Double-lumen tube position should be confirmed by fiberoptic bronchoscopy

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Purpose of review

This review is part of Pro and Contra use of fiberoptic bronchoscopy to confirm the position of a double lumen tube. The purpose of this review is to highlight the circumstances where fiberoptic bronchoscopy should be used in conjunction with lung separation, right sided double-lumen tube positioning, and to identify fine malposition for generally missed by clinical signs.

Recent findings

Until several years ago, confirmation of a double-lumen tube (DLT) position was limited to inspection and auscultation. Fiberoptic bronchoscopes were usually only available in the bronchoscope suite for the exclusive use of the pulmonary personnel. Today, in most institutions, fiberoptic bronchoscopes of different diameters are available in the operating room for use by the anesthesia personnel.

Summary

Advances in technology and improved quality of the endoscopes image make the technique easy to use with a relatively simple learning curve. In fact, fiberoptic workshops, thoracic workshops and difficult airway workshops are offered in nearly all important anesthesia meetings.

Keywords

double lumen tube, fiberoptic bronchoscopy, malposition, one lung ventilation

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Abbreviations

DLT double-lumen tube
VAT video-assisted thoracoscopy

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Introduction

Until several years ago, confirmation of a double-lumen tube (DLT) position was limited to inspection and auscultation. Fiberoptic bronchoscopes were usually only available in the bronchoscopy suite for the exclusive use of the pulmonary personnel. Today, in most institutions, fiberoptic bronchoscopes of different diameters are available in the operating room for use by the anesthesia personnel. Advances in technology and improved quality of the endoscopic image make the technique easy to use with a relatively simple learning curve. In fact, fiberoptic workshops, thoracic workshops and difficult airway workshops are offered in nearly all important anesthesia meetings around the country. Therefore, the rationale for the use of fiberoptic bronchoscopy for correct DLT positioning has changed in the last 10 years. Before one can judge whether DLTs should be positioned with fiberoptic bronchoscopy, some issues should be considered.

Indications for one-lung ventilation: what has changed?

The indications for one-lung ventilation are customarily classified either as absolute or as relative [1]. The absolute indications include life-threatening complications, such as massive bleeding, sepsis and pus, or bronchopulmonary lavage, when the non-diseased contralateral lung must be protected from contamination. Broncho-pleural fistulae offer a low resistance pathway for the delivered tidal volume, while giant unilateral bullae may rupture under positive pressure. Ventilatory exclusion in both is therefore mandatory.

Video-assisted thoracoscopy (VAT) has been introduced to thoracic practice in recent years with increasing popularity [2–6]. A considerable number of diagnostic and therapeutic procedures can be performed with VAT. Unlike conventional thoracoscopy, VAT should be included in the category of absolute indication for one-lung ventilation for the following reasons. The lung needs to be well collapsed, otherwise the surgeon would be unable to visualize the surgical field, as well as being unable to palpate the lesion, or to place the staple. Finally, if a staple is placed on a noncollapsed lung, free from air in the lung parenchyma, there is the potential for a persistent postoperative air leak.

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Lung separation: double-lumen endobronchial tubes

Left sided DLT (most widely used) or right sided DLT may be used to achieve lung separation.

Choice of tubes

The clear, disposable, polyvinyl chloride DLTs, designed by Robertshaw, are the most commonly used in clinical practice [7]. These tubes have a fixed curvature, are without a carinal hook to avoid tracheal laceration, and reduce the likelihood of kinking. The internal diameter is large and it is composed of two D-shaped lumen that reduce the dead space and the resistance to airflow at equivalent external diameters. The advantages of these tubes include the following: they are easier to pass and to position, the thin wall offers a low resistance to airflow, and the distinct color coding of the pilot balloon reduces the confusion in identifying the lumen. In addition, the clear material allows continuous observation of the moisture, and the bright blue bronchial cuff is easy to identify during bronchoscopy through the tracheal lumen for correct tube position [8]. Numerous manufacturers produce these DLTs; they are available in French sizes 35–41 (Mallinckrodt (Argyle, New York), Rusch, Sheridan (Argyle, New York), Portex, Kenee, New Hampshire). Essentially, they consist of similar features but differ in cuff shape and location. Two pilot balloons are connected to the tracheal and bronchial cuffs. Each lumen can be independently opened to allow gas venting from the nonventilated lung. The internal lumen of the 35, 37, 39, and 41 Fr polyvinyl chloride DLTs correspond to 5, 5.5, 6, 6.5 mm, respectively. Several sizes of bronchoscope are available for clinical use: 5.6, 4.9, and 3.9 mm external diameter (Olympus Co, Melville, NY or Pentax Golden, Colorado). The 3.9 mm diameter bronchoscope is the most widely used and can easily be passed through a 37 Fr or larger tube, while it is a tight fit through a 35 Fr tube.

Right-sided tubes

In the Robertshaw design, the right endobronchial cuff is donut-shaped to allow the right upper lobe ventilation slot to ride over the right upper lobe orifice. In most cases, however, adequate ventilation cannot be ensured since the slot must directly open into the right upper lobe bronchial orifice. Because of the narrow margin of safety in right-sided DLTs, they are more likely to be malpositioned. Fiberoptic confirmation requires special operator experience, and would not guarantee intraoperative dislocation with position change and surgical manipulation. In a recent report by McKenna *et al.* [9] verification of the position of disposable right-sided DLTs with fiberoptic bronchoscopy revealed that the right upper lobe orifice was occluded in 89% of cases. Only 10% of malpositions were detected with the nondisposable red rubber right-sided DLT. Most practitioners refrain from using right-sided DLTs simply to avoid potential obstacles. The author uses right-sided tubes only in the presence of a left main bronchus tumor, in case of narrowing of the left main bronchus from extrinsic compression such as an aortic arch aneurysm, or for teaching purposes.

Positioning of double-lumen tubes

If a DLT is properly positioned, it presents little difficulty to the anesthesiologist; otherwise, the anesthesiologist is faced with a myriad of potential problems.

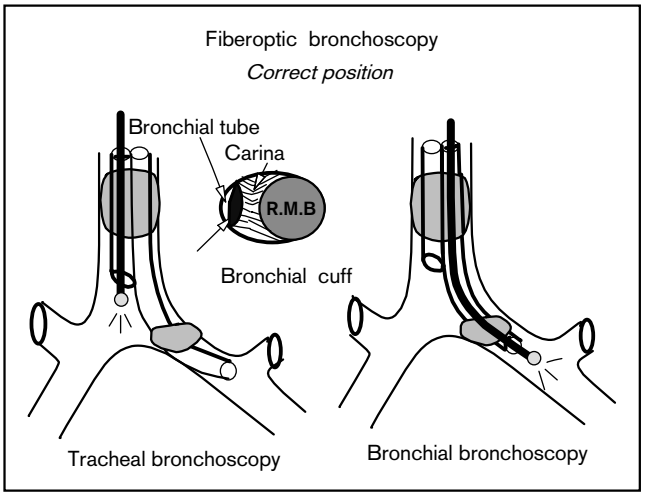
Auscultation and inspection

Following a blind intubation the tracheal cuff should be inflated first and equal breath sounds should be confirmed. The bronchial cuff should be inflated with incremental volume to seal air leaks around the bronchial cuff into the tracheal lumen. Inflation of the bronchial cuff seldom requires more than 2 ml of air. Bilateral breath sounds should be re-checked to confirm that the bronchial cuff is not herniating and thus impeding the ipsilateral lung ventilation. An important step is to verify that the tip of the bronchial lumen is located in the designated bronchus. One simple way to check this is to first clamp the trachea, observe and auscultate. Usually, inspection will reveal unilateral ascent of the ventilated hemithorax. Following proper auscultation, the bronchial lumen is clamped to ventilate the tracheal lumen. The risk of occluding the left upper lobe bronchus by the bronchial tip advanced far into the left main bronchus should be kept in mind. If the peak airway pressure is 20 cm H_2O during two-lung ventilation, for the same tidal volume, that pressure should not exceed 40 cm H_2O on one-lung ventilation.

Fiberoptic bronchoscopy

Perhaps the most important advancement in the proper positioning of DLTs is the introduction of fiberoptic bronchoscopy to clinical practice [10,11]. It has recently been shown that DLTs thought to be correctly positioned by inspection and auscultation were subsequently revealed by fiberoptic bronchoscopy to be malpositioned in 20–48% of cases [12]. The simplest method to evaluate proper positioning of a left-sided DLT is to perform a bronchoscopy via the tracheal lumen following blind intubation. The carina is then visualized, while only the proximal edge of the endobronchial cuff should be identified just below the tracheal carina. Herniation of the bronchial cuff over the carina to partially occlude the ipsilateral main bronchus should be excluded. The bronchial blue cuff of the clear, disposable, polyvinyl chloride DLT is easily visualized (Fig. 1). When using a right-sided DLT, the carina is visualized through the tracheal lumen. More importantly, the right upper lobe bronchial orifice must be identified while the bronchoscope is passed through the

Figure 1. Fiberoptic bronchoscopy: correct position



RMB, right main bronchus.

Figure 2. Left-sided double lumen tube malposition

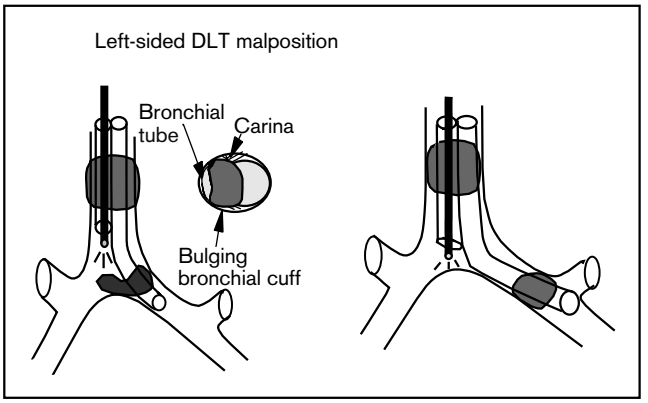
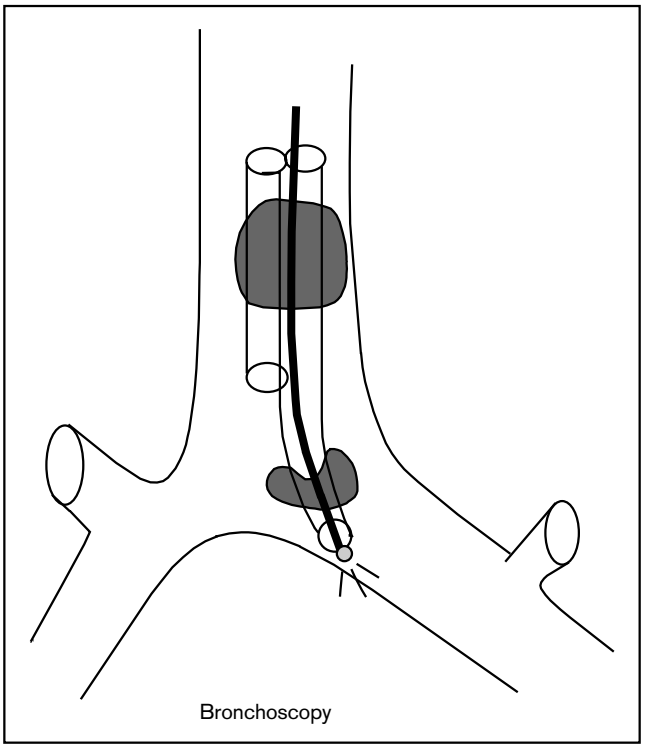


Figure 3. Method of DLT positioning with the aid of a bronchoscope following intubation is to place the fiberoptic bronchoscope through the bronchial lumen and to direct it into the desired bronchial lumen



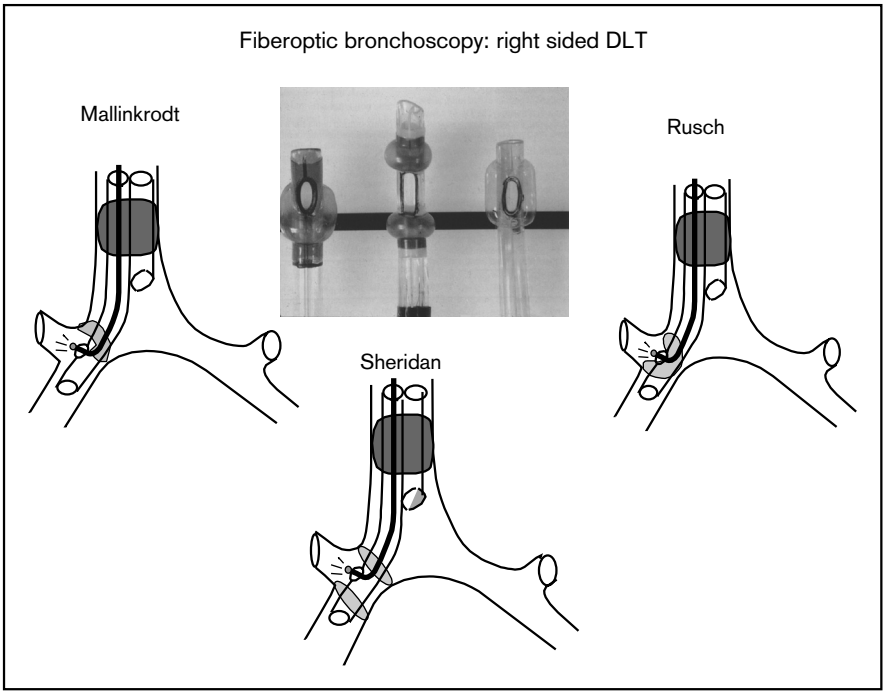
right upper lobe ventilating slot (Fig. 2). This is somewhat complex to accomplish and requires a relatively skilled endoscopist.

