16 Lung Isolation

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Key Points

- During the preoperative period, review of the posterior–anterior chest radiograph is necessary to measure the tracheal width and also appreciate the pattern of the tracheobronchial anatomy to determine what device and size to use.
- The left-sided DLT is the most common device used for lung isolation because of its greater margin of safety.
- The use of bronchial blockers is indicated in patients who present with difficult airways and require lung isolation.
- Patients with a tracheostomy in place requiring lung isolation are best managed with the use of an independent bronchial blocker and flexible fiberoptic bronchoscopy.
- Flexible fiberoptic bronchoscopy is the recommended method to achieve optimal position of lung isolation devices, first in supine position, later in lateral decubitus, or whenever a malposition occurs.

Introduction

Lung separation techniques are used to provide one-lung ventilation (OLV) in patients undergoing thoracic, mediastinal, cardiac, vascular, or esophageal procedures [1, 2]. Lung separation can be achieved with two different techniques. The first involves a device made of disposable polyvinylchloride material, the double-lumen endotracheal tube (DLT) [3]. The DLT is a bifurcated tube with both an endotracheal and an endobronchial lumen and can be used to achieve isolation of either the right or left lung. The second technique involves blockade of a mainstem bronchus to allow lung collapse distal to the occlusion [4]. Currently, there are different bronchial blockers available to facilitate lung separation collapse; these devices are either attached to a single-lumen endotracheal tube with an enclosed bronchial blocker (Torque Control Blocker Univent) (Vitaid, Lewiston, NY) [5] or are used independently over a standard single-lumen endotracheal tube, as with the

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TABLE 16.1. Indications for lung isolation with a double-lumen endotracheal tube (DLT) or a bronchial blocker.

A. *Indications for lung isolation with the use of a DLT*
- Protection of one lung from a contralateral contamination
  - Lung abscess
  - Lung cyst
  - Pulmonary hemorrhage
- Bronchopulmonary lavage
  - Pulmonary alveolar proteinosis
- Control and continuity of the airway gas exchange
  - Bronchopleural fistula
  - Bronchial disruption (i.e., laceration with a knife)
  - Pneumonectomy

B. *Indication for lung isolation with the use of a DLT or a bronchial blocker*
- Any operation that requires surgical exposure through the chest cavity with lung collapse
  - Video-assisted thoracoscopic surgery
  - Lobectomy bilobectomy
  - Mediastinal mass resection through the chest (selective cases)
  - Esophageal surgery
  - Orthopedic procedures (spine surgery involving chest)
  - Minimally invasive cardiac surgery

C. *Specific indications for bronchial blockers*
  - Difficult airways
  - Limited mouth opening
    – Nasotracheal intubation
  - Awake orotracheal intubation
  - Already intubated patient requiring lung isolation
  - Tracheostomy patient requiring lung isolation
  - Selective lobar blockade
  - Potential for mechanical ventilation in the postoperative period

TABLE 16.2. Displays the external and internal diameters of the different sizes of DLTs and the size of the flexible fiberoptic bronchoscope recommended.

DLT French size (F)				
F size	OD (mm)	Bronchial ID (mm)	Trachea ID (mm)	FOB size OD (mm)
26	8.7	3.5	3.5	2.2
28	9.3	3.2	3.1	2.2
32	10.7	3.4	3.5	2.2
35	11.7	4.3	4.5	3.5 or 4.2
37	12.3	4.5	4.7	3.5 or 4.2
39	13.0	4.9	4.9	3.5 or 4.2
41	13.7	5.4	5.4	3.5 or 4.2

OD outer diameter; *ID* internal diameter; *FOB* fiberoptic bronchoscope

wire-guided endobronchial blocker (Arndt® blocker) [6] (Cook Critical Care, Bloomington, IN), the Cohen tip-deflecting endobronchial blocker [7] (Cook Critical Care, Bloomington, IN), or the Fuji Uni-blocker® [8] (Fuji Corp, Tokyo, Japan). There are a number of recognized indications for OLV. In practice, the most common indications for lung separation are (1) for surgical exposure, (2) for prevention of contamination to the contralateral lung from bleeding pus material or saline lavage (abscess, hemoptysis, bronchiectasis, and lung lavage), and (3) during differential lung ventilation or for continuity of the airway gas exchange such as with bronchopleural fistula. Table 16.1 describes common indications for lung isolation with a DLT or a bronchial blocker.

Double-Lumen Endotracheal Tubes

Currently, all DLTs are based on a design suggested by Carlens and Björk [9]. There are two versions of DLTs, left-sided and a right-sided, which are designed to accommodate the unique anatomy of each mainstem bronchus [10]. DLTs are available from different manufacturers: Mallinckrodt Broncho-Cath (St. Louis, MO) is the most common brand name in North America; there is also the Sheridan Sher-I-Bronch (Argyle, NY) and DLTs from Rüsch (Duluth, GA) and Portex (Keene, NH). The sizes of the DLTs vary among manufacturers; the smallest available is 26 French (F) followed by 28, 32, 35, 37, 39, and 41 F. Table 16.2 displays the external and internal diameters of the different sizes of DLTs and the size of the flexible fiberoptic bronchoscope recommended (of note, the size of the DLTs varies among manufacturers). The ones described in this table are: Mallinckrodt Broncho-Cath, Sher-I-Bronch, and Rüsch.

Size Selection

Regarding selection of the proper size of a DLT, all studies have focused on the left-sided DLT in part because the right-sided DLT is used infrequently. A common problem with the left-sided DLT is the lack of objective guidelines to properly choose the correct or approximate size of DLT.

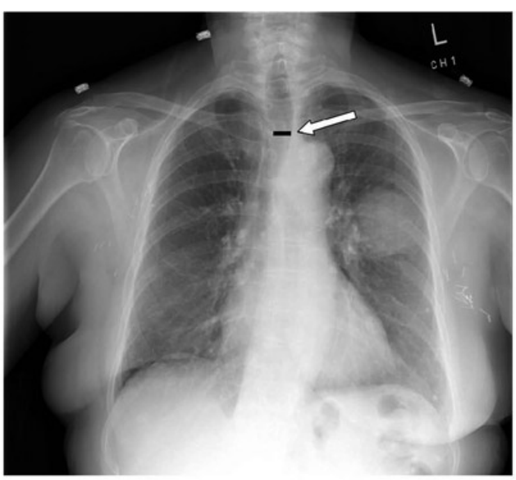
A left-sided DLT that is too small requires a large endobronchial cuff volume, which might increase the incidence of malposition. In addition, a small DLT does not readily allow fiberoptic bronchoscope placement and can make suction difficult. A properly sized DLT is one in which the main body of the tube passes without resistance through the glottis and advances easily within the trachea, and in which the bronchial component passes into the intended bronchus without difficulty. In a study performed in adult cadavers, it was shown that the cricoid ring diameter never exceeds the diameter of the glottis. If a DLT encounters resistance when passing the glottis, it is likely that the DLT would encounter resistance while passing the cricoid ring [11].

There are reports of complications related to the use of an undersized DLT. A tension pneumothorax and pneumomediastinum occurred after the endobronchial tip of an undersized DLT had migrated too far into the left lower bronchus, and the entire tidal volume was delivered into a single lobe [12]. Also, smaller DLTs might present with more resistance to gas flow and more intrinsic auto-positive end-expiratory pressure compared with the wider lumen of larger DLTs [13]. Airway-related complications have been reported with undersized left-sided DLTs. A rupture of the left mainstem bronchus by tracheal portion of a DLT has been reported

[14]. A longitudinal laceration of the left mainstem bronchus occurred. The cause of this complication was believed to be an undersized DLT, which allowed the endotracheal portion of the DLT to enter the left mainstem bronchus. In addition, an oversized DLT also can be associated with bronchial rupture in a small adult patient [15].

Brodsky et al. [16] reported that measurement of tracheal diameter at the level of the clavicle on the preoperative posteroanterior chest radiograph can be used to determine proper left-sided DLT size. These methods lead to a 90% increase in the use of larger left-sided DLTs (i.e., 41 F DLT in men and 39 F and 41 F DLT in women). However, a study involving Asian patients by Chow et al. [17], using the methodology of Brodsky et al. [16], found this approach less reliable. In the Chow et al. [17] study, the overall positive predictive value for the proper left size of a left-sided DLT was 77% for men and 45% for women. This method seems to have limited use in patients of smaller stature, such as women and people of Asian descent, and an alternative method should be sought, including placement of a different lung isolation device such as an independent bronchial blocker through a single-lumen endotracheal tube. Figure 16.1 shows the guidelines to predict the proper left-sided DLT based upon measurements of the tracheal width from the chest X-ray according to Brodsky et al. [16].

A recent study involving thoracic anesthesiologists by Amar et al. [18] has shown that the use of a smaller DLT (i.e., 35 F or 37 F left-sided DLT) rather than a conventionally large sized DLT (i.e., 39 or 41 F) was not associated with any difference in clinical intraoperative outcomes, regardless of patient size or gender in 300 patients undergoing thoracic surgery requiring lung isolation. However, in their study only 51 (35%) of the patients who received a 35 F, DLT were males and 92 (65%) were females. In practice, women usually receive a 35 F DLT; therefore, the question of whether or not a 35 F for all patients is favorable remains unclear.



The arrow indicates the level of the clavicles. The black line indicates the width of the trachea.

Left Bronchocath Double-Lumen Endotracheal Tubes Guidelines		
Measured Tracheal Width (mm)	Predicted Left Bronchus Width (mm)	Recommended DLT size (F)
≥ 18	≥ 12.2	41
≥ 16	≥ 10.9	39
≥ 15	≥ 10.2	37
≥ 14	≥ 9.5	35

Fig. 16.1. Left bronchocath double lumen endotracheal tubes guideline. Modified from Brodsky et al. [16].

