

BRONCHIAL BLOCKERS

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I. INTRODUCTION

Separation of two lungs is essential for a variety of thoracic surgical procedures and can be life-saving in certain clinical situations. A variety of methods have been described and used to isolate one lung. These methods include mainstem intubation of a standard endotracheal tube (ETT), double-lumen ETT (DLT), and a variety of bronchial blockers. This lecture will discuss the various ways to provide one-lung anesthesia using bronchial blockers. I briefly discuss the DLT, as it serves as a comparison.

II. ABSOLUTE AND RELATIVE INDICATIONS FOR TWO LUNG SEPARATION

Absolute indications for one-lung ventilation (OLV) are not usually related to types of surgical procedures. Instead, absolute indications are related to contamination of a normal lung and in difficulties with ventilation due to large air leaks. The remaining indications are all relative, however, certain procedures have a higher priority than others. Many categorize video assisted thoracoscopic surgery (VATS) as a relative indication, however, I believe it is an absolute indication as the surgery would be next to impossible without OLV. Below is a table (adapted from *Anesthesia for Thoracic Surgery*, by Benumof) listing the absolute and relative indications for separation of two lungs and/or OLV.

Table 1. Indications For Separation Of Two Lungs and/or OLV

ABSOLUTE

1. To avoid contamination of a non-diseased lung
 - A. Infection (e.g. unilateral pulmonary abscess)
 - B. Massive pulmonary hemorrhage
 - C. Unilateral pulmonary lavage (e.g. for pulmonary alveolar proteinosis)
2. Control of distribution of ventilation
 - A. Bronchopleural fistula
 - B. Bronchopleural cutaneous fistula
 - C. Surgical opening of a major conducting airway
 - D. Giant unilateral lung cyst or bulla
 - E. Tracheobronchial tree disruption
 - F. Life-threatening hypoxemia due to unilateral lung disease
3. Video assisted thoracoscopy (VATS)

RELATIVE

1. High Priority
 - A. Thoracic aortic aneurysm repair
 - B. Pneumonectomy
 - C. Pulmonary resection via median sternotomy
 - D. Upper lobectomy
 - E. Lung transplantation
2. Medium Priority
 - A. Middle and lower lobectomies and subsegmental resections
 - B. Esophageal resection
 - C. Thoracic spine procedures
3. Other
 - A. Post-cardiopulmonary bypass status after removal of totally occluding chronic unilateral pulmonary emboli
 - B. Unilateral lung disease causing severe hypoxemia

III. DOUBLE-LUMEN ENDOTRACHEAL TUBES

The double-lumen ETT (DLT) is briefly discussed, as it provides a comparison for bronchial blockers. In my opinion, a DLT is the “gold-standard” for providing lung isolation and OLV. Several advantages of a DLT exist when compared to a bronchial blocker. First, a DLT allows for independent suctioning of each lung. The isolated lung can be suctioned at any time without deflating the cuff and losing lung isolation. Second, each lung can be separately ventilated through a DLT. Finally, continuous positive airway pressure (CPAP) is more easily applied through a DLT.

Although a DLT is the gold standard for lung isolation and OLV, disadvantages and contraindications do exist. To begin, it may be impossible to place a DLT in a patient with a difficult airway. The large size and design of DLTs can cause airway damage during insertion, prolonged use, and removal. At times, they can be very difficult to place and properly position, especially if the tracheal or bronchial anatomy is severely distorted. Lesions within the trachea, i.e. tumors, are relative contraindications to DLT placement. Additionally, mechanical ventilation may be required postoperatively and changing a DLT to a single-lumen ETT at the end of surgery can be hazardous. Along these same lines, an intubated patient may present for a surgery requiring OLV, which would necessitate the need for changing from a single-lumen ETT to a DLT. Changing ETTs is especially dangerous in patients who have received massive infusions of blood products and other fluids, those with cervical spine injuries, difficult airways, and in those that will not tolerate periods of apnea. DLTs are made in limited sizes, 28, 35, 37, 39, and 41 French and are often too big for the majority of pediatric patients. Finally, the lumens of DLTs are narrow. Later in the handout, a comparison of internal diameters between ETTs, DLTs, and Univent ETTs will be compared. Finally, DLTs do not allow

for single lobe isolation. The above drawbacks can be addressed and remedied by using bronchial blockers.

IV. BRONCHIAL BLOCKERS

A variety of devices have been used and developed as bronchial blockers to provide lung isolation. These include the Univent system (Torque Control Blocker Univent®, Vitaid Lewinston, NY), Fogarty embolectomy catheters (Edwards Lifesciences, Irving CA), Foley catheters, balloon-tipped pulmonary artery catheters, and most recently, the Arndt endobronchial blocker system (Cook® Critical Care, Bloomington, IN). Bronchial blockers can overcome the previously discussed disadvantages and contraindications of DLT use.

ADVANTAGES

In patients with a recognized and/or unrecognized difficult airway, placement of a DLT with direct laryngoscopy can be extremely difficult and at times, impossible. This includes patients with cervical spine injuries and/or pathology. In this situation, placement of a single-lumen ETT is easier and often necessary, requiring the need for a bronchial blocker for subsequent lung isolation.

Placing a DLT in patients with distorted tracheobronchial anatomy is often difficult and at times, contraindicated. Use of a bronchial blocker, in this situation, is more often successful and safe.

Often, intubated patients present for surgery requiring OLV. These include trauma patients and patients from the emergency department and ICU. In addition, occasionally these patients are nasally intubated. Also, the particular surgery or intraoperative events (i.e. massive fluid infusion) will require postoperative ventilation. Use of a bronchial blocker negates the need to change the ETT in these situations, therefore avoiding the possibility of losing the airway altogether. Furthermore, some of these patients may not tolerate periods of apnea. Some bronchial blockers can be placed during continuous ventilation.

CPAP can be applied through several bronchial blockers, as well. Additionally, bronchial blockers can provide selective blockade of a specific lobe. This is particularly useful in the patient with an isolated air leak, hemorrhage, or infection in one lobe, thereby allowing ventilation of more lung units. Finally, bronchial blockers are useful in patients who have had a prior pneumonectomy and now present for a selective lobectomy.

LIMITATIONS

Bronchial blockers do have limitations. Collapse of the desired lung is often slow. Several bronchial blockers have a small lumen, which can be connected to suction,

facilitating a more rapid deflation of the lung. Another alternative is to deflate the bronchial blocker and allow gas to exit through the ETT. Once the lung is collapsed, the bronchial blocker cuff is inflated and the other lung is expanded. Finally, the surgeon can manually compress the lung while the bronchial blocker cuff is down. Once the lung is collapsed, the cuff is inflated.

Bronchial blockers do not allow for suctioning of the deflated lung, as compared to a DLT. The small lumens of some bronchial blockers allow for suctioning of air, but secretions, blood, and pus cannot be eliminated through them. Occasionally, secretions, blood, and/or pus obstruct the small lumen of the bronchial blocker, thereby preventing the application of CPAP. This is remedied by injecting saline or by placing suction and/or an appropriate sized wire down the lumen.

Bronchial blockers are more easily dislodged during patient positioning and surgical manipulation of the lung. Elliptical-shaped balloons, versus spherical, help to prevent dislodgment. Whenever, patient position is changed, correct bronchial blocker placement needs to be confirmed with bronchoscopy. If the blocker dislodges during the procedure, it can be repositioned with the aid of a fiberoptic scope or by having the surgeon manually guide it into position. The Arndt bronchial blocker is easier to reposition with the aid of a fiberoptic scope, by nature of its wire-guided tip (discussed later).

Bronchial blockers present the potential risk of perforating a bronchus or lung parenchyma causing a pneumothorax.

Finally, bronchial blockers are more easily used when collapse of the left lung is indicated. The left upper lobe takeoff is, on average, about 4 cm distal to the carina. This allows ample space to place the bronchial blocker cuff within the left mainstem bronchus. In comparison, the right upper lobe takeoff is, on average, about 19 mm distal to the carina. However, the right mainstem bronchus takeoff can be quite variable and at times, the right upper lobe can come off of the trachea. Hence, at times blocking the right upper lobe is impossible preventing isolation of the entire right lung. This can be overcome, albeit with some difficulty, by using two separate bronchial blockers on the right side. Also, a spherical-shaped balloon is more successful at blocking the right upper lobe when isolating the entire right lung.

A. The Univent Tube®



The Univent tube, introduced in 1982, is a single-lumen silicone tube with a small separate lumen along the anterior concave wall. This separate lumen contains the small hollow nonlatex bronchial blocker that can extend about 8-10 cm beyond the tip. The

lumen of the bronchial blocker is 2 mm in internal diameter. The Univent is supplied in sizes 6.0-9.0 mm internal diameter, however, the anterior channel for the blocker adds significantly to its overall external diameter size. See table 2 below for ETT, DLT, and Univent ETT comparisons.

Table 2

Single-lumen endotracheal tube ^a		Univent® tube		Double-lumen endotracheal tube ^c			
ID	OD	ID	OD ^b	French	OD	Bronchial ID	Tracheal ID
6.0	8.2	6.0	9.7/11.5	26	8.7	3.5	3.5
6.5	8.9	6.5	10.2/12.0	28	9.3	3.2	3.1
7.0	9.6	7.0	10.7/12.5	32	10.7	3.4	3.5
7.5	10.2	7.5	11.2/13.0	35	11.7	4.3	4.5
8.0	10.9	8.0	11.7/13.5	37	12.3	4.5	4.7
8.5	11.5	8.5	12.2/14.0	39	13.0	4.9	4.9
9.0	12.1	9.0	12.7/14.5	41	13.7	5.4	5.4
10.0	13.5						

Sizes are given in millimeters.

^a Sheridan Hudson Respiratory Care, Inc., Temecula, CA.

^b Two OD measures are given because of the oval shape of the tube.

^c Rüsch (Duluth, GA) (26), Sheridan (Argyle, NY) (32), Mallinckrodt (St. Louis, MO) (28, 35, 37, 39, 41).

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The high-pressure, low-volume bronchial cuff is blue to help visualize the cuff during positioning. When blindly passed, the blocker will enter the right mainstem the majority of the time. Once the Univent is placed, a fiberoptic scope should be used to visualize correct placement of the blocker. Often, the Univent tube needs to be rotated about 90° to the left so that the blocker can be more easily guided into the left mainstem. Visualization during placement of the blocker also helps to prevent perforation of the trachea by the somewhat stiff bronchial blocker.

-Advantages

The Univent has several advantages over a DLT. It is easier to initially insert and can be placed nasally, as well. The blocker can provide selective lobe blockade. The blocker is hollow and allows for continuous positive airway pressure (CPAP) if needed and high-frequency jet ventilation has successfully been used in a patient with a tracheal carina resection. Finally, the Univent can be used to provide postoperative ventilation without the need for a dangerous tube change at the conclusion of surgery.

-Limitations

The Univent has all of the limitations of bronchial blockers as previously discussed. Additionally, one must be careful with tube selection, because of the large overall size of the Univent. At times, the bronchial blocker of the Univent can be very difficult to place down the left mainstem bronchus. Fragments torn from the inner wall when the connector was reattached to the tube resulted in aspiration of silicone material into the bronchus. Finally, from my own personal experience, the Univent is quite rigid and does not soften when in-situ. I have seen tracheal mucosal damage from a Univent left in place for postoperative ventilation. I was asked by the surgeons to replace the Univent with a normal ETT, because of the mucosal damage caused by the Univent ETT.

B. Fogarty Embolectomy, Foley, and Balloon-Tipped Pulmonary Artery Catheters

Fogarty, Foley, and pulmonary artery catheters have all been used to provide lung isolation. However, they are complicated and difficult to use for this purpose, as they were not designed for lung isolation. To begin, guiding these catheters into the left mainstem bronchus is difficult and at times, practitioners have had to use rigid bronchoscopy for placement. Often, these catheters are placed through the lumen of the ETT and brought out through a suction adapter placed on the connecting elbow. Typically, an air leak results, requiring waterproof tape, bone wax, or some other novel approach. A variety of methods have been described to overcome the air leak, including the use of multiple elbow adapters, syringes, and perforating the ETT with the bronchial blocker. For further inquiry, please refer to the references at the end of the handout. Another option is to place the catheter into the trachea along side the ETT. With either option, it is difficult to properly position the catheter and it is difficult to ventilate the patient during positioning of the bronchial blocker. Furthermore, should the catheter become dislodged, it is very difficult to reposition. Which brings up the final point. These catheters have spherical balloons, as opposed to elliptical, and frequently displace from the left mainstem bronchus.

With the above in mind, I cannot recommend the use of these catheters for lung isolation and OLV.

