An Update on the Use of Bronchial Blockers

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Introduction

Techniques for one-lung ventilation (OLV) can be accomplished with two different methods. The first and more commonly used involves the use of a double-lumen endotracheal tube (DLT), which independently can block either the right or left lung.\(^1\)\(^-\)\(^2\) The second method involves blockade of a mainstem bronchus or a selective bronchus with the use of a bronchial blocker (BB) to allow lung collapse distal to the occlusion.\(^3\)\(^-\)\(^4\)\(^-\)\(^5\)

Recent advances in surgical techniques for thoracic, cardiac, or esophageal surgery have led to an increased use of lung separation techniques. Minimally invasive surgery for robotic, thorascopic or cardiac surgery has required more use of methods of lung isolation with a single-lumen endotracheal tube complemented by the use of a BB.\(^6\)\(^-\)\(^7\)

In contemporary thoracic anesthesia there are four BBs that have been introduced in clinical practice in recent years: the Arndt,\(^8\) the Cohen flexitip,\(^9\) the Fuji Uniblocker,\(^10\) and the EZ-Blocker.\(^11\) The purpose of this review is to provide an update on the use of bronchial blockers. The basic principle of successful lung isolation with a BB relies on familiarity with the devices, knowledge of tracheobronchial anatomy, skills with fiberoptic bronchoscopy, and awareness of potential problems and complications.

Familiarity with Bronchial Blockers

The current BBs used in thoracic anesthesia are designed in a form of catheter with one or two distal balloons incorporated near the tip that, when inflated, interrupt airflow distal to the occlusion.

The Arndt Blocker

The Arndt BB is attached to a 5F, 7F, or 9F catheter that is available in 65 cm and 78 cm lengths with an inner lumen that measures 1.4 mm in diameter. Near the distal end of the catheter, there are side holes (Murphy eyes) incorporated to facilitate deflation. These side holes are present in the 9F Arndt blocker only. The Arndt blocker has a high-volume, low-pressure cuff with either an elliptical or spherical shape. I personally prefer to use the spherical shaped balloon whenever I use this blocker. A unique feature of the Arndt blocker is that the inner lumen contains a flexible nylon wire passing through the proximal end of the catheter and extending to the distal end, which exists as a small flexible wire-loop. The wire-loop of the Arndt blocker is coupled with the fiberoptic bronchoscope and serves as a guide wire to introduce the blocker into a bronchus.

The Cohen Flexitip Blocker

In principle, the Cohen blocker is quite similar to the Arndt blocker. This blocker is available only in size 9F and 65 cm length with an inner lumen measuring 1.6 mm in diameter. This device comes with a spherically shaped balloon. Near the distal end of the catheter there are side holes (Murphy eyes) incorporated to facilitate lung deflation. This BB also has a high-volume, low-pressure cuff. The Cohen blocker relies on a wheel-twisting device located in the most proximal part of the unit that allows deflecting of the tip of the distal part of the blocker into the desired bronchus. This device has been purposely pre-angled at the distal tip to facilitate insertion into a target bronchus. Also, there is a torque grip located at the 55 cm mark to allow rotation of the blocker. In the distal tip above the balloon, there is an arrow that when seen with the fiberoptic bronchoscope indicates which direction the tip deflects.
The Fuji Uniblocker
The Fuji blocker is an independent BB that is available in 4.5F and 9F size and is 65 cm in length and has a high-volume balloon made of silicone with a gas barrier property to reduce diffusion of gas into or out of the cuff. Also, with its maximal cuff inflation of 6 ml of air, this new BB’s transmitted pressure, as tested in vitro, is <30 mmHg, which does not exceed the recommended safety limit in relationship to bronchial mucosa. The Fuji blocker has a torque-control blocker with an incorporated shaft that allows guidance through the desired bronchus.12

The EZ-Blocker
The EZ-blocker is a new BB that has a Y-shaped distal end. The peculiar characteristic of this device is that both distal ends are fitted with an inflatable cuff and a center hollow channel in each end. Therefore each inflatable balloon can be placed on the right or left mainstem bronchus, respectively. The shape of this balloon is spherical and there is only one size available at the present time, 7F.

