Double-Lumen Endotracheal Tubes

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Introduction

Methods to achieve lung separation have been available since the introduction of the red rubber Robert-Shaw double lumen endotracheal tube (DLT) more than 60 years ago. This review focuses on the current methods used to achieve lung separation with the use of DLT’s in a surgical patient undergoing thoracic, esophageal, vascular or mediastinal surgery.

A disposable left-sided DLT made of polyvinyl chloride material is the most commonly used device for lung separation in North America. In practice the most common indications for lung separation are: for surgical exposure, for prevention of contamination to the contralateral lung from bleeding or pus material and differential lung ventilation or for continuity of the airway gas exchange such as with bronchopleural fistula.

Left-Sided Double-Lumen Endotracheal Tubes
Size Selection

A common problem with the left-sided DLT is lack of objective guidelines to choose properly 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. The most accurate method to select a left-sided DLT is to measure the left main bronchus diameter.

Because the left bronchus can be seen in approximately 75% of chest radiographs, an alternative and indirect measurement to estimate the left bronchus width is the tracheal width taken from the chest radiograph. Brodsky, et al has shown that the best predictor to estimate the size of a DLT is the tracheal width from the posterior – anterior chest radiograph. This method led to a 90% increase in the use of larger left-sided DLTs (i.e. 41 F DLT in men and 39 and 41 F DLT in women). Another study found this approach predicted the use of overly large tubes in many Asian patients.

Another method for selecting a left-sided DLT uses measurements of left mainstem bronchial diameter from a CT scan. Seymour showed that the mean diameter of the cricoid ring is the same as that of the entrance of the left mainstem bronchus. In this cadaver study the left mainstem bronchus-to-cricoid ratio almost invariably exceeded 83% in both sexes. A CT scan can identify the bronchial wall or cricoid ring, facilitating measurement of bronchial diameter. For this method to be reliable, the distal outside diameter of the bronchial portion of the DLT must be known. Currently this information is not included in the manufacturer’s package insert.

A recent study by Amar, et al have shown that regardless of the gender or patient height the incidence of hypoxemia, inadequate lung isolation or need for DLT repositioning did
not differ among patients receiving 35, 37 or 39 F DLT. However, in their study of the patients that received 35 F DLT, 92 patients (65%) were females. In practice this group usually receives a 35 F DLT; therefore the outcome of their study is not significant.

Methods of Insertion of Left-Sided Double Endotracheal Tubes

Two techniques are used most commonly by anesthesiologist when inserting and placing a DLT. The first is the blind technique, which is where the DLT is passed with direct laryngoscopy, then turned 90° counterclockwise after the endobronchial cuff has passed beyond the vocal cords (see figure 1). The DLT is advanced until moderate resistance is felt, which usually indicates that the endobronchial lumen of the DLT has entered the bronchus. Alternatively, the tube is advanced until the depth of insertion at the teeth is approximately 29 cm for both men and women if their height is at least 170 cm.

The second technique uses fiberoptic bronchoscopy guidance in which the tip of the endobronchial lumen is guided after the DLT passes the vocal cords; direction is sought with the aid of a flexible fiberoptic bronchoscope (see figure 2). In a study by Boucek, et al, comparing the blind technique versus the fiberoptic bronchoscopy guided technique; it was shown that of the 32 patients who underwent the blind technique approach, primary success occurred in 30 patients. In contrast, in the 27 patients using the bronchoscopy guided technique, primary success was achieved only in 21 patients and eventual success in 24 patients. In addition, two patients in each group required an alternative method for tube placement. Either method may fail when used alone.

Confirmation of a Left-Sided Double-Lumen Endotracheal Tube

Evidence strongly suggests that auscultation alone is unreliable for confirmation of proper DLT placement. A study by Klein, et al, involving 200 patients who were intubated by the blind technique followed by confirmation with a fiberoptic bronchoscope, found that more than one third of the DLTs required repositioning by at least 0.5 cm.

A study by Brodsky and Lemmens reported clinical experience with the use of left-sided DLTs in 1,170 patients. Using auscultation and clinical signs, there were 71 patients (6.2%) in whom the DLT was found to be in unsatisfactory position and required readjustment after initial placement. What is important from the Brodsky study is the fact that in 56 patients the DLT was too deep into the left bronchus, and indirectly was a cause of hypoxemia in 21 of 56 patients who had a malpositioned tube. Auscultation and bronchoscopy should both be used each time a DLT is placed and again when the patient is repositioned.

