Brief Review

Expert opinion on the use of fiberoptic bronchospe to check the insertion depth of the left-sided double-lumen tube

ABSTRACT

Left-sided double-lumen tube (LDLT) is commonly used to achieve one lung isolation in most thoracic surgical procedures. Traditionally, the LDLT is blindly placed using direct or video laryngoscopy. In this brief report, we highlight the importance of using our novel insertion depth formula to predict the appropriate LDLT insertion depth and demonstrate the current evidence supporting the efficacy of the formula. Also, we will discuss two relatively new devices of LDLTs: one with an embedded camera at the distal end of the tracheal lumen and the other with a carinal cuff between the bronchial cuff and the tracheal lumen in reducing the incidence of too deep inserted LDLT. We advocate that using our novel formula and these two new devices may reduce but not eliminate the need for FOB to check the insertion depth of LDLT.

Key words: FOB, LDLT, thoracic anesthesia

Introduction

Left-sided double-lumen tube (LDLT) is commonly used to achieve one lung isolation in most thoracic surgical procedures. Traditionally, the LDLT is blindly placed using direct or video laryngoscopy. The stylet is removed after the LDLT is advanced past the vocal cords, and then, it is rotated 90 degrees to the left (counterclockwise) and simultaneously advanced until mild resistance is encountered. A flexible fiberoptic bronchoscope (FOB) then is used to confirm placement of the LDLT, or placed in the bronchial lumen after removal of the stylet to navigate LDLT into the left mainstem bronchus. Ideally, the bronchial cuff of the LDLT should be placed 2–3 cm distal to the carinal level. A shorter distance to the carina would result in cuff herniation. A longer length might be associated with either inadequate lung collapse or risks of hypoxemia. Currently, there is no supportive solid evidence of having a predetermined method to ascertain the proper insertion depth of LDLT and whether knowing the appropriate insertion depth of the DLT would prevent tracheobronchial injury or disruption with too deep insertion. The current standard of care practice requires confirmation of the correct LDLT position and insertion depth with FOB after or during placement. However, theoretically predicting the individualized appropriate insertion depth of the LDLT before intubation may allow for correct positioning of the LDLT directly and reduce the times of malpositioning, the

Access this article online	
Website: https://journals.lww.com/sjan	Quick Response Code
DOI: 10.4103/sja.sja_698_23	

How to cite this article: Eldawlatly AA, Basheer MK, AlHamdi MA, El-Tahan MR. Expert opinion on the use of fiberoptic bronchospe to check the insertion depth of the left-sided double-lumen tube. Saudi J Anaesth 2024;18:272-5.

Abdelazeem A. Eldawlatly, Musaab K. Basheer[1], Malik A. AlHamdi[2], Mohamed R. El-Tahan[3]

Department of Anesthesia, College of Medicine, King Saud University, Riyadh, [1]Department of Anesthesia, King Abdullah Medical City, Makkah, [2]Department of Anesthesia, King Saud University Medical City, Riyadh, [3]Department of Anesthesia, Imam Abulrahman Bin Faisal University, Dammam, Kingdom of Saudi Arabia

Address for correspondence: Prof. Abdelazeem A. Eldawlatly, Department of Anesthesia, College of Medicine, King Saud University, Riyadh, Kingdom of Saudi Arabia.
E-mail: dawlatly2@yahoo.com

Submitted: 14-Aug-2023, **Revised:** 15-Aug-2023, **Accepted:** 16-Aug-2023, **Published:** 14-Mar-2024

need for FOB repositioning, and risks of airway injury due to an improperly LDLT placement depth.[1]

The critical need for a precise technique to confirm the insertion depth of LDLT is addressed in a study by Liu *et al*.[2] Considering that a majority of patients presenting for surgery have chest CT for surgical guidance, anesthesiologists should carefully review the relevant data, such as left mainstem bronchial diameter and the distance from the carina to the vocal cords, to guide LDLT size selection and depth of insertion, respectively. Another point emphasized by Liu *et al*.[2] is that CT-guided determination of the depth of LDLT insertion reduces the need for costly FOB to position a LDLT.

