CASE REPORTS

Single-lung Ventilation in a Critically Ill Patient Using a Fiberoptically Directed Wire-guided Endobronchial Blocker

George A. Arndt, M.D.,* Paul W. Kraner, M.D.,† Deborah A. Rusy, M.D.,† Robert Love, M.D.†

INTRAOPERATIVELY, one-lung ventilation (OLV) may be achieved with a double-lumen (DLT) or Univent endotracheal tube but postoperatively may be changed to a single-lumen endotracheal tube. We report the use of a new fiberoptically directable wire-guided endobronchial blocker (WEB), developed by one of the authors, in a critically ill patient after lung transplantation. The technique allows precise and timely placement of an endobronchial blocker using a conventional endotracheal tube, fiberoptic bronchoscope, and special bronchoscopy port (SBP).

Case Report

A 67-yr-old, 78-kg woman underwent bilateral lung transplantation for severe chronic obstructive pulmonary disease. Her medical history was significant for a previous anterior wall myocardial infarction, paroxysmal atrial tachycardia, gastroesophageal reflux, and non-insulin-dependent diabetes mellitus. She had failed previous lung volume reduction surgery. Intraoperatively, she was managed with a DLT, which was changed to a single-lumen, 8.5-mm ID endotracheal tube at the conclusion of surgery. Her intraoperative course was unremarkable.

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* Associate Professor of Anesthesiology.
† Assistant Professor of Anesthesiology.
‡ Assistant Professor of Cardiothoracic Surgery.

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Address reprint requests to Dr. Arndt: Department of Anesthesiology, University of Wisconsin Clinical Sciences Center, B6/319 CSC, 600 Highland Avenue, Madison, Wisconsin 53792-3272. Address electronic mail to: gaarndt@facstaff.wisc.edu

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The patient’s clinical condition deteriorated in the hours after her arrival to the intensive care unit (ICU). Active bleeding of 100–400 cc/h primarily through the right chest tube and coagulopathy necessitated transfusion of 10 U of packed erythrocytes, 6 U of fresh frozen plasma, 6 U of cryoprecipitate, and 20 U of platelets. She was hemodynamically unstable, requiring dopamine and dobutamine infusions to maintain a systolic blood pressure between 70 and 150 mmHg. Svo2 was 92–94% on FiO2 100%, pressure-controlled ventilation with a peak of 33 cm H2O, rate 20 breaths/min, with positive end-expiratory pressure (PEEP) 8 cm H2O. Nitric oxide was administered at 80 ppm. The patient received insulin, aminophylline, FK-506, midazolam, morphine sulfate, and cisatracurium infusions.

After 14 h of ongoing hemorrhage and hemodynamic instability, the decision was made to surgically reexplore the patient in the ICU. The anesthesiology service was consulted to provide OLV for surgical exposure. Fiberoptic placement of a WEB was chosen, and informed consent for investigational placement was obtained from the patient’s husband following University of Wisconsin Institutional Review Board protocol.

The WEB system is placed coaxially through a conventional endotracheal tube using a pediatric bronchoscope and SBP. In this patient, it was placed through an 8.5-mm ID endotracheal tube. The WEB (Cook Inc., Bloomington, IN) is 9 French, 70-cm, double-lumen catheter with 1.4-mm and 0.4-mm ID lumens. The catheter is made from a radio-opaque radiologic plastic material commonly used for angiography. At the distal end is a 3.0-cm, elliptical, low-pressure, high-volume balloon inflated via the 0.4-mm lumen. The 1.4-mm lumen contains a flexible wire passing through a Leuer fitting at the proximal end of the catheter and extending to the distal end, where it exits as a small, flexible wire loop of approximately 6 mm diameter. The size of the loop is variable by extending and retracting the wire within the Leuer fitting. Alternately, the wire may be removed completely and the lumen used for suctioning or continuous positive airway pressure of the isolated lung.

The WEB is placed through a SBP (Cook Inc.). The SBP offers multiple access ports, allowing simultaneous introduction of the bronchoscope and WEB while maintaining ventilation of the patient. The bronchoscopy port has a standard plastic sealing cap, whereas the WEB port has a Tuohy-Borst type valve that locks the block in place and maintains an air-tight seal. The WEB port is oriented 30° to the bronchoscopy port to facilitate introduction of both devices into the endotracheal tube.