C. Arndt Endobronchial Blocker

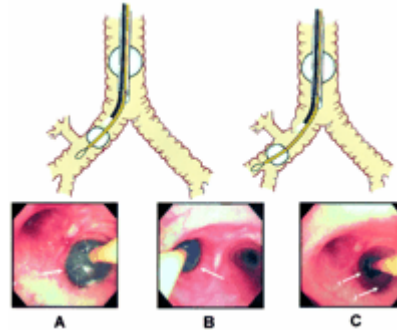


George Arndt, M.D., from the University of Wisconsin-Madison, designed and developed a very simple, yet very effective bronchial blocker. The Arndt endobronchial blocker (AEBB) solves many of the problems of the above blockers and it is used with a standard ETT. All of the discussed advantages apply to the AEBB. Its design makes it, in my opinion, the bronchial blocker of choice.

The Arndt endobronchial blocker (AEBB) is available as a 7 or 9 French, wire-guided, yellow catheter, 65 and 78cm lengths, with centimeter markings from 10-60. The high-volume, low-pressure balloon is blue, which allows for easy identification and its elliptical shape prevents dislodgment from the left mainstem bronchus. It also comes with a spherical balloon, which is more advantageous when placing it in the right mainstem bronchus in order to block the right upper lobe. It has a looped nylon wire, which exists through a 1.4mm lumen. Supplied with the blocker is a multiport adapter. The adapter has a 15 mm port that attaches to the ETT, a port for the blocker that can be tightened to secure the catheter in place, a port for a flexible fiberoptic scope, and a ventilation port that connects to the breathing circuit. Finally, a 15 mm adapter is supplied which fits into the lumen of the blocker and can attach to a standard CPAP circuit. A 7 French AEBB is best used with a 7.0mm ID or larger ETT and the 9 French with a 8.0mm ID or larger ETT.

(Of note, a pediatric, 5 French Arndt bronchial blocker with a 2 French lumen is also available.)

The above design makes the Arndt very simple to use. The fiberoptic scope (a pediatric scope is most easily used) and the blocker are placed through their specific ports in the adapter. One important key is to use an adequate amount of lubricant on the scope and the blocker. The scope is threaded through the wire loop at the end of the blocker and the wire loop should remain loose. The entire unit is placed on the ETT and the circuit connected to the ventilation port, allowing continuous ventilation during placement. The fiberoptic scope is “driven” into the left mainstem bronchus and the blocker is gently passed down over the scope until resistance is encountered. The scope is then gently withdrawn until the carina and the blocker are in view. Once accomplished, the balloon is positioned appropriately below the carina and is then inflated.



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A-Right Mainstem B-Left Mainstem C-Selective Lobe

It is possible to remove the wire from the blocker allowing for more space within the lumen, however, I do not recommend this, as it is nearly impossible to replace the wire through the lumen. I leave the wire in the lumen of the blocker in case the catheter needs repositioning. Once the patient is positioned, fiberoptic confirmation of proper placement is critical. Placing the blocker with the patient supine is easiest. However, if the blocker becomes dislodged during positioning or during surgery, the wire allows for easy replacement of the catheter into its proper position. Occasionally, the blocker fails to go into the left mainstem. A helpful hint is to turn the patient's head to the right when passing the blocker over the scope, allowing the catheter to be guided more easily into the left mainstem. Finally, advancing the blocker about one centimeter before turning the patient from supine to the lateral decubitus position, helps prevent blocker dislodgement during patient positioning.

When the blocker is no longer needed, the balloon is deflated. Then, the catheter and the multiport adapter are simply removed *together* and the breathing circuit reattached to the ETT. There has been one report of the cuff shearing off when the blocker was pulled completely out of its port before removal of the multiport adapter from the ETT. If postoperative ventilation is required, a standard ETT is already in place and the need for exchanging the tube is negated.

As a final note, the AEBB can also be used through a nasal ETT or through a tracheostomy tube.

V. SUMMARY

A variety of techniques and equipment are available to provide lung isolation and/or one-lung ventilation. As discussed above the DLT is the gold standard, however, it has several disadvantages, contraindications, and pitfalls. Many times, a bronchial blocker is advantageous, for the reasons discussed above. In this instance, the Arndt is the preferred bronchial blocker of choice, because of its design, ease of use, and low complication rate. As a side note, Table 3 below lists the acquisition costs, at Denver Health Medical Center, of some of the various devices.

Table 3: Acquisition Costs (Denver Health Medical Center)

<u>Sheridan DLT</u>	<u>\$54.00</u>
<u>Arndt Endobronchial Blocker</u>	<u>\$110.00</u>
<u>Univent Tube</u>	<u>\$130.00</u>
<u>Fogarty Catheter</u>	<u>\$85.00-\$217.00</u>

(We stock multiple brands of Fogarty catheters)

Cost of losing an airway during a ETT exchange: Priceless

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