® (Vitaid Ltd., Lewiston, NY, USA) endotracheal tube and double-lumen tubes (Marraro pediatric bi-lumen tube).¹ However, each technique is associated with various problems. While selective endobronchial intubation under direct fibreoptic view may appear to be a simple technique requiring only a bronchoscope, there may be difficulty in creating an adequate seal for lung deflation, especially when an uncuffed endotracheal tube is used.¹ Balloon tipped bronchial blockers have been associated with displacement into the trachea proper and airway damage and rupture from the low volume, high pressure cuff.^{1,2} The pediatric Univent® endotracheal tube has a second lumen for the blocker thus increasing the outer tube diameter and a balloon requiring large volumes of air.^{1,3} The Marraro bi-lumen tube with its small tube diameter and increased length, produces high airway resistance.^{1,4}

The PWEB system is a new version of the wire guide endobronchial blocker used in adults. The most important advantage of this system is its impact on the ID total cross sectional area of a conventional endotracheal tube. This design incorporates a new smaller 5-French diameter catheter with a cross sectional area of only 2.2 mm². When this device is installed in a 7.0-mm ID endotracheal tube the total cross sectional area is 36 mm², including the blocker. In comparison, a 28-

French endotracheal tube has the same approximate OD as a 7.0-mm ID endotracheal tube yet only offers a total cross sectional area of 15.5 mm², approximately the size of a 4.5-mm ID endotracheal tube. And since the ID of the bronchial lumen of a double-lumen tube is 3.2 mm², the patient is ventilated during single-lung ventilation through an equivalent cross sectional area of a 3.0-mm ID endotracheal tube. Therefore based on these considerations, the PWEB offers the clinician the option of achieving single-lung ventilation with small endotracheal tubes while maintaining a large ID cross sectional area for maximal ventilation. This system allows one to conserve total internal cross sectional area of the conventional endotracheal tube.

There are further advantages to this system. The PWEB fits into conventional endotracheal tubes as small as a 4.5-mm ID. The PWEB is placed with a conventional pediatric or 2.0-mm OD neonatal fibre-optic scope. The integral guide wire loop couples the PWEB to the bronchoscope, allowing the bronchoscope to guide the PWEB into position quickly and precisely. Removal of the guide wire following placement provides a lumen for insufflating or removing gas from the blocked segment.

Finally, the balloon has an elliptical shape to offer maximal contact with the bronchial wall and minimize the likelihood of dislodgment and bronchial rupture.

Also, it incorporates a low pressure, high volume design to minimize balloon airway trauma. The SBP is also unique to the PWEB system. It is a hollow body that houses four ports for fiberoptic bronchoscopy, endobronchial blockade, mechanical ventilation and endotracheal tube connection. This arrangement facilitates the maintenance of ventilation during blocker placement. This is especially useful in pediatric patients who are at risk of rapid desaturation. The incorporation of a compressible diaphragm in the blocker port allows fixation of the position of the blocker and establishment of an airtight seal.

The PWEB system is designed to be placed fibre-optically and under direct vision. Since a balloon tipped catheter is inserted in the airway, there is always the possibility of balloon herniation into the trachea or overinflation and damage to the airway. The device balloon should always be inflated under direct vision to ensure the correct volume of air is used. It is not necessary to reinsert the bronchoscope every time it is inflated, only to fully deflate and inflate initially with the correct volume of air.

In conclusion, the PWEB system offers a new tool to achieve single-lung ventilation in the pediatric patient. It offers the clinician another alternative for managing a challenging pediatric anesthesia situation.

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