The last method of DLT positioning with the aid of a bronchoscope following intubation is to place the fiberoptic bronchoscope through the bronchial lumen and to direct it into the desired bronchial lumen (Fig. 3).

Margin of safety

The margin of safety is the length of the tracheobronchial tree over which the DLT may be moved or positioned without obstructing a conducting airway [13]. The margin of safety of a DLT was studied *in vivo*, during an autopsy, and from a lung cast. The distance from the carina to the left or right upper lobe orifice was respectively found to be 49 ± 8 and 19 ± 6 mm in males, and 44 ± 1 and 15 ± 5 mm in females. The average margin of safety in positioning a left-sided tube was 15 and 8 mm for the right-sided DLT. In the conclusion of their study, the authors made some practical clinical recommendations [13]. First, since the average margin of safety of a left-side DLT is almost three times that of the right DLT, left-sided DLTs should be used whenever possible. Second, following auscultation and inspection, fiberoptic bronchoscopy should be performed to ensure appropriate positioning and the blue bronchial cuff should be positioned just below the tracheal carina. The left upper lobe orifice may also be obstructed by a left-sided DLT. Although the left upper lobe takeoff is between 5.0 and 5.5 cm from the carina, it is feasible to obstruct the left upper lobe by the bronchial tip and still have the tracheal orifice above the carina which will be associated with a large shunt (Fig. 4). Third, a right-sided DLT may occlude the right upper lobe orifice because of the short distance from the carina to the right upper lobe takeoff (2.3 ± 0.17 cm in males and 2.1 ± 0.7 cm in females). The margin of safety is only between 1 and 8 mm, and it is hard to ensure appropriate ventilation to that right upper lobe. Each time a right-sided DLT is used, appropriate ventilation of the right upper lobe should be ensured either by careful auscultation over the right upper lung field or, more accurately, by fiberoptic bronchoscopy [14].

Figure 4. Fiberoptic bronchoscopy: right-sided double lumen tube



Finally, because the margin of safety of both left and right DLTs is small, flexion and extension of the head can dislocate and easily malposition a previously well positioned tube. Saito *et al.* [15] have shown that the tip of the DLT can move an average of 2.7 and 3.5 cm with the flexion and extension of the neck. Therefore, particular attention should be given during turning of the patient and the tube position should be reconfirmed in the lateral position.

Why we need a fiberoptic bronchoscope for positioning a double-lumen tube

Based on the information described above, the real question is not if we need fiberoptic bronchoscopy for DLT positioning, but should we practice thoracic anesthesia without the routine use of a fiberoptic bronchoscope? Clearly, in modern practice not having a fiberoptic bronchoscope as part of the thoracic setup is less than satisfactory for the following reasons.

The introduction of video-assisted thoracoscopy

VAT is a clear indication for optimal lung separation, and in our institution about 60% of thoracic procedures start with VAT. This new reality has brought three important considerations to the practice of thoracic anesthesia.

First, the number of patients that need a lung collapse has increased drastically. Without a well collapsed lung the surgeon would not be able to visualize the operative field or to perform any safe resection without the risk of postoperative air leak. The old-fashioned way of opening the chest and retracting the lung by compression is not possible. If a fiberoptic bronchoscope were not employed to verify an optimal tube position it would be very difficult to correct it in the lateral position.

Second, prior to the time of VAT, out of 100 patients scheduled for lung surgery, two or three would be classified as absolute indications, as described above. However, the possibility that these patients would have difficult airways is remote. Among the other 97–98 patients, in those who present with a difficult airway, surgery would be done with a single-lumen tube, intermittent ventilation, and compressing the lung with lap pads. Today, out of 100 patients scheduled for thoracic surgery, in approximately 60 the procedure would start with VAT requiring lung collapse. The chances are that there will be more patients with difficult airways among these 60 patients. In these patients, DLTs would be difficult to place and alternative methods such as a Univent tube or placement of a bronchial blocker would be required [16–19]. These alternative devices must be positioned by fiberoptic bronchoscopy. In modern thoracic anesthesia, DLTs represent only one aspect of lung separation; a competent practitioner must be trained and ready to use alternative methods should they be required.

Third, some will argue that the fiberoptic bronchoscope equipment is costly. Today, VAT equipment is available

in every operating room for use by the surgical team. As anesthesiologists, all we need is the correct size fiberoptic bronchoscope; the rest of the equipment is already available for us to use. It is somewhat difficult to justify not using fiberoptic bronchoscopes for proper patient management!

Fine malpositions

If one accepts the argument that the position of the DLT does not require a fiberoptic bronchoscope, the main problem would be that it is placed blindly. Apart from the fact that there is no guarantee that the tube will remain in place throughout the surgical procedure, several investigators have found that auscultation would not recognize a fine malposition. Smith *et al.* [12] found that in 48% of cases a left-sided DLT was not ideally positioned by blind placement when checked by fiberoptic bronchoscopy. A high incidence of fine malpositions was found by a study on disposable polyvinyl chloride and nondisposable DLTs [20]. One could argue that it was not proven that these fine malpositions made any difference to oxygenation. However, should one proceed with surgery accepting the possibility of fine malpositions that may be unable to protect the dependent lung from blood, pus or water?

Right-sided double-lumen tube

The margin of safety of right-sided DLTs is extremely small and blind positioning is not an acceptable practice. Again, the clinical skills of an anesthesiologist should not be tested in a difficult situation of proper positioning of a right-sided DLT. If anesthesiologists were to use fiberoptic bronchoscopy routinely, they would be trained and comfortable to correct right-sided DLT malpositions, Univent tube positioning, or awake fiberoptic intubation.

Persistence intubation of the contralateral main bronchus

It is not uncommon for left-sided DLTs to be persistently placed in the right main bronchus. Then, despite turning the tube 90° to the left and turning the head to the right, the malposition will not correct. In these cases a fiberoptic bronchoscope should be inserted through the bronchial lumen that will be drawn back above the carina to be pushed over the bronchoscope, under direct vision, into the left main bronchus.

Difficult intubation

As previously discussed, the anesthesiologist should be well trained, comfortable and ready to perform a fiberoptic intubation with a single- or a double-lumen tube, to place a Univent tube, or to provide a lung separation using a bronchial blocker through the single-lumen tube. This should be part of the routine setup for thoracic procedures.

In a recent study by Brodsky and Lemmens [21•], they reported their clinical experience in 1170 patients using a left-sided DLT. The size of the DLT and the depth of insertion were derived from the width of the trachea and the left main bronchus. These authors concluded that left-sided DLTs can be used for left-sided procedures including left pneumonectomies. After intubation, the DLT should be pushed to a certain depth based on the patient's height. The most important conclusion of the report is that the fiberoptic bronchoscope is the most common adjuvant used to confirm DLT position. It is essential, however, for every anesthesiologist to know how to place a DLT using clinical signs alone. With this statement I am in full agreement.

Conclusion

Fiberoptic bronchoscopy is an essential tool and an integral part of thoracic anesthesia. Proper positioning of left-sided DLTs without fiberoptic bronchoscopy is less than satisfactory. Right-sided DLT positioning without fiberoptic bronchoscopy is clinically unacceptable. Continuous and routine use of fiberoptic bronchoscopy is a must in modern practice. One must gain the expertise and competency required to face difficult airways, or to use an alternative to DLTs such as a Univent tube or bronchial blockers. Finally, one should be certain that the tube is optimally positioned throughout the entire length of the procedure.

Can we provide anesthesia without end tidal CO_2 monitoring or a pulse oximeter? We sure can, it has been done for years. Would any one in modern practice consider doing so? Most certainly not. No practicing anesthesiologist would provide an anesthetic without end tidal CO_2 monitoring or pulse oximetry. Although not as clear cut, practicing thoracic anesthesia without routine use of fiberoptic bronchoscopy is an analog situation, and I believe the answer to the title of the manuscript is therefore clear.

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This is an important study that evaluates the positioning and the size selection of a large number of left-sided DLTs.