Another alternative that has been suggested in order to predict the proper size of a right-sided or left-sided DLT is a three-dimensional image reconstruction of tracheobronchial anatomy generated from spiral computed tomography (CT) scans combined with superimposed transparencies of DLTs [19]. Taken together, these studies suggest that chest radiographs and CT scans are valuable tools for selection of proper DLT size, in addition to their proven value in assessment of any abnormal tracheobronchial anatomy. These images should be reviewed before placement of a DLT. Particular emphasis should be made in viewing a posteroanterior chest radiograph in order to asses the shadow of tracheobronchial anatomy along with bronchial bifurcation. It is estimated that in 75% of the films the left mainstem bronchus shadow is seen. The trachea is located in the midline position, but often can be deviated to the right at the level of the aortic arch, with a greater degree of displacement in the setting of an atherosclerotic aorta, advanced age, or in the presence of severe chronic obstructive pulmonary disease (COPD). With COPD or aging, the lateral diameter of the trachea may decrease with an increase in the anteroposterior diameter. Conversely, COPD may also lead to softening of the tracheal rings with a decrease in the anteroposterior diameter of the trachea. The cricoid cartilage is the narrowest part of the trachea with an average diameter of 17 mm in men and 13 mm in women.

Figure 16.2a shows a multidetector three-dimensional CT scan of the chest displaying the trachea and bronchial anatomy in a 25-year-old healthy volunteer; Fig. 16.2b shows the changes that occur in a 60-year-old man with severe COPD, which shows a deviated trachea and narrow bronchus. Points of importance include the recognition of any distorted anatomy identified in the films prior to placement of DLTs.

Methods of Insertion

Two techniques are used most commonly by anesthesiologists when inserting and placing a DLT. The first is the blind technique, that is, when the DLT is passed with direct laryngoscopy, then turned to the left (for a left-sided DLT) or right (for a right-sided DLT) after the endobronchial cuff has passed beyond the vocal cords. The DLT then is advanced until the depth of insertion at the teeth is approximately 29 cm for both men and women if the patient's height is at least 170 cm [20].

The second technique employs fiberoptic bronchoscopy guidance, where the tip of the endobronchial lumen is guided

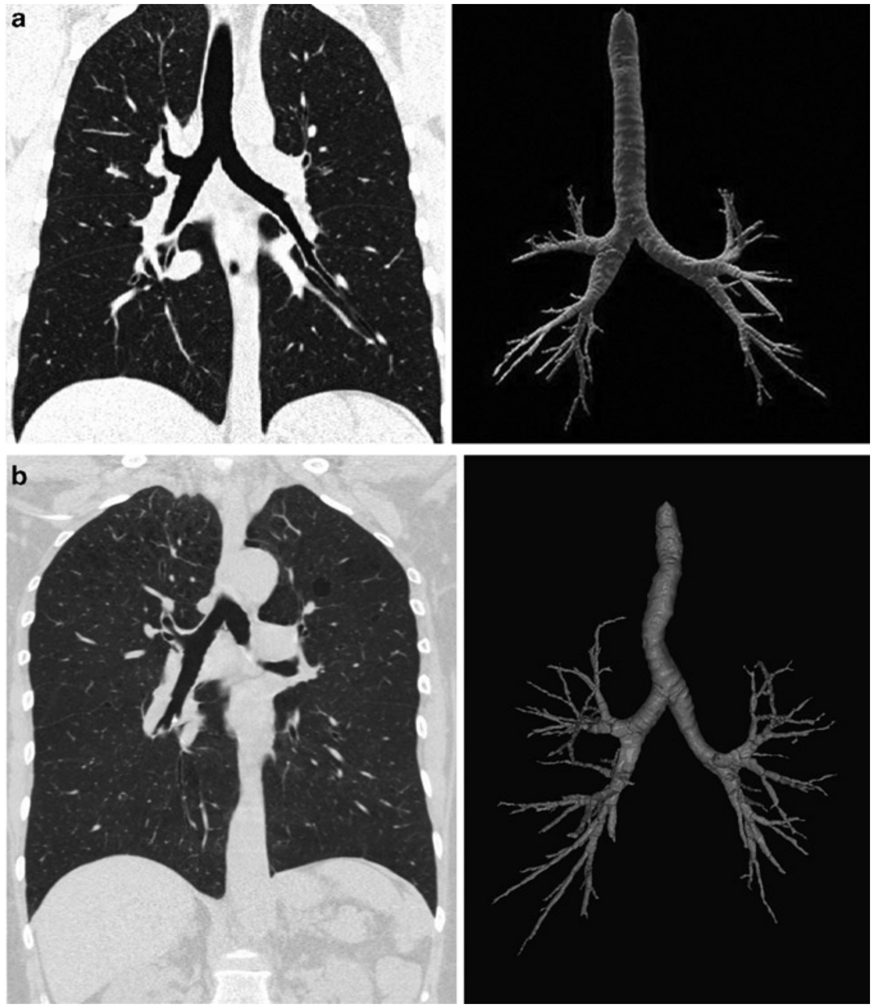


FIG. 16.2. (**a**) Male tracheobronchial tree via multidetector three-dimensional computer tomography scan in a healthy 25 year old. (**b**) Male tracheobronchial tree via multidetector three-dimensional computer tomography scan in a 60 year old with chronic obstructive pulmonary disease (COPD) [29].

after the DLT passes the vocal cords; direction is sought with the aid of a flexible fiberoptic bronchoscope. A study by Boucek et al. [21] comparing the blind technique versus the fiberoptic bronchoscopy-guided technique showed that of the 32 patients who underwent the blind technique approach, primary success occurred in 30 patients. In contrast, in the 27 patients receiving the bronchoscopy-guided technique, primary success was achieved only in 21 patients and eventual success in 25 patients. This study also showed that the time spent placing a DLT was an average of 88 s for the blind technique and 181 s for the directed bronchoscopic approach. Although both methods resulted in successful left mainstem bronchus placement in most patients, more time was required when the fiberoptic bronchoscopy guidance technique was used. In addition, two patients in each group required an alternative method for tube placement. Either method may fail when used alone. Figure 16.3 shows the blind method technique and Fig. 16.4 shows a fiberoptic bronchoscopy guidance technique for placement of a left-sided DLT.

Right-Sided Double-Lumen Endotracheal Tubes

Although a left-sided DLT is used more commonly for most elective thoracic procedures [22], there are specific clinical situations in which the use of a right-sided DLT is indicated. Table 16.3 displays the indications for use of a right-sided DLT.

The anatomic differences between the right and left mainstem bronchus are reflected in fundamentally different designs of the right-sided and left-sided DLTs. Because the right mainstem bronchus is shorter than the left bronchus and because the right upper lobe bronchus originates at a distance of 1.5–2 cm from the carina, techniques using right endobronchial intubation must take into account the location and potential obstruction of the orifice of the right upper lobe bronchus. The right-sided DLT incorporates a modified cuff, or slot, on the endobronchial side that allows ventilation of the right upper lobe. Figure 16.5 displays the Sheridan and the Mallickrodt right-sided DLTs.

FIG. 16.3. Blind technique for placement of a left-sided DLT [63].

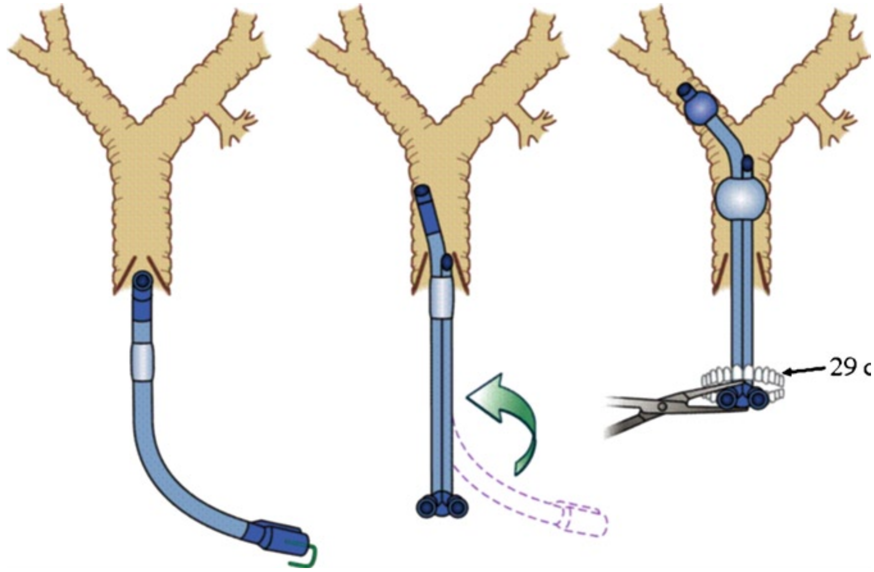


FIG. 16.4. Shows a fiberoptic bronchoscopy guidance technique for placing a left-sided DLT [63].

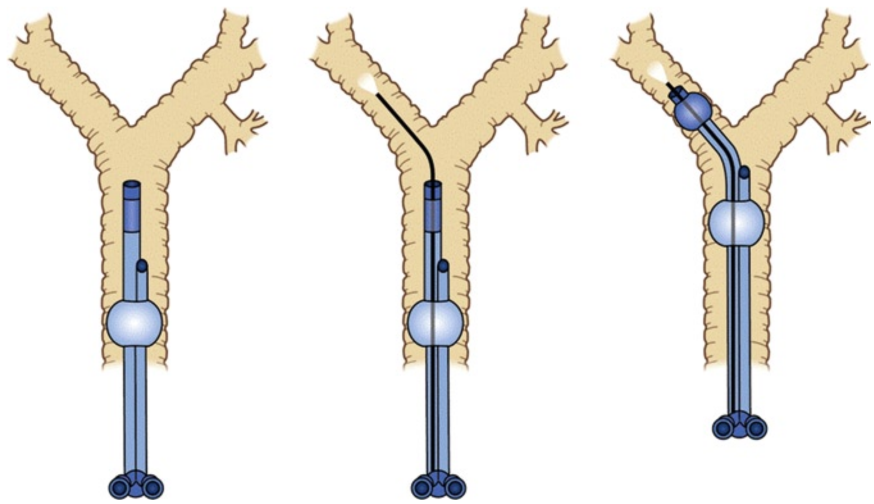


TABLE 16.3. Indications for a right-sided DLT.

- Any contraindication to placement of a left-sided DLT
- Distorted anatomy of the entrance of left mainstem bronchus by an intra-bronchial or external compression
- Compression of the entrance of the left mainstem bronchus due to a descending thoracic aortic aneurysm
- Left lung transplantation
- Left-sided sleeve resection
- Left-sided pneumonectomy

Safety

In theory, the left-sided DLT and right-sided DLT should be equally safe and efficacious for collapse of either the right or the left lung. In practice, however, use of the right-sided DLT has become controversial. An early study showed that because of bronchial anatomy, the left-sided DLT is simpler to use and has a greater margin of safety than the right-sided DLT [23]. Another study [24] has shown failure to ventilate the right upper lobe in 11% of patients and obstruction of the right upper bronchus in 89% of patients after right-sided DLT placement; studies relying on fiberoptic bronchoscopy guidance techniques have shown no increased risk of obstruction of the right upper lobe orifice [25]. A right-sided DLT from the Mallinckrodt brand has been modified to increase the margin of safety. In this right-sided Broncho-Cath® DLT, the opening slot of the ventilating orifice for the right upper bronchus lobe has been widened and consists of an enlarged area of the lateral orifice; this modification has increased the alignment between the opening slot and the right upper lobe bronchus [26]. A contraindication for right-sided DLT use is the presence of an anomalous right upper lobe takeoff from

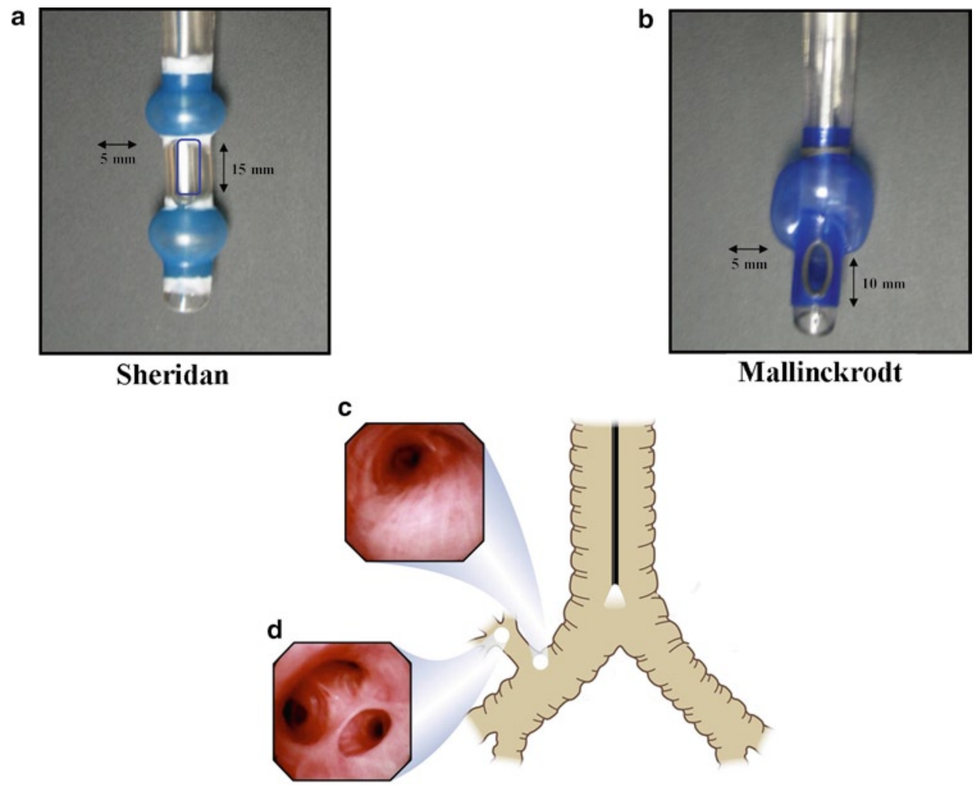


FIG. 16.5. (**a**) Sheridan right-sided DLT. (**b**) Mallinckrodt right-sided DLT. (**c**) View of the right mainstem bronchus showing the bronchus intermedius towards the center of the photo and the smaller right upper lobe orifice to the right. (**d**) The three segments of the right upper lobe (the "clover-leaf" view).

the trachea, which has been estimated to be present in 1 of 250 otherwise normal subjects [27]. A recent study involving the use of right- or left-sided DLTs has shown that these have identical clinical performances. In this study, the authors hypothesized that placing a left-sided DLT for a right-sided lung isolation; the tubes will have similar performance. This retrospective study reported no difference in the incidence of duration of hypoxemia hypercarbia or high airway pressures [28]. Unfortunately, this study was retrospective in nature, and also the authors showed greater than 35 cm H_2O of peak inspiratory pressure in over 65% of the cases reported in both groups during OLV.

Placement Technique

The preferred technique for placement of a right-sided DLT is with the fiberoptic bronchoscopy guidance technique. After the right-sided DLT is passed beyond the vocal cords under direct laryngoscopy, the fiberoptic bronchoscope is advanced through the endobronchial lumen. Before advancing the DLT, the tracheal carina, the entrance of the right mainstem bronchus, and the entrance of the right-upper lobe bronchus are identified. Then the DLT is rotated 90° to the right and advanced with the aid of the fiberoptic bronchoscope. The optimal position of a right-sided DLT is one that provides good alignment between the opening slot of the endobronchial lumen in relationship to the entrance of the right-upper lobe bronchus and, distally, a clear view of the bronchus intermedius and the right lower lobe bronchus seen from the endobronchial lumen. From the tracheal view, the optimal position for a right-sided DLT provides a view of the edge of the blue cuff of the endobronchial balloon when inflated just below tracheal carina and a view of the entrance of the right mainstem bronchus [29]. Figure 16.6 shows the optimal position of a right-sided DLT seen from the endobronchial or endotracheal view with a fiberoptic bronchoscope.

Left-Sided Double-Lumen Endotracheal Tubes

Placement Technique

Placement and positioning of a left-sided DLT can be accomplished with either technique discussed earlier, the blind technique in which the left-sided DLT is passed beyond the vocal cords (endobronchial cuff) and the tube is rotated 90° counterclockwise and advances until the tip of the tube enters the left mainstem bronchus, or the bronchoscopy guidance technique, in which the endobronchial tip is passed beyond the

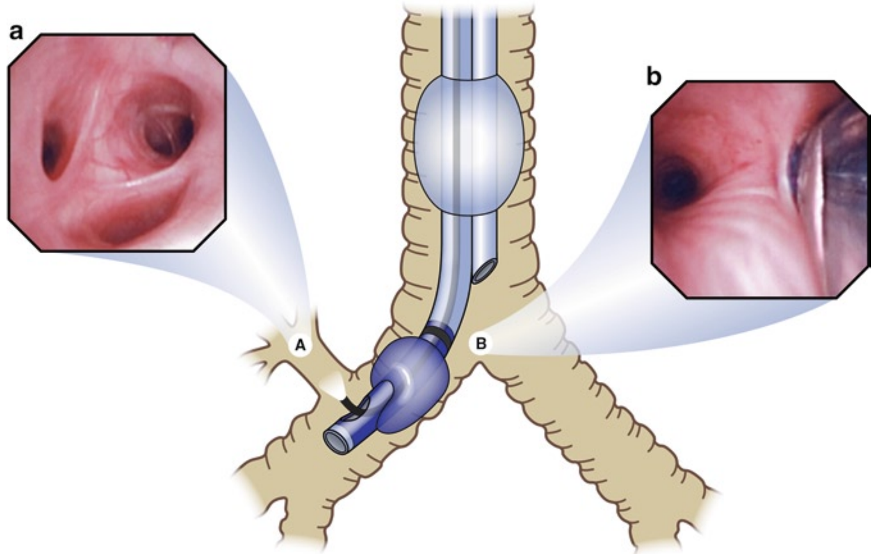


FIG. 16.6. Optimal position of a right-sided DLT. (**a**) The view of the right upper lobe through the ventilating side slot of the bronchial lumen. (**b**) The view from the tracheal lumen of the main carina with the bronchial lumen in the right mainstem bronchus [29].

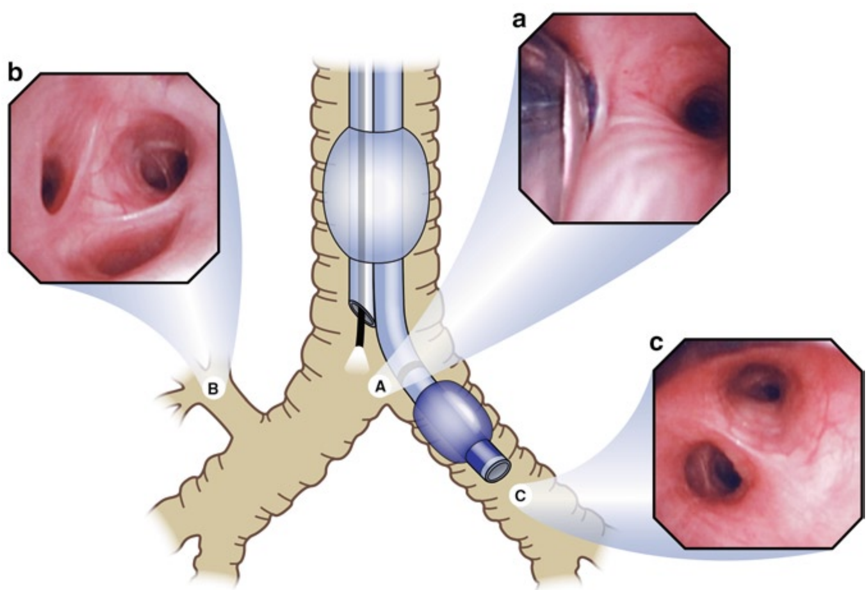


FIG. 16.7. The optimal position of a left-sided DLT. (**a**) View from the tracheal lumen of the unobstructed entrance of the right mainstem bronchus. (**b**) View from the tracheal lumen of the right-upper bronchus. (**c**) View from the bronchial lumen of the left-upper (*above*) and left-lower (*below*) lobe bronchi [29].

vocal cords and guided through the trachea with the aid of the fiberoptic bronchoscope until the entrance of the left mainstem bronchus is identified and the tube is introduced into the left bronchus. The optimal position for a left-sided DLT as seen with the fiberoptic bronchoscope is the one that allows, from the tracheal lumen view, observation of a fully inflated endobronchial cuff with no more than 3 mL of air located 5–10 mm below the tracheal carina inside the left mainstem bronchus. The second important view is the endobronchial bronchoscopy view. Two observations are relevant: first, the fiberoptic bronchoscope is advanced inside the endobronchial lumen, and the patency of the lumen is observed before advancing the bronchoscope through the blue portion of the tube; the second view is at the distal end of the endobronchial tip of the tube, where a clear and unobstructed view of the left-upper and lower lobe bronchus entrance orifices are visualized distally. In order to recognize the right mainstem bronchus while placing a left-sided DLT, the fiberoptic bronchoscope is advanced through the tracheal lumen below the main tracheal carina to the right side approximately 1–2 cm at which the point the orifice of the right-upper lobe bronchus is seen at 3–4 o'clock on the lateral wall. Advancing the fiberoptic bronchoscope inside this orifice should provide a clear view of the apical, anterior, and posterior segments (the "clover-leaf" view). This is the only structure in the tracheobronchial tree that has three orifices. Figure 16.7 shows the optimal position of a left-sided DLT as seen with a fiberoptic bronchoscope.

Auscultation and Fiberoptic Bronchoscopy when Placing Double-Lumen Endotracheal Tubes

Evidence strongly suggests that auscultation alone is unreliable for confirmation of proper DLT placement. However, the basic principle of auscultation and clamping maneuvers while testing the proper placement of a DLT must be routinely applied prior to the use of fiberoptic bronchoscopy. For a left-sided DLT, the endobronchial lumen should be placed below the tracheal carina into the left mainstem bronchus and the depth of the tube in a 170 cm tall subject should be approximately 29 cm at the level of the teeth. Clamping the limb connector of the tracheal lumen should reveal absence of breath sounds on the right side of the chest (right hemithorax). After this maneuver is completed, the next step is to ventilate both lungs then to clamp the limb connector of the endobronchial lumen should reveal absence of breath sounds on the left side of the chest (left hemithorax). If none of these maneuvers are successful, or confusion ensues with breath sounds and the location of the DLT, a fiberoptic bronchoscopy exam takes precedent. A study involving 200 patients who were intubated by the blind technique in whom confirmation of placement of DLTs was done first with auscultation and clamping one of the ports of the connector of the DLT and with a second anesthesiologist with expertise in fiberoptic bronchoscopy reconfirming the placement of the DLT showed that 35% of the tubes placed were malpositioned when auscultation was used alone. All detected malpositions were eventually corrected [30]. A study by Brodsky and Lemmens [22] reported their clinical experience with the use of left-sided DLTs. Using auscultation and clinical signs, they reported 98% efficacy in lung collapse, yet in only 58 instances they used fiberoptic bronchoscopy to attempt to place the DLTs correctly. In this study, there were 71 patients (6.2%) in whom the DLT was found not to be in a satisfactory position, requiring readjustment after initial placement. What is important from the Brodsky study [22] is the fact that in 56 patients the DLT was considered too deep into the left bronchus, and indirectly this was a cause of hypoxemia in 21 of 56 patients who had a malpositioned tube. Anesthesiologists should be able to avoid this complication with the use of fiberoptic bronchoscope. In a report related to the national confidential inquiry into perioperative deaths in Great Britain [31], which detailed the management of patients undergoing esophagogastrectomy, it was shown that 30% of deaths reported were associated with malposition of DLTs. The problems ranged from use of multiple DLTs to prolonged periods of hypoxia and hypoventilation. The anesthesiologists did not use a fiberoptic bronchoscope to confirm DLT position before surgery, during surgery, or when the DLT was placed incorrectly [32].

In another report from Great Britain, Seymour [33] reported a survey among anesthesiologists in a single institution, in which they participated in 506 placements of left- or right-sided DLTs; in their report, only 56% of the cases managed used fiberoptic bronchoscopy to confirm the proper placement of the DLTs. In more than 10% of their cases, hypoxemia was present in the intraoperative period. An editorial by Slinger [34] pointed out the importance of using fiberoptic bronchoscopy to confirm placement of DLTs.

A study involving nonthoracic anesthesiologists with very limited experience in lung separation techniques showed that when placing lung isolation devices (DLTs or bronchial blockers) there was a 38% incidence in unrecognized malpositions when these devices were placed with the fiberoptic bronchoscope. The possible causes were lack of skill with fiberoptic bronchoscopy and lack of recognition of the tracheobronchial anatomy [35]. It is the author's opinion that fiberoptic bronchoscopy is essential and mandatory to achieve 100% success in placement and positioning of DLTs as long as the anesthesiologist is able to recognize proper tracheobronchial anatomy and has skills with flexible fiberoptic bronchoscopy. Table 16.4 displays the findings and outcomes when auscultation, clamping maneuvers, and or fiberoptic bronchoscopy were used to position and achieve optimal position of the DLTs.

Table 16.4. Role of auscultation, fiberoptic bronchoscopy, and/or both during lung isolation.

References	Number of patients	Method	Outcome
Brodsky and Lemmens [22]	1,170 DLTs (retrospective study)	Clinical experience over 8-year period (1993–2001) Auscultation and clinical signs	Successful lung isolation 98% 56 DLT too deep in the left bronchus ($n=21$ hypoxemia) Fiberoptic bronchoscopy was used $n=58$
Klein et al. [30]	200 L-R DLT's (prospective study)	Auscultation/clamping/followed by a fiberoptic bronchoscopy with a second	35% malpositions Optimal position achieved with the use of fiberoptic bronchoscopy in all cases
Seymour et al. [33]	506 L-R DLTs (survey)	Audit of DLT Auscultation/clamping maneuvers or fiberoptic bronchoscopy	56% used fiberoptic bronchoscopy >10% hypoxemia ($SpO_2<88\%$)

DLT double-lumen endotracheal tube; *R* right; *L* left

New Technology with Double-Lumen Endotracheal Tubes

Fuji Systems in Tokyo, Japan has introduced the Silbroncho DLT, which is made of silicone. The unique characteristic of this device relies on the wire-reinforced endobronchial tip. Also, the short bronchial tip and reduced bronchial cuff should increase the margin of safety when compared with a Bronchocath left-sided DLT. At the present time, only a left-sided Silbroncho DLT is available on the market [36]. Its effectiveness has not been reported.

Also, there is a newly designed right-sided DLT, the Cliny® (Create Medic Co., Ltd, Yokohama, Japan). This device has a long oblique bronchial cuff and two ventilation slots for the right-upper lobe. The proximal part of the bronchial cuff is located immediately opposite the tracheal orifice. This device can be useful in patients with a very short right mainstem bronchus [37]. Figure 16.8a displays the Silbroncho left-sided DLT and (b) displays the Cliny® right-sided DLT.

Another newly designed DLT has been designed to enable rapid and reliable lung isolation using a bronchial blocker. The Papworth BiVent Tube [38, 39] is a DLT with two D-shaped lumens arranged in a side-by-side configuration, separated by a central position. The tube characteristics include a preformed single posterior concavity and a single inflatable, low-volume, high-pressure tracheal cuff. At the distal end, there are two pliable crescent-shaped flanges arising from the central position to form a forked tip. The purpose of the forked tip is to seat at the tracheal carina. A bronchial blocker can be advanced blindly through either lumen and is guided into a bronchus. The size available for the Papworth BiVent tube at the present time is 43 F. According to the developers, the Papworth BiVent tube can be used without the requirement for endoscopic guidance. Unfortunately, at the present time there are no studies in humans to confirm its clinical use during lung separation.

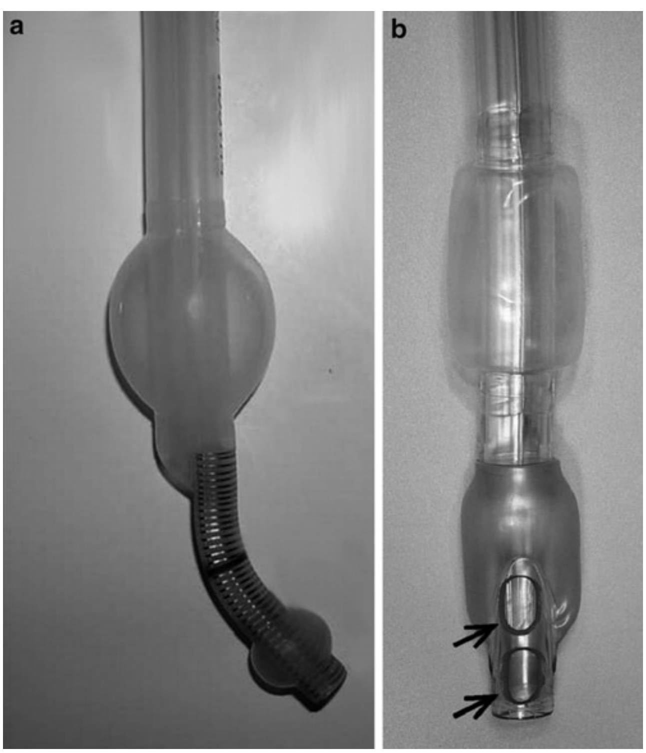


Fig. 16.8. (**a**) Silbroncho left-sided DLT. (**b**) Cliny® right-sided DLT.

Complications Associated with Double-Lumen Endotracheal Tube Placement

The most common problems and complications from the use of DLTs are malpositions and airway trauma. A malpositioned DLT fails to allow collapse of the lung, causing gas trapping during positive pressure ventilation, or it may partially collapse the ventilated or dependant lung, producing hypoxemia. A common cause of malposition is dislodgement of the endobronchial cuff because of overinflation, surgical manipulation of the bronchus, or extension of the head and neck during or after patient positioning [40].

Airway trauma and rupture of the membranous part of the trachea or the bronchus continue to be infrequent problems with the use of DLTs [14, 15]. These complications can occur during insertion and placement, while the case is in progress, or during extubation [41–43]. Another problem that has been reported is the development of bilateral pneumothoraces or a tension pneumothorax in the dependent, ventilated lung [44, 45]. A 25-year review of the literature by Fitzmaurice and Brodsky [46] found that most airway injuries were associated with undersized DLTs, particularly in women who received a 35 F or 37 F disposable DLT. It is likely that airway damage occurs when an undersized DLT migrates distally into the bronchus and the main tracheal body of the DLT advances into the bronchus, producing lacerations or rupture of the airway. Airway damage during the use of DLTs can present as unexpected air leaks, subcutaneous emphysema, massive bleeding into the lumen of the DLT, or protrusion of the endotracheal or endobronchial cuff into the surgical field, with visualization of this by the surgeon. If any of the aforementioned problems occur, a bronchoscopic examination should be performed and surgical repair performed.

Benign complications with the use of the DLT have been reported by Knoll et al [47]. In their comparative study between the DLT and the endobronchial blocker, the development of postoperative hoarseness occurred significantly more commonly in the DLT group when compared to the endobronchial blocker group; however, the incidence of bronchial injuries was comparable between groups.

Bronchial Blockers

An alternative method to achieve lung separation involves blockade of a mainstem bronchus to allow lung collapse distal to the occlusion [4]. Bronchial blockers also can be used selectively to achieve lobar collapse, if needed [48–54]. Currently, there are different bronchial blockers available to facilitate lung separation collapse; these devices either are attached to a single-lumen endotracheal tube with an enclosed bronchial blocker (Torque Control Blocker Univent) [4] or are used independently through or alongside a conventional single-lumen endotracheal tube, such as the wire-guided endobronchial blocker Arndt® blocker [6], the Cohen tip-deflecting endobronchial blocker [7], or the Fuji Uniblocker® [8, 55].

Torque Control Blocker Univent

The Univent® tube consists of a single-lumen endotracheal tube with an enclosed and movable bronchial blocker made of flexible, nonlatex material, and it includes a flexible shaft that is easier to guide into a bronchus [5]. The bronchial balloon has a high-pressure, low-volume cuff that requires approximately 2 mL of air to produce an airtight seal if selective lobar blockade is used or 4–8 mL of air if the total blockade of the bronchus is desired. The bronchial blocker has a 2-mm diameter lumen that can be used for suctioning or for oxygen administration and it should be closed before insertion. One of the advantages of the Univent® blocker is its utility in patients in whom the airway is considered difficult for direct laryngoscopy and during unanticipated difficult endotracheal intubation [56–62].

Placement of the Univent® blocker is straightforward. First the bronchial blocker is lubricated to facilitate passage. The enclosed bronchial blocker is fully retracted into the lumen of the tube. Conventional endotracheal tube placement is performed via direct laryngoscopy, and then a fiberoptic bronchoscope is passed through a Portex swivel adaptor into the endotracheal tube. Under direct vision, the enclosed bronchial blocker is advanced into the targeted bronchus. All bronchial blockers must be directed into the bronchus of the surgical side, where the lung collapse is to occur.

Independent Bronchial Blockers During Lung Isolation

Another alternative to achieve lung separation is by using an independent blocker passed through an in situ single-lumen endotracheal tube. The various devices considered to be independent blockers include the wire-guided endobronchial blocker (Arndt® blocker), the Cohen tip-deflecting endobronchial blocker, and the Fuji Uniblocker® [8, 55] (see Fig. 16.9).

Arndt® Wire-Guided Endobronchial Blocker

The Arndt® blocker [6] is an independent blocker attached to a 5 F, 7 F, or 9 F catheter that is available in 65- and 78-cm lengths with an inner lumen that measures 1.4 mm in diameter. Near the distal end of the catheter, side holes are incorporated to facilitate lung deflation. These side holes are present only in the 9 F Arndt® block. The Arndt® blocker has a high-volume, low-pressure cuff with either an elliptical or spherical shape (see Fig. 16.10). A unique feature of the Arndt®

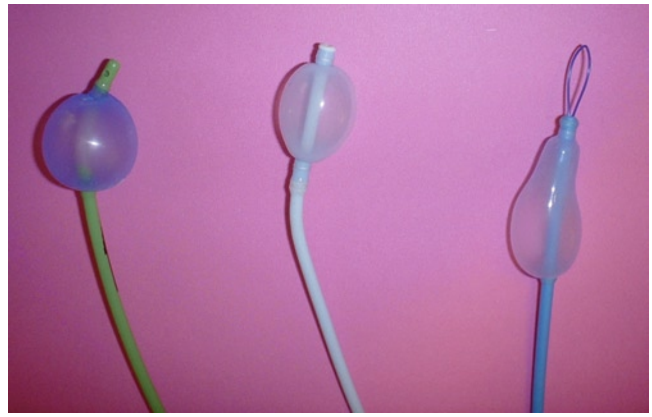


Fig. 16.9. Three independent bronchial blockers currently available in North America (see Table 16.5 for details). *Left*: The Cohen® Tip-Deflecting Endobronchial Blocker 9F (Cook Critical Care, Bloomington, IN), which allows anesthesiologists to establish single-lung ventilation by directing its flexible tip left or right into the desired bronchus using a control wheel device on the proximal end of the blocker in combination with fiberoptic bronchoscope (FOB) guidance. Middle: The Fuji Uniblocker®, 9F (Fuji Corp., Tokyo, Japan). It has a fixed distal curve that allows it to be rotated for manipulation into position with FOB guidance. Unlike its predecessor, the Univent, the Uniblocker is used with a standard endotracheal tube. *Right*: The wire-guided endobronchial blocker (Arndt® bronchial blocker; Cook Critical Care) introduced in 1999. It contains a wire loop in the inner lumen; when used as a snare over a FOB, it allows directed placement. The loop is then removed, and the 1.4-mm lumen may be used as a suction channel or for oxygen insufflation.

Fig. 16.10. The recently introduced Arndt® spherical bronchial blocker cuff (Cook Critical Care, Bloomington, IN). Some clinicians prefer to use this spherical cuff for right-sided surgery versus the original elliptical cuff because of the short length of the right mainstem bronchus.

blocker compared with other blockers 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 exits as a small flexible wire loop. This blocker comes with a multiport connector. The wire loop of the Arndt® blocker is coupled with the fiberoptic bronchoscope and serves as a guide wire to introduce the blocker into the bronchus [63]. For the Arndt® blocker to function properly and allow manipulation with the adult fiberoptic bronchoscope, the proper size endotracheal tube must be used. For a 7 F blocker which can be used for a 40-kg patient, a 7.5-mm internal diameter (ID) single-lumen endotracheal tube is used, and for the larger 9 F Arndt® blocker, at least an 8.0-mm ID single-lumen endotracheal tube is used. Figure 16.11 displays the placement of an Arndt® blocker through a single-lumen endotracheal tube with the fiberoptic bronchoscope advanced through the guide wire loop.

The advantages of the Arndt® blocker include its use in patients who are already tracheally intubated [64], who present a difficult airway and require an awake orotracheal or nasotracheal intubation [65], or who require OLV during acute trauma to the chest [66, 67]. In addition, an Arndt® blocker can be used as a selective lobar blocker in patients with previous pneumonectomy who require selective one-lobe ventilation [68] or as a selective blocker during severe pulmonary bleeding [69]. Figure 16.12 displays the use of a bronchial blocker for selective lobar blockade.

Methods of Placement

The Arndt® blocker is an independent endobronchial blocker that is passed through an existing single-lumen endotracheal tube. To facilitate insertion through the endotracheal tube, the blocker and the fiberoptic bronchoscope are lubricated. For a right-sided mainstem bronchus intubation, the spherically shaped blocker is recommended; for the left mainstem bronchus intubation, the elliptical or the spherical blocker is used.

The placement of the Arndt® blocker involves placing the endobronchial blocker through the endotracheal tube and using the fiberoptic bronchoscope and wire-guided loop to direct the blocker into a mainstem bronchus. The fiberoptic bronchoscope has to be advanced distally enough so that the

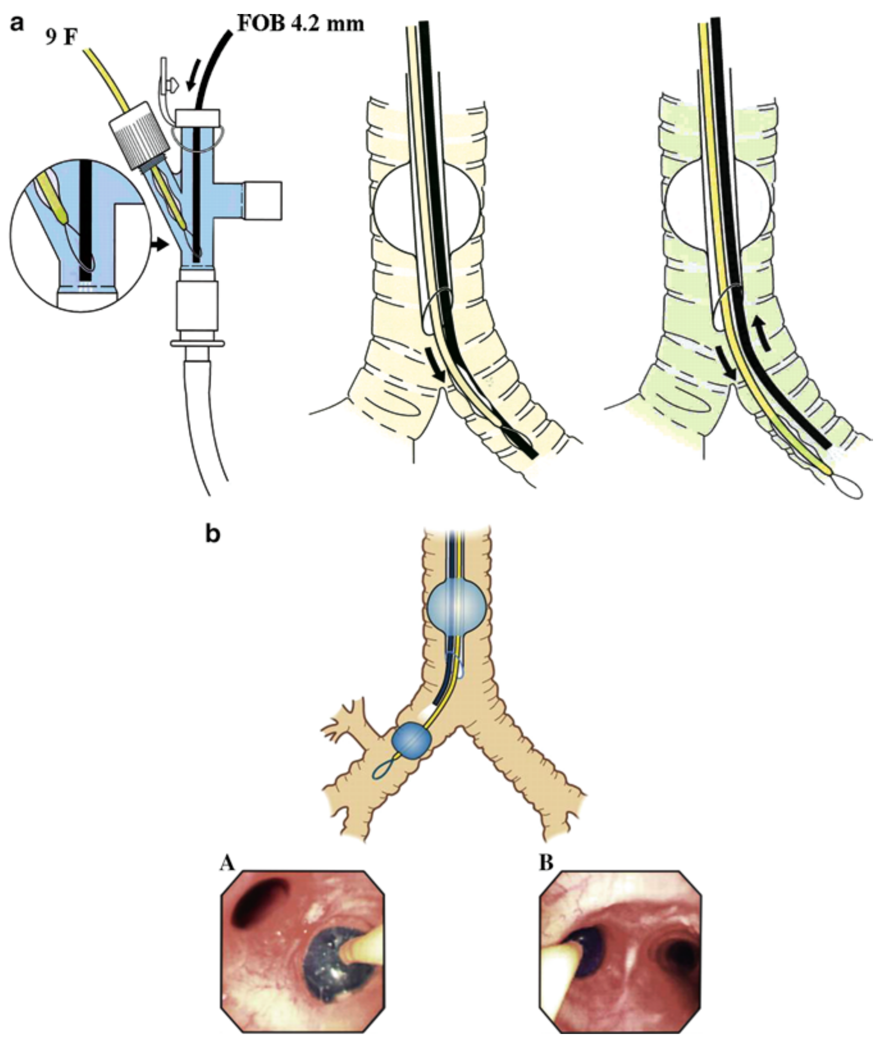


Fig. 16.11. (**a**) Placement of an Arndt® blocker through a single-lumen endotracheal tube with the fiberoptic bronchoscope advanced through the guide wire loop. (**b**) Optimal position of a bronchial blocker in the right or left mainstem bronchus as seen with a fiberoptic bronchoscope. *A* right mainstem blocker; *B* left mainstem blocker [63].

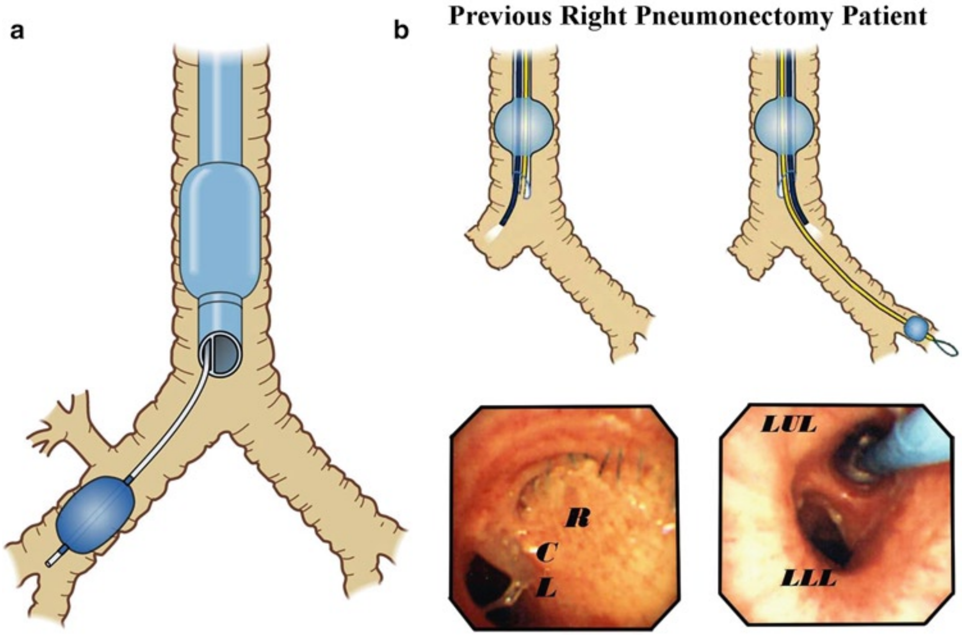


FIG. 16.12. (**a**) Selective lobar blockade where the blocker is sealing the right bronchus intermedius. (**b**) Patient with a previous right pneumonectomy where selective lobar blockade is used to occlude the left upper lobe. *R* stump of right mainstem bronchus; *C* main carina; *L* left mainstem bronchus; *LUL* left upper lobe; *LLL* left lower lobe [54].

Arndt® blocker enters the bronchus while it is being advanced. When the deflated cuff is beyond the entrance of the bronchus, the fiberoptic bronchoscope is withdrawn, and the cuff is fully inflated with fiberoptic visualization with 4–8 mL of air to obtain total bronchial blockade.

For right mainstem bronchus blockade, the Arndt® blocker can be advanced independently of the wire loop by observing its entrance into the right mainstem bronchus under fiberoptic visualization. Before turning the patient into a lateral decubitus position, the cuff of the blocker should be deflated, then advanced 1 cm deeper to avoid proximal dislodgement while changing the patient's position; the placement again is confirmed in the lateral decubitus position. The wire loop can be withdrawn to convert the 1.4-mm channel into a suction port to expedite lung collapse. The newest version of the Arndt® blocker has a cone-shaped device that is attached to the center channel to connect and facilitate suction [70, 71]. It is important to remove the wire loop to avoid inclusion in the stapling line of the bronchus [72]. The optimal position of the Arndt® blocker in the left or in the right bronchus is achieved when the blocker balloon's outer surface is seen with the fiberoptic bronchoscope at least 5 mm below the tracheal carina on the targeted bronchus and the proper seal is obtained.

Cohen® Flexitip Endobronchial Blocker

The Cohen® blocker is an independent endobronchial blocker that is available only in size 9 F and 65-cm length with an inner lumen measuring 1.4 mm in diameter. This device comes with a spherically shaped balloon. Near the distal end of the catheter, there are side holes incorporated to facilitate lung deflation. This bronchial blocker has a high-volume, low-pressure cuff. The Cohen® blocker relies on a wheel-turning device located in the most proximal part of the unit that allows deflection of the tip of the distal part of the blocker into the desired bronchus [2, 7]. This device has been purposely preangled 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 rotating the blocker. In the distal tip above the balloon, there is an arrow that when seen with the fiberoptic bronchoscope indicates in which direction the tip deflects. This Cohen® blocker also comes with a multiport adaptor to facilitate an airtight seal when in place. The indications for use of the Cohen® blocker are the same as for the Arndt® blocker. Figure 16.13 displays the Cohen® blocker.

Methods of Placement

The Cohen® blocker is advanced through an 8.0-mm ID single-lumen endotracheal tube; before insertion, the blocker balloon is tested and then fully deflated. This blocker needs to be lubricated to facilitate insertion and passage through the single-lumen endotracheal tube.

The placement of the Cohen® blocker involves placing the endobronchial blocker through the endotracheal tube and using the fiberoptic bronchoscope to observe the direction of the blocker into a mainstem bronchus. For blocking the right mainstem bronchus, the optimal position is the one that provides

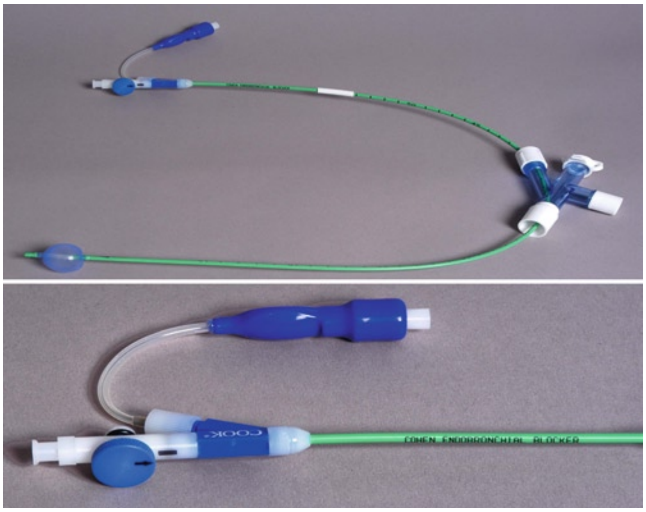


FIG. 16.13. The Cohen flexitip bronchial blocker with a multiport connector [7].

a view of the outer surface of the fully inflated balloon (4–8 mL of air) with the fiberoptic bronchoscope at least 5 mm below the tracheal carina on the right mainstem bronchus.

Intubation of the left mainstem bronchus can be facilitated by allowing the tip of the single-lumen endotracheal tube to be near the entrance of the left bronchus, then twisting the Cohen® blocker to the left side. After the blocker is seen inside the left bronchus, the single-lumen endotracheal tube is withdrawn a few centimeters. A different alternative is to turn the head towards the right allowing the left main bronchus to displace to the midline. This maneuver will facilitate the placement of a Cohen® blocker into the left mainstem bronchus. The optimal position in the left mainstem bronchus is achieved when the blocker balloon's outer surface is seen with the fiberoptic bronchoscope at least 5 mm below the trachea carina inside the left mainstem bronchus.

Fuji Uniblocker®

The Fuji Uniblocker® is an independent bronchial blocker that is available in 4.5 F and 9 F size and is 65 cm in length that 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 bronchial blocker's transmitted pressure tested in vitro was <30 mmHg, which does not exceed the recommended safety limit in relationship to bronchial mucosa [73]. In addition, the Fuji Uniblocker® is equipped with a swivel connector. The swivel connector allows easy insertion of the fiberoptic bronchoscope. The Fuji Uniblocker® has a torque-control blocker with an incorporated shaft that allows the guidance through the desired bronchus. A recent study [8] involving the use of the Fuji Uniblocker® compared with the Arndt® and Cohen® blocker showed that surgical exposure was clinically equivalent to left-sided DLTs for thoracoscopic or open thoracotomies; however, the bronchial blockers including the Fuji Uniblocker® took a longer time to position and required more intraoperative repositioning when compared to left-sided DLTs. Another report [74], this one examining the use Fuji Uniblocker® in patients undergoing thoracoscopic surgery, showed a better quality of lung collapse with left-sided procedures than right-sided procedures. The indications for use of the Fuji Uniblocker® are the same as for the Arndt® blocker. Table 16.5 displays the characteristics of the Arndt® blocker, the Cohen® Flexitip Endobronchial Blocker, and the Fuji Uniblocker®. The Cohen® and Fuji® blockers can be easily placed through the glottis or tracheostomy external to an endotracheal tube, if required in small patients, and the blocker position confirmed with a FOB passed through the endotracheal tube.

Methods of Placement

The Fuji Uniblocker® size 9 F is advanced through an 8.0-mm ID single-lumen endotracheal tube; before insertion the blocker balloon is tested, and then fully deflated. This blocker needs to be lubricated to facilitate insertion and passage through the single-lumen endotracheal tube.

The placement of the Fuji Uniblocker® involves placing the endobronchial blocker through the endotracheal tube and using the fiberoptic bronchoscope to observe the direction of the blocker into a mainstem bronchus. The torque control shaft with the blocker allows guidance into the desired target bronchus. For blocking the right mainstem bronchus, the optimal

TABLE 16.5. Characteristics of the Arndt® blocker, the Cohen® flexitip endobronchial blocker, and the Fuji Uniblocker®.

	Cohen blocker	Arndt® blocker	Fuji Uniblocker®
Size	9 F	5 F, 7 F, and 9 F	4.5 F, 9 F
Balloon shape	Spherical	Spherical or elliptical	Spherical
Guidance mechanism	Wheel device to deflect the tip	Nylon wire loop that is coupled with the fiberoptic bronchoscope	None, preshaped tip
Smallest recommended *ETT for coaxial use	9 F (8.0 ETT)	5 F (4.5 ETT), 7 F (7.0 ETT), 9 F (8.0 ETT)	4.5 F (4.5 ETT) 9 F (8.0 ETT)
Murphy eye	Present	Present in 9F	Not present
Center channel	1.6-mm internal diameter	1.4-mm internal diameter	2.0-mm internal diameter

Reprinted from Campos [55], with permission
ETT single endotracheal tube

position is the one that provides a view of the outer surface of the fully inflated balloon (4–8 mL of air) with the fiberoptic bronchoscope at least 5 mm below the tracheal carina on the right mainstem bronchus. The optimal position in the left mainstem bronchus is achieved when the blocker balloon's outer surface is seen with the fiberoptic bronchoscope at least 5–10 mm below the trachea carina inside the left mainstem bronchus.

Complications with the Use of Bronchial Blockers

Although serious complications have been reported with the use of current bronchial blockers, these complications appear to be more benign than those involving DLTs. A structural complication has been reported in the torque-control Univent blocker in which a fracture of the blocker cap connector occurred in 2 of the first 50 tubes used [75]. Failure to achieve lung separation because of abnormal anatomy, in which the entrance of the right-upper lobe bronchus was located above the tracheal carina, or lack of seal within the bronchus, also has been reported [76, 77]. Inclusion of the enclosed bronchial blocker into the stapling line has been reported during a right-upper lobectomy [78]. Communication with the surgical team regarding the presence of a bronchial blocker in the surgical side is crucial. Another potential and dangerous complication with the bronchial cuff of the Univent has been reported: the cuff of the bronchial blocker was inflated mistakenly near the tracheal lumen, precluding all airflow and producing respiratory arrest [79].

Complications with the Arndt® blocker include a report of a sheared balloon of the Arndt® blocker that occurred when the blocker was removed through the multiport blocker side [80]. It is advised that when an independent bronchial blocker is not in use it needs to be removed with the multiport connector in place rather than through the connector to prevent shredded material into the single-lumen endotracheal tube. Another near-fatal complication reported with the use of the Arndt® blocker occurred when the fully inflated balloon of the blocker dislodged into the patient's trachea, leading to a complete airway obstruction. Severe air trapping led to pulseless activity in the patient, who was undergoing a rupture descending thoracic aortic aneurysm. A prompt deflation of the bronchial blocker cuff resolved the problem [81].

Another complication reported with the Arndt® blocker involved inadvertent resection of the guide wire and part of the tip of the bronchial blocker during stapler resection of the left lower lobe; this complication required surgical reexploration after unsuccessful removal of the bronchial blocker after extubation [72].

There are not yet any reports of complications with the Cohen® blocker of the Fuji Uniblocker®, perhaps because of their relatively recent introduction and use. With the use of the current bronchial blockers, there have not yet been any reports of a ruptured trachea or bronchus; however, the number of complications with the DLTs is higher than for bronchial blockers.

Lung Isolation in Patients with Tracheostomy in Place

OLV can be a challenge in patients with a tracheostomy in place because the airway has been shortened and the stoma can be small and restrictive. Although a shortened version of a DLT for tracheostomy patients has been used [82, 83], there is no shortened DLT available for tracheostomy patients in the United States. An alternative to achieve successful lung separation through a tracheostomized patient involves the use of a bronchial blocker, either attached to a single-lumen endotracheal tube such as the Univent® blocker [84, 85], or passed independently through a Shiley 8.0-mm ID tracheostomy tube (Mallinckrodt, St. Louis MO) with the Arndt® bronchial blocker [68], or placed independently through a single-lumen endotracheal tube [86]. An alternative way to manage these cases is with the Cohen® Blocker [7] or the Fuji Uniblocker® [8]; when passing a 9 F bronchial blocker through a tracheostomy tube, the recommended flexible fiberoptic bronchoscope should be 3.5-mm ID so the independent blocker and the fiberscope can navigate together to achieve optimal position of these devices into the designed bronchus. In some instances when using a Shiley tracheostomy tube, the multiport connector is attached to the ventilating port of the Shiley cannula to maintain the bronchial blocker in place. Optimal position is achieved with the fiberoptic bronchoscope. Figure 16.14 displays the use of an independent blocker through a tracheostomy stoma.

Lung Collapse During Lung Isolation

A challenge for every anesthesiologist is to properly position a lung isolation device and make it work by allowing the lung to collapse. In a study [5] comparing the Broncho-Cath left-sided DLT with the Univent® torque control blocker and the Arndt® wire-guided blocker, it was shown that the average time for lung collapse is 17 min for a DLT (spontaneous lung collapse without suction) versus 19–26 min for the Univent® or Arndt® bronchial blocker (assisted with suction). Once lung isolation was achieved, however, the overall clinical performance was similar for the three devices studied.

Another study [8] involving left-sided DLTs and comparing it with the Arndt®, the Cohen®, or the Fuji® blocker showed that the surgical exposure was equivalent among the devices studied. However, the bronchial blockers required longer time to position and were more prone to intraoperative reposition. It is important to emphasize that these two studies involved at least one senior thoracic anesthesiologist with broad experience with lung isolation devices.

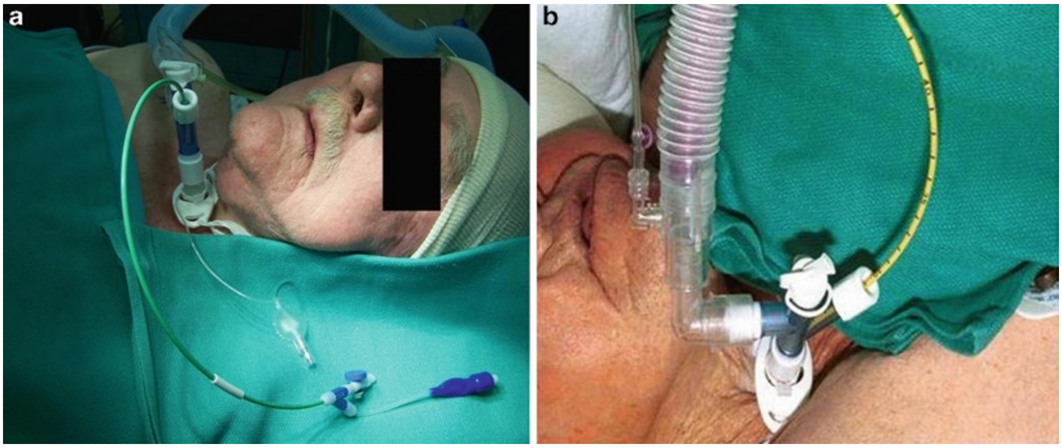


FIG. 16.14. (**a**) Cohen® blocker in a patient with a tracheostomy. (**b**) Use of an Arndt® blocker via a tracheostomy.

TABLE 16.6. Advantages and disadvantages of DLTs and bronchial blockers.

Double-lumen endotracheal tubes	Bronchial blockers (Arndt®, Cohen®, Fuji®)
Advantages	
• Large lumen facilitates suctioning	• Easy recognition of anatomy if the tip of a single tube is above carina
• Best device for absolute indications for lung separation, to protect the lung from soiling	• Best device for patients with difficult airways
• Conversion from 2- to 1-lung ventilation and back easy and reliable	• Cuff damage during intubation rare • No need to replace a tube if mechanical ventilation is needed
Disadvantages	
• Difficulties in selecting proper size	• Small channel for suctioning
• More difficult to place during laryngoscopy	• Conversion from 1- to 2- then to 1-lung ventilation problematic more complicated
• Potential damage to tracheal cuff during intubation	• High maintenance device (frequent dislodgement or loss of seal during surgery)
• Rare major tracheobronchial injuries	

Modified from Campos [55]

A recent study [87] has shown that denitrogenation of the lung which is to be collapsed with a FiO_2 1.0 is a useful strategy to improve surgical conditions during OLV; in contrast, the use of air in the inspired gas mixture during two-lung ventilation and prior to OLV delays lung collapse during OLV. Table 16.6 displays the advantages and disadvantages of DLTs and bronchial blockers.

Future Trends in Lung Isolation

With the advances in thoracic, cardiac, esophageal surgery, and minimally invasive surgery, it has led to an increased need for lung isolation techniques among anesthesiologists. A previous study [35] has shown that anesthesiologists with limited thoracic experience often fail to correctly place lung isolation devices. Increased clinical experience would likely reduce this failure rate, but greater experienced may not be possible, particularly for anesthesiologists working in centers that perform relatively few thoracic cases. Therefore, improved nonclinical training methods are needed.

Anesthesia simulators have been used to enhance learning and to improve performance [88–90], usually under the personal direction of an experienced clinician. Therefore, one educational approach to lung isolation techniques might involve training on an airway simulator mentored by an experienced thoracic anesthesiologist. An alternative is to train in a fiberoptic bronchoscopy simulator [91] on lung isolation techniques particularly for the occasional anesthesiologist who does not perform thoracic cases on a regular basis. It is the author's personal opinion that every surgical center that performs lung isolation techniques must consider the development of a pulmonary workstation along with simulator training facility to enhance teaching to residents, fellows, and staff anesthesiologists. Figure 16.15 displays a pulmonary workstation including simulator. Also, a free online bronchoscopy simulator is available on the website www.thoracicanesthesia.com to teach anesthesiologists tracheobronchial anatomy (see Fig. 16.16).