Before placement of the endobronchial blocker, the WEB shaft, wire loop, and fiberoptic bronchoscope are all lubricated with a medical grade silicone lubricant. The wire loop is adjusted to loosely approximate the outer diameter of the bronchoscope (3.4 mm OD Pentax, Tokyo, Japan), and the WEB is passed through its port in the SBP. The SBP can then be connected to the endotracheal tube and ventilation...
Fig. 1. Wire-guided endobronchial blocker installed through the special bronchoscopy port and an endotracheal tube. A fiberoptic bronchoscope has been placed through the endotracheal tube and the guidewire loop. This system allows one-lung ventilation to be performed using a conventional single-lumen endotracheal tube. Unique features of this system are the special bronchoscopy port, which contains a port specifically meant for holding an endobronchial blocker and making an air-tight seal. The distal end of the endobronchial blocker contains a small wire loop, which effectively couples the endobronchial blocker and fiberoptic bronchoscope together yet allowing them to move independently. The bronchoscope is then advanced into the SBP and passed through the wire loop of the WEB, effectively coupling the two together. Figure 1 shows the WEB, SBP, and endotracheal tube with the pediatric fiberoptic scope inserted. In this patient, the right mainstem bronchus was blocked; however, in other patients, the authors have blocked the left mainstem bronchus easily using the loop guide system. Figure 2 shows a close-up of the fiberoptic bronchoscope through the guidewire loop.

Bronchoscopy in our patient proved to be technically difficult because of airway edema and serosanguineous fluid. Initial surgical exploration was to be directed at the right lung, so the bronchoscope was advanced into the right mainstem bronchus. The threaded blocker port was then loosened, and the WEB was advanced. The wire loop kept the WEB in close approximation to the bronchoscope, guiding it into the right mainstem bronchus. As the bronchoscope was withdrawn, the position of the WEB was verified, and the balloon was slowly inflated until direct vision of the entire bronchial lumen was occluded (requiring 14 cc of air).

The lung immediately began to collapse as a result of absorption atelectasis and continued to deflate for approximately 3 min. A large tear in the right upper lobe was identified and oversewn, as was a small aortic bleeder. The lung was intermittently reinflated based on vital signs requiring intubation, with a total of three deflation-inflation cycles. After surgical repair, the chest was closed, and the WEB system was removed.

Discussion

Critically ill patients requiring OLV in the ICU setting present a clinical dilemma. DLT or Univent endotracheal tubes may be used, but both require reintubation, and it may be advantageous to manage critically ill patients with a conventional single-lumen endotracheal tube. The continuation of DLTs from the operating room is problematic because of displacement or tracheal damage. The 8.5-mm ID endotracheal tube used in this patient will have less flow resistance than a 6.5-mm ID Univent endotracheal tube, but will have the same approximate outer diameter. The decreased inner diameter results from channel molded for the blocker.

One-lung ventilation can also be achieved with the use of a Fogarty embolectomy catheter. The Fogarty catheter was designed for embolectomies and not airway management. The balloon is spherical, predisposing to dislodgement with surgical manipulation, and is designed to be inflated with saline solution (unlike other airway device balloons). The WEB balloon is elliptical to offer increased contact area between it and the airway. The balloon has been designed to be filled with air and is a low-pressure, high-volume type. The Fogarty incorporates only a single lumen for balloon inflation, leaving no means for gas insufflation or removal of gas from a blocked area. Placement may be challenging because of the lack of a guide mechanism. The use of a bronchoscope to place the catheter under direct vision requires one or two conventional bronchoscopy ports placed in series. In the authors’ experience, after placement, gas...
leakage from conventional bronchoscopy ports remains a problem.

The WEB system was specifically designed to achieve OLV with a single-lumen endotracheal tube. Two patents are pending on this device, which are assigned to Cook, Inc. First of all, it allows OLV to be achieved in patients with conventional endotracheal tubes. An 8.0- or 8.5-mm ID endotracheal is preferable, but placement is technically possible through tubes as small as 6.5-mm ID. The WEB is placed using a conventional pediatric fiberoptic bronchoscope, which is commonly available and is the standard of care for positioning DLTs in many institutions. The integral guidewire loop couples the WEB to the bronchoscope, allowing the scope to guide the WEB into position quickly and precisely. The flexible wire loop holds the blocker in loose approximation to the pediatric bronchoscope, allowing it to be advanced without damaging the bronchoscope. Removal of the wire after placement provides a lumen for insufflating or removing gas from the blocked segment. Finally, the elliptical shape of the balloon offers maximal contact with the bronchial wall and minimizes the likelihood of dislodgement caused by surgical manipulation.

The SBP is a hollow body that incorporates four ports for fiberoptic bronchoscopy, endobronchial blockade, mechanical ventilation, and endotracheal tube connection. This arrangement facilitates the maintenance of ventilation during placement of the blocker. The incorporation of a compressible diaphragm in the blocker port allows fixation of the position of the blocker and establishment of an air-tight seal.

In conclusion, the WEB system is not a replacement for either DLTs or Univent endotracheal tubes. It, however, offers another tool to achieve OLV. It will allow the clinician to achieve OLV with a single-lumen endotracheal tube in those situations when management is optimal with a single-lumen endotracheal tube.

References