Fiberoptic bronchoscopy is performed first through the tracheal lumen to ensure that the endobronchial portion of the DLT is in the left bronchus and that there is no bronchial cuff herniation over the carina after inflation. Through the tracheal view, the blue endobronchial cuff ideally should be seen approximately 5 mm below the tracheal carina in the left bronchus. Also, it is crucial to identify the take off of the right upper lobe bronchus through the tracheal view. Going inside the right upper lobe with the bronchoscope should reveal three orifices (apical, anterior and posterior). Broncho-cath tubes from Mallinckrodt have a radiopaque line encircling the tube. This line is proximal
to the bronchial cuff and can be useful while positioning a left-sided DLT. The radiopaque marker is 4 cm from the distal tip of the endobronchial lumen, this marker reflects white during fiberoptic visualization and when positioned slightly above the tracheal carina should provide the necessary margin of safety for position into the left mainstem bronchus \( ^{12-13} \). The next observation with the fiberoptic bronchoscope is made through the endobronchial lumen to check for patency and determination of margin of safety. The orifices of both the left upper and left lower lobes must be identified to avoid distal impaction in the left lower lobe \( ^{14} \). Figure 3 displays the tracheo-bronchial anatomy, along with fiberoptic bronchoscopy findings from the endotracheal or endobronchial lumen for a left-sided DLT.

**Right-Sided Double-Lumen Endotracheal Tubes**

The anatomic differences between the right and left mainstem bronchus are reflected in the fundamentally different designs of the right-sided and left-sided DLT’s. 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 to 2 cm from the carina, techniques using right endobronchial intubation must take into account the location and potential for 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 for the right-upper lobe. Specific clinical situations in which the use of the right-sided DLT is indicated are shown in table I.

**Safety of Right-Sided Double-Lumen Endotracheal Tubes**

In theory, the left-sided DLT and right-sided DLT should be equally safe and efficacies for collapse of either the right or the left lung. In practice however, the 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 \( ^{15} \). Another study \( ^{16} \) 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 \( ^{17-18} \). The only absolute contraindication for right-sided DLT use is the presence of an anomalous right-upper lobe take off from the trachea; which has been estimated to be present in 1 of 250 otherwise normal subjects \( ^{19} \). In a prospective and randomized study by Campos, et al \( ^{17} \), right-sided DLT’s compared favorably with left-sided DLT’s in patients requiring one-lung ventilation for left-sided thoracic surgery. In this study, the incidence of right-upper lobe collapse was assessed intraoperatively by a chest radiograph, which showed good expansion of the right-upper lobe in all patients who received right-sided DLT’s. A recent retrospective review study by Ehrenfeld, et al \( ^{20} \), has challenged the question of whether or not right and left-sided DLT’s have an identical clinical performance. In this retrospective study, the authors identified 241 patients that had a right-sided DLT and 450 had a left-sided DLT. The end points studied included hypoxemia (SPo\(_2\) <90%), hypercapnia (Etco\(_2\) >45% mmHg) and high airway pressures (peak inspiratory pressure >35 cmH\(_2\)O).

According to their results there were no differences in the incidence or duration of hypoxemia, hypercarbia, or high airway pressures, yet their peak inspiratory pressure >35 cmH\(_2\)O reported in both groups were: left-sided DLT group n=301 (69%) and right-sided
DLT group n=173 (71.8%). Although no clinical differences were found among groups, their higher peak inspiratory pressure in their study is of concern because of the potential of inducing acute lung injury. Furthermore, the authors failed to include crucial information regarding the use of DLT’s such as quality of lung isolation and incidence of malpositions. It is my personal opinion that this study does not answer the question of identical clinical performance regarding right or left-sided DLT’s and further prospective comparative studies on a large scale are needed.

**Placement and Positioning of a Right-Sided Double-Lumen Endotracheal Tube**

The preferred technique for placement of a right-sided DLT is with the use of a bronchoscope, with the patient first in the supine position, then in the lateral decubitus position for tube placement confirmation. After the right-sided DLT is passed beyond the vocal cords, 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 takeoff 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 proper position of the right-sided DLT is one that provides a good alignment between the opening slot of the endobronchial lumen in relationship to the take off of the right-upper lobe bronchus and distally (endobronchial lumen) a free view of the bronchus intermedius and the right-lower lobe bronchus. From the tracheal view, the optimal position for a right-sided DLT provides a view of the edge of the blue cuff (the endobronchial balloon) when inflated just below tracheal carina and a view into the entrance of the right mainstem bronchus. Figure 4 displays the tracheo-bronchial anatomy, along with fiberoptic bronchoscopy findings from the endotracheal or endobronchial lumen for a right-sided DLT. The same fiberoptic bronchoscopy exam should be performed after the patient is turned into lateral decubitus position to confirm DLT placement. A modified right-sided BronchoCath® double-lumen tube consisting of an enlarged area of the orifice slot to ventilate the upper-lobe bronchus has been compared with the conventional right-sided BronchoCath® in patients requiring lung isolation. Their results showed more frequent and adequate position between the enlarged opening of the tube in relationship to the entrance of the right-upper lobe bronchus and easy reposition with the modified right-sided DLT version.

**Current Problems Associated with the Use of Double-Lumen Endotracheal Tubes**

The most common problems and complications of the use of DLTs are malposition 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 dislodgment of the endobronchial cuff because of over inflation, surgical manipulation of the bronchus, or extension of the head and neck during or after patient positioning.