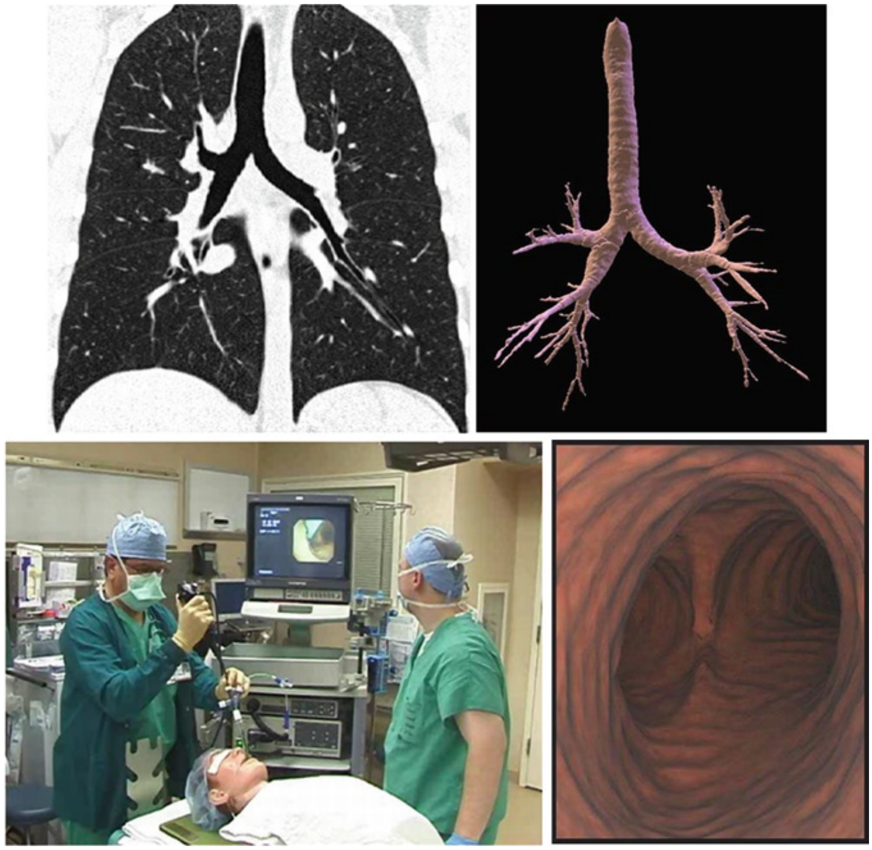


FIG. 16.15. Ideal teaching facility with a pulmonary work station for placement of lung isolation devices by trainees.

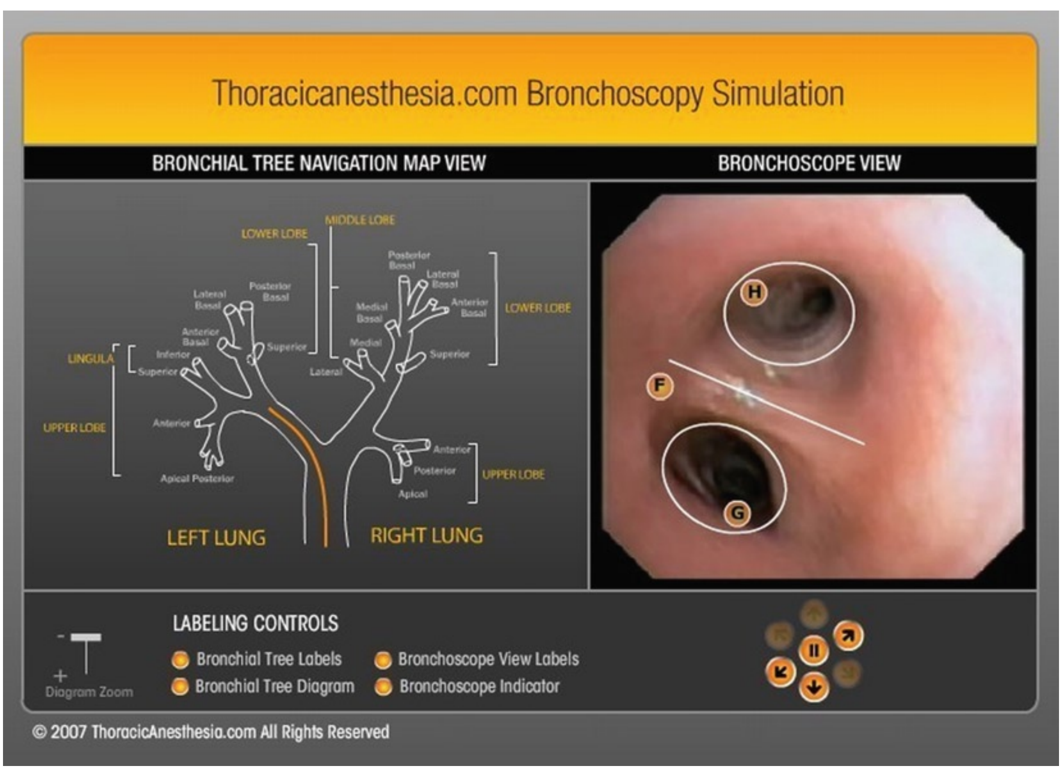


FIG. 16.16. The free online bronchoscopy simulator at www.thoracicanesthesia.com. The user can navigate the tracheobronchial tree using real-time video by clicking on the lighted directional arrows under the "Bronchoscopic view" (*right*). Clicking on the labels on the "Bronchoscopic view" gives details of the anatomy seen. The process is aided by the "Bronchial Tree Navigational Map" (*left*), which shows the simultaneous location of the bronchoscope as the orange line in the airway.

Summary

The basic principle of successful lung separation requires (1) recognition of tracheobronchial anatomy with a posterior–anterior chest radiograph in the preoperative evaluation and with flexible fiberoptic bronchoscopy in the perioperative period, (2) familiarity and skills with flexible fiberoptic bronchoscopy, and (3) familiarity and expertise with DLTs and bronchial blockers.

Because of its greater margin of safety, a left-sided DLT is the more common and easiest device used during lung separation. A right-sided DLT is recommended for a left-sided pneumonectomy or any contraindication to placement of a left-sided DLT. For patients with a difficult abnormal airway or a tracheostomy in place, the use of a bronchial blocker is indicated. Bronchial blockers require more time for placement and are more prone to intraoperative dislodgement. Lung collapse is facilitated with a denitrogenation technique using FiO_2 1.0 during two-lung ventilation prior to lung collapse. Every lung isolation device placement requires auscultation and clamping maneuvers followed by a fiberoptic bronchoscopy to obtain 100% success during lung separation techniques. The optimal position of these devices (DLTs and bronchial blockers) is achieved best with the use of fiberoptic bronchoscopy techniques with the patient first in the supine and then in the lateral decubitus position or whenever repositioning of the device is needed.

Clinical Case Discussion

Case: A 60-year-old female, weight 61 kg and is 161 cm tall, has a left lower lobe mass and is scheduled for a left lower lobectomy (Fig. 16.17a, b). She is a former smoker and the predicted value of forced expiratory volume in 1 s (FEV_1) is 75% of the predicted value. She has no significant known comorbidities and past history otherwise unremarkable.

Questions

- What lung isolation device will be indicated?
- What side and size of lung isolation device will be indicated?
- What anatomical structures in the chest radiograph are relevant while planning the use of lung isolation devices?
- What are the different alternatives for lung isolation devices?
- What technique should be used to achieve optimal position of lung isolation devices?
- What are the common problems in the intraoperative period with lung isolation devices?
- What are the complications associated with lung isolation devices?

Focus on the Patient's Gender, Size, Height, and Preoperative Chest Radiograph

- To determine the lung isolation device.
- Focus on the use of left-sided DLT for routine, uncomplicated cases or a right-sided DLT for selective cases.
- Focus on the indication of lung isolation.
- Knowledge of tracheobronchial anatomy and the use of flexible fiberoptic bronchoscopy to confirm device placement are essential for success on lung isolation.
- Alternative devices for lung isolation such as bronchial blockers should be considered in specific cases.

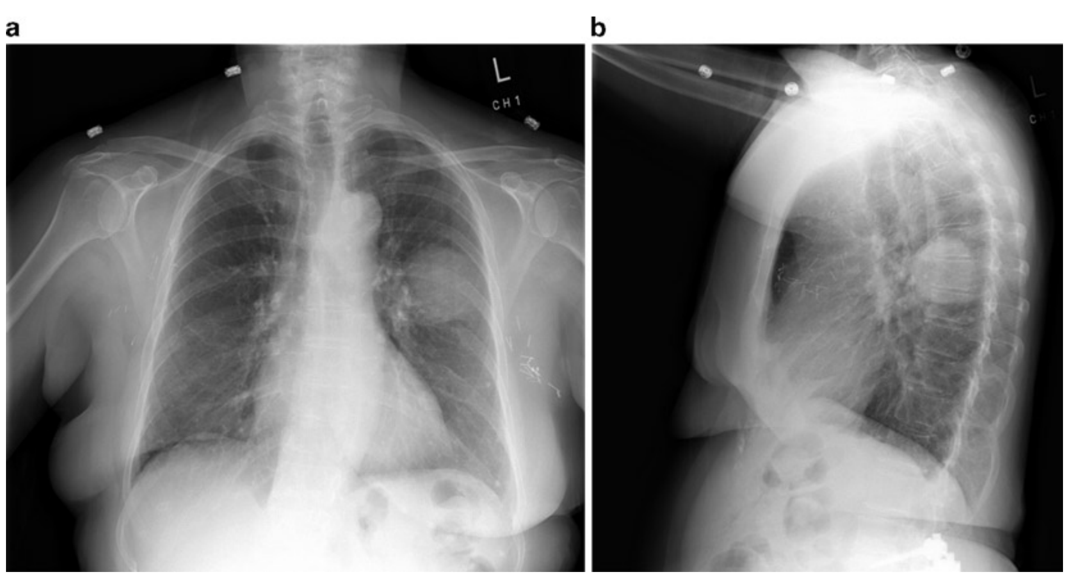


Fig. 16.17. (**a**, **b**) Chest X-ray of a female patient with a carcinoma of the left lower lobe undergoing a lobectomy.

Choice of Lung Isolation Device

- If there is nothing in the patient's history or physical examination to suggest the possibility of difficult airway in a left- or right-sided DLT, depending on the clinician's preference, would be equivalent first choices to manage this case.
- The patient's sex and height suggest that either a 35 F or 37 F DLT would be appropriate, the choice can be further refined by measuring the tracheal width on the PA chest X-ray (see Fig. 16.1).
- In the absence of a difficult airway, the problem of intraoperative displacement with bronchial blockers makes them a second choice for lung isolation in this patient.
- Correct positioning of the device for lung isolation should be confirmed with fiberoptic bronchoscopy.

Expected Intraoperative Problems During Lung Isolation

- Malpositions and the potential for tracheobronchial injuries.

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