All independent BBs come with a multiport connector where a blocker and a fiberoptic bronchoscope can be passed separately. Also, in the vast majority of the cases, a single-lumen endotracheal tube is used first, followed by a BB.13 Table 1 describes the specific characteristics of the BBs. Figure 1 shows A) the distal tip of an Arndt blocker, B) the Cohen flexitip blocker, C) the Fuji Uniblocker, and D) the EZ-Blocker with a bifurcated distal tip with a balloon in each end.

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Arndt Blocker</th>
<th>Cohen Blocker</th>
<th>Fuji Uniblocker</th>
<th>EZ Blocker</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td>5F, 7F, and 9F</td>
<td>9F</td>
<td>4.5F, 9F</td>
<td>7F</td>
</tr>
<tr>
<td><strong>Balloon shape</strong></td>
<td>Spherical or elliptical</td>
<td>Spherical</td>
<td>Spherical</td>
<td>Spherical x 2</td>
</tr>
<tr>
<td><strong>Guidance mechanism</strong></td>
<td>Nylon wire loop that is coupled with the fiberoptic bronchoscope</td>
<td>Wheel device to deflect the tip</td>
<td>None, preshaped tip</td>
<td>None</td>
</tr>
<tr>
<td>*<em>Smallest recommended <em>SLET for coaxial use</em></em></td>
<td>5F (4.5 SLET), 7F (7.0 SLET), 9F (8.0 SLET)</td>
<td>9F (8.0 SLET)</td>
<td>9F (8.0 SLET)</td>
<td>7.5</td>
</tr>
<tr>
<td><strong>Murphy eye</strong></td>
<td>Present in 9F</td>
<td>Present</td>
<td>Not Present</td>
<td>Not Present</td>
</tr>
<tr>
<td><strong>Center Channel</strong></td>
<td>1.4 mm internal diameter</td>
<td>1.6 mm internal diameter</td>
<td>2.0 mm internal diameter</td>
<td>1.4 mm internal diameter</td>
</tr>
</tbody>
</table>

SLET = Single-lumen endotracheal tube

Modified from: Campos JH.13 Curr Opin Anaesthesiol 2007; 202: 27-31
Knowledge of Tracheobronchial Anatomy

In order to achieve optimal position and performance with the use of BBs, every anesthesiologist must have knowledge of trachea and bronchial anatomy and its variants.\(^{(14)}\) In a study done by Campos et al\(^{(15)}\) it was shown that anesthesiologists with limited thoracic experience have a high incidence of malpositions (38%) while placing DLTs or BBs. In this study, one of the factors that contributed to unsuccessful placement of these devices was the lack of recognition of tracheobronchial anatomy.

The adult trachea is on average 15 cm long. The trachea is composed of 16–22 C-shaped cartilages. The cartilages compose the anterior and lateral walls of the trachea and are connected posteriorly by the membranous wall of the trachea, which lacks cartilage and is supported by the trachealis muscle. The average diameter in a normal trachea is 22 mm in men and 19 mm in women. The tracheal wall is about 3 mm in thickness. The trachea is located in the midline position, but often can be deviated to the right at the level of the aortic arch or due to a presence of left-sided mediastinal masses, advanced age, or the presence of severe chronic obstructive pulmonary disease.\(^{(16)}\)

The cricoid cartilage is the narrowest part of the trachea with an average diameter of 17 mm in men and 13 mm in women. The trachea bifurcates at the carina into the right and left mainstem bronchus. An important fact is that the tracheal lumen narrows slightly as it progresses towards the carina. The right mainstem bronchus lies in a more vertical orientation relative to the trachea; therefore, for use of a BB in the right bronchus, advancing the blocker through the single-lumen endotracheal tube (in the vast majority of cases), there is no need for any guidance mechanism because the alignment of the trachea and with the right bronchus seldom allows easy passage to the bronchus. In contrast, because the left mainstem bronchus lies in a more horizontal plane, whenever a BB is used for a left-sided bronchus a
guidance mechanism is needed via a wire loop attached to a bronchoscope (Arndt), a twisting wheel device (Cohen), or a torque rotation (Fuji Uniblocker). The right mainstem bronchus continues as the bronchus intermedius after the take-off of the right upper lobe bronchus. In men the distance from the tracheal carina to the take-off of the right upper lobe bronchus is an average of 2.0 cm, whereas it is approximately 1.5 cm in women. It is estimated that one in every 250 individuals from the general population may have an abnormal take-off of the right upper lobe bronchus beginning from above the tracheal carina on the right side.

Under these anatomical variations one alternative to achieve lung isolation with a BB is with the use of two separate BBs as reported by Wisher;\(^{(17)}\) one BB is advanced through the inner part of the single-lumen endotracheal tube and the other one is passed through the outer part of the endotracheal tube. In these cases a smaller blocker (e.g., Arndt 5F) should be used to block the entrance of the right upper lobe bronchus above the tracheal carina. It is important that every anesthesiologist recognizes the trifurcation of the right upper lobe bronchus, which consists of apical, anterior, and posterior division. This is an important landmark to identify while performing fiberoptic bronchoscopy in order to distinguish the right from the left mainstem bronchus. The distance from the tracheal carina to the bifurcation of the left upper and left lower lobe is approximately 5.0 cm in men and 4.5 cm in women (see figure 2). The left mainstem bronchus is longer than the right mainstem bronchus, and it divides into the left upper and the left lower lobe bronchus (for more detail information on tracheobronchial anatomy please refer to reference #14).

**Figure 2** Displays the anatomical distances of the airway. These anatomical distances apply to individuals with a height of 170 cm.
Skills with Fiberoptic Bronchoscopy during the Use of Bronchial Blockers

Because independent BBs rely on the use of a single-lumen endotracheal tube, selection of a size of a BB in a patient of average stature is not an issue. I prefer to use the largest single-lumen endotracheal tube whenever I use a 9F BB (i.e., 8.5 mm internal diameter); this facilitates an easy passage and advancement of the blocker and the flexible fiberoptic bronchoscope (3.5 or 4.0 mm outer diameter). Prior to the advancement of the BB, I always do, and recommend, a complete fiberoptic bronchoscopy exam to ensure that the distal tip of the single-lumen endotracheal tube is approximately 2–3 cm above tracheal carina and also to identify the tracheal carina and the exact location of the take-off of the right upper lobe bronchus. All BBs and the flexible fiberoptic bronchoscope need to be tested and lubricated prior to insertion into the airway. The advantage of the Cohen, Fuji Uniblocker, and EZ-blocker over the Arndt blocker is that during passage through the single-lumen endotracheal tube while using the fiberoptic bronchoscope, one can observe the direction of the tip of the blocker and deflect the blocker into a desired target bronchus. In contrast, with the Arndt blocker, when the guide wire is coupled with the fiberoptic bronchoscope the distal tip of the blocker is not seen because the fiberoptic bronchoscope is emerging farther than the tip of the blocker.

For a right mainstem bronchus blockade, all blockers can be advanced independently, and confirmation on the entrance into the right mainstem bronchus is done under fiberoptic visualization. I prefer to advance the BB 1 or 2 cm beyond the tracheal carina into the bronchus while the patient is still in the supine position; optimal placement is achieved when the patient is already turned into the lateral decubitus position. The optimal position in the right bronchus is achieved when the blocker balloon’s outer surface is seen with the fiberoptic bronchoscope at least 1 cm below the tracheal carina on the right bronchus and a proper seal is obtained when the balloon is inflated with approximately 6 ml of air.

For a left sided mainstem bronchus blockade, the Arndt blocker has the advantage of the wire guide while coupled with the fiberoptic bronchoscope because it can guide the blocker into the entrance of left bronchus. For the other blockers (Cohen, Fuji Uniblocker, and EZ-Blocker) turning the patient’s head to the right and twisting the torque part of the blocker facilitates insertion into the left bronchus; this is also done by deflecting the tip with the wheel device incorporated in the Cohen flexitip blocker. The optimal position in the left bronchus is achieved when the blocker balloon’s outer surface is seen with the fiberoptic bronchoscope at least 1 cm below tracheal carina on the left bronchus and a proper seal is obtained when the balloon is inflated with air after the patient is turned into the lateral decubitus position. Figure 3A and B display the proper placement of a BB with the balloon fully inflated.

Figure 3

A) bronchial balloon fully inflated in the entrance of right bronchus and B) on the left main bronchus.
How Do We Make the Bronchial Blocker Work?

In order to expedite lung collapse, denitrogenation of the lung that is to be collapsed with a $\text{FiO}_2$ 1.0 is a useful strategy to improve surgical conditions during OLV.\(^{(12)}\) In contrast, the use of air in the inspired gas mixture during two-lung ventilation and prior to OLV delays lung collapse during OLV.

Inflation of the BB balloon should be done after the patient is turned into the lateral decubitus position. Prior to inflation of the balloon, the ventilator should be turned off to allow the lung to drop; after the balloon is inflated ventilation is resumed. In addition, all BBs should be placed on suction for a few minutes by connecting an adaptor through the center channel to expedite lung collapse. The suction technique has been used and reported in previous studies.\(^{(10-18)}\) Two studies involving thoracic anesthesiologists with expertise in the use of BB have shown that lung collapse is clinically equivalent when compared to a left-sided DLT. In fact, lung collapse scores were ranked as optimal by the surgeons who were unaware of which device was used. However, both studies reported more malpositions with the groups that received a BB when compared to the DLT. This increase in malposition can be reflected by a learning curve while placing the BB; as more experience is acquired the problem with malposition becomes less of an issue. In addition, if during OLV with a BB unexpectedly there is an increase in peak inspiratory pressure (i.e., $>50 \text{ cm H}_2\text{O}$) it is likely that the blocker has been dislodged into the trachea. Therefore the balloon must be deflated immediately and inspection with fiberoptic bronchoscope ensues. Table 2 shows the advantages and disadvantages of DLTs and BBs.

Table 2

<table>
<thead>
<tr>
<th>Double-Lumen Endotracheal Tubes (DLTs)</th>
<th>Bronchial Blockers (BBs) (Arndt, Cohen, Fuji)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advantages</td>
<td>Advantages</td>
</tr>
<tr>
<td>• Large lumen facilitates suctioning</td>
<td>• Easy recognition of anatomy if the tip of a single tube is above carina</td>
</tr>
<tr>
<td>• Best device for absolute lung separation</td>
<td>• Best device for patients with difficult airways</td>
</tr>
<tr>
<td>• Conversion from 2- to 1-lung ventilation easy and reliable</td>
<td>• No cuff damage during intubation</td>
</tr>
<tr>
<td>Disadvantages</td>
<td>Disadvantages</td>
</tr>
<tr>
<td>• Difficulties in selecting proper size</td>
<td>• Small channel for suctioning</td>
</tr>
<tr>
<td>• Difficult to place during laryngoscopy</td>
<td>• Conversion from 1- to 2- then to 1-lung ventilation (problematic for the novice)</td>
</tr>
<tr>
<td>• Damage to tracheal cuff</td>
<td>• High-maintenance device (dislodgement or loss seal during surgery)</td>
</tr>
<tr>
<td>• Major tracheo-bronchial injuries</td>
<td></td>
</tr>
</tbody>
</table>

Modified from: Campos JH.\(^{13}\) Curr Opin Anaesthesiol 2007; 202: 27-31

Which Patients Will Benefit from the Use of Bronchial Blockers?

In contemporary thoracic anesthesia, for any patient who requires lung isolation and is scheduled for thoracoscopic surgery, minimally invasive robotic, or cardiac surgery, I recommend the use of a BB. Any patient who presents with a difficult intubation and requires awake nasotracheal or orotracheal intubation,
patients requiring selective lobar blockade, any patient with an existing tracheostomy in place, or patients who require mechanical ventilation in the postoperative period should receive a single-lumen endotracheal tube and a BB.\(^\text{[19-20]}\) In addition, a BB can be used as a rescue technique when a DLT failed to perform, as reported in some cases.\(^\text{[21-22]}\)

A study by Campos, et al\(^\text{[23]}\), in the morbidly obese patient undergoing OLV comparing a left-sided DLT with a single-lumen tube plus the Arndt® blocker showed that a similar degree of difficulty to pass the device at first attempt at laryngoscopy was found in both groups; 3/25 in the DLT group required a second laryngoscopy and 2/25 in the Arndt® blocker group. After the devices were placed in the optimal position the quality of lung collapse was clinically equivalent in both groups, therefore there is no specific advantage overall of the DLT over the bronchial blocker in the morbidly obese patient.

**Potential Problems and Limitations with the Use of Bronchial Blockers**

It is my personal opinion that misperception exists regarding the routine use of BB. This is due, in part, for the lack of use or improper use of BBs by anesthesiologists. If every anesthesiologist met the basic principles of lung isolation, the effective use of BBs should be no different than DLTs. Scientific evidence reported by our studies and others has clearly documented the effectiveness of these devices. Perhaps the only problem that I perceive with the BB is that it should be considered a high-maintenance device. One must be aware and alert of potential malpositions with catastrophic consequences such as dislodgement of the blocker balloon occluding the tracheal lumen of an endotracheal tube and resulting in a respiratory arrest and transient asystole.\(^\text{[24]}\) However, in general malpositions are easy to correct when they occur in the intraoperative period.

Another important consideration when comparing DLTs versus BBs is related to the airway injuries after OLV. A study reported by Knoll, et al\(^\text{[25]}\) showed that postoperative hoarseness occurred significantly more frequently in the DLT group, 44% versus 17% respectively, compared to the group that received a single-lumen endotracheal tube followed by a BB. Also, similar findings were observed for vocal cord lesions, 44% versus 17% respectively, in the 60 patients studied. However, the incidence of bronchial injuries was similar in both groups.

In contrast, a recent study by Ruetzler, et al\(^\text{[11]}\) comparing a DLT versus the EZ-blocker during OLV showed similar incidence of hoarseness and sore throat in the 40 patients studied (7/20 in the DLT group versus 8/19 in the EZ-blocker group). There were no reports of serious complications such as a bronchial rupture with the use of these lung isolation devices. Although serious complications have been reported with the use of current BBs, these complications appear to be more benign than those involving DLT’s.\(^\text{[13]}\) With the use of the current BBs there have not yet been any reports of a ruptured trachea or bronchus; however, the number of complications with DTLs is higher than with BBs.

The issue related to which device should be used routinely for lung isolation has been a topic of debate.\(^\text{[26-27]}\) My personal opinion is that BBs have a unique place in our practice of contemporary thoracic anesthesia. Once the learning curve process is achieved, the BB becomes another technique to achieve lung isolation—no different than a DLT. Fiberoptic bronchoscopy should be the gold standard while placing a BB.\(^\text{[28]}\) The basic principle of successful lung separation that allows us to make a BB work in a
similar fashion to a DLT relies on recognition of tracheobronchial anatomy, familiarity and skills with flexible fiberoptic bronchoscopy, and expertise with every BB available.
References