Optimal position of a DLT after placement is crucial to the outcome of the patient requiring lung isolation. Inoue, et al have shown that if a DLT is malpositioned in the supine or lateral decubitus position, there is a greater likelihood that the patient will develop multiple episodes of hypoxemia during one-lung ventilation (OLV) and will require more ventilatory interventions such as positive end expired pressure (PEEP) and
continuous positive airway pressure (CPAP) ventilation. In addition, lack of lung collapse due to failed placement of a DLT might contribute to direct damage to the lung during surgery.

Other factors to consider when placing lung isolation devices is the familiarity with a device (i.e. left sided DLT), expertise with flexible fiberoptic bronchoscopy techniques and recognition of tracheobronchial anatomy. A study involving devices for lung isolation used by anesthesiologists with limited thoracic experience showed an overall incidence of unrecognized malpositions of 39% among the devices studied (left-sided DLT or bronchial blockers). Lack of recognition of tracheobronchial anatomy was one of the factors that led to a high incidence of malpositions.

Airway trauma with the use of a DLT can lead to minor or major complications. A study by Knoll et al showed that the incidence of postoperative hoarseness and soar throat were more common in the patients that received DLT versus bronchial blockers (44% DLT versus bronchial blocker 17%). Airway trauma and rupture of the membranous portion of the trachea or bronchus continues to be an isolated problem with the use of DLTs. This problem can occur during insertion and placement, while the case is in progress, or during extubation. Another problem that has been reported is the development of bilateral pneumothoraces or a tension pneumothorax in the dependant and ventilated lung during OLV. A 25-year review of the literature by Fitzmaurice and Brodsky 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 using an undersized DLT and it migrates distally into the bronchus and the main (i.e. tracheal) body of the DLT comes into contact with 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 airway 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 above mentioned problems occur, a bronchoscopic examination should be performed and, if indicated, surgical repair performed.

**Summary**
A left-sided DLT is the most common device used for lung isolation, due in part to the greater margin of safety. The optimal placement of a left or right-sided DLT is achieved with the confirmation of flexible fiberoptic bronchoscopy first in supine position, followed by reconfirmation in lateral decubitus position. Recognition of tracheobronchial anatomy with flexible fiberoptic bronchoscope leads to a successful placement of lung isolation devices.
References

Figure Legend

Figure 1: The blind method technique for placing a left-sided double-lumen endotracheal tube (DLT)
A. The DLT is passed with direct laryngoscopy beyond the vocal cords.
B. The DLT is rotated 90 degrees to the left.
C. The DLT is advanced until moderate resistance is felt, indicating that the endobronchial lumen of the DLT has entered the bronchus (in general 29 cm marks the level of the teeth).

Figure 2: The fiberoptic bronchoscopy guidance technique for placing a left-sided DLT.
A. The DLT is passed with direct laryngoscopy beyond the vocal cords.
B. The fiberoptic bronchoscope is advanced through the endobronchial lumen. The tracheal carina and left mainstem bronchus are visualized.
C. The DLT is rotated 90 degrees to the left and, with the aid of the fiberoptic bronchoscope, the tube is advanced into the left mainstem bronchus.

Figure 3: The optimal position of a left-sided DLT.
A. shows an unobstructed view of the entrance of the right mainstem bronchus when the fibrescope is passed through the tracheal lumen, the white marker line above the tracheal carina and the blue edge of the fully inflated endobronchial cuff below the tracheal carina in the left bronchus.
B. shows an unobstructed view of the left upper and left lower bronchus when the fibrescope is advanced through the endobronchial lumen.
C. shows the take-off of the right upper bronchus with the three segments (apical, anterior and posterior). (With permission from Campos JH: Thorac Surg Clin 15: 71-83; 2005.)

Figure 4: Shows a fiberoptic bronchoscopy exam with a right-sided double-lumen endotracheal tube.
A. The take-off of the right-upper bronchus with three segments (apical, anterior, and posterior) when the fiberoptic bronchoscope emerges from the opening slot located in the endobronchial lumen.
B. An unobstructed view of the entrance of the left mainstem bronchus when the fibrescope is passed through the tracheal lumen and the edge of the fully inflated endobronchial cuff is below the tracheal carina in the right bronchus.
Figure 1

Patient height 170 cm

Figure 2
Figure 3

Modified from #14: Campos JH: Thorac Surg Clin: 15; 71-83; 2005

Figure 4
Table I:  **Indications for right-sided double-lumen endotracheal tubes**

- Distorted anatomy of the entrance of the left mainstem bronchus due to:
  - External or intraluminal tumor compression
  - Descending thoracic aortic aneurysm
- Site of surgery involving the left mainstem bronchus
  - Left lung transplantation
  - Left-sided tracheobronchial disruption
  - Left-sided pneumonectomy
  - Left-sided sleeve resection