In this brief report, we highlighted the importance of using the insertion depth formulae including our novel formula to predict the appropriate insertion depth of LDLT and demonstrated the current evidence supporting the efficacy of our formula in determining the depth of LDLT. Also, we will discuss two relatively new devices of LDLTs one with an embedded camera at the distal end of the tracheal lumen and the other with a carinal cuff between the bronchial cuff and the tracheal lumen in reducing the incidence of too-in deep inserted LDLT. We advocate that using our novel formula and these two new devices may reduce but not eliminate need for FOB to check the insertion depth of LDLT.

Insertion Depth Formulae

Several height-based formulae have been described to predict the correct insertion depth of LDLT. Chow *et al*.[3] developed a formula based on the clavicular-to-carinal distance of the trachea and the body height (BH) in 78% of their patients ($0.15 \times BH + 3.80$ cm). Brodsky *et al*.[4] demonstrated that a height-based formula could predict the insertion depth of LDLT ($0.11 \times BH + 10.5$ cm). In a pilot study on 41 patients, we have developed a formula for predicting the accurate insertion depth of LDLT into the left main bronchus based on the BH as follows: ($0.249 \times BH^{0.916}$).[5] In another study on the efficacy of our formula on 66 patients,[6] we demonstrated the correlation between our formula with other five height-based formulae to predict the optimum insertion depth of the LDLT, Chow *et al*.,[3] r¼0.71, $P < 0.0001$; Brodsky *et al*.,[4] r¼0.75, $P < 0.0001$; Bahk and Oh ($0.15 \times BH + 3.96$ cm)[7] r¼0.74, $P < 0.0001$; Takita *et al*.,[8] ($0.10 \times BH + 12.5$ cm) r¼0.65, $P < 0.0001$; Lin and Cherng ($0.20 \times BH + 4.24$ cm)[9] r¼0.72, $P < 0.0001$. Using our novel formula correctly predicted the insertion depth of the LDLT without further adjustments in 70% (95% confidence interval: 58–80%) of our patients, as was confirmed with the FOB; withdrawal or advancement with only 0.5–1 cm to achieve optimal position was only required in 18% and 12% of patients, respectively. None of the studied patients had a compromised airway due to obstruction of a bronchus or a lobe by the endobronchial cuff. DLTs can be challenging to insert and are likely to move during patient position and surgical manipulations, which may compromise patient safety and prolong surgery time. Furthermore, the gold standard practice is to check for correct tube placement using a fiberoptic or video-enabled bronchoscope after tube insertion and after changing the patient's position to the final lateral surgical position, which further increases the risk of tube displacement. We should emphasize here that using our height-based formula does not preclude using FOB to check the correct position of the LDLT.

DLT with Integrated Camera

Continuous visualization of the LDLT position in the main bronchus ensures more accurate and safer tube placement, significantly reducing the number of failed intubations, and the time spent verifying placement. The VivaSight-DLT (ETView Medical Ltd./Ambu A/S, Ballerup, Denmark) is a single-use DLT with an integrated camera, which allows for more accurate tube placement using continuous real-time visualization and airway control during the entire surgical procedure.[10] Reusable bronchoscopes are thought to be associated with high repair costs, reprocessing costs, and possible transmission of infectious agents via cross-contamination, which further increases the economic burden.[11] Currently, single-use FOB is commonly used nowadays to check the LDLT insertion depth. In a cost analysis study, it was found that the utilization costs of both reusable and single-use FOB were very close. However, the use of single-use FOB has the advantage of eliminating cross-contamination and hence reduces transmission of infection.[12] Furthermore, using bronchoscopy to ensure correct tube placement may prolong the intubation procedure time compared with VivaSight-DLT, which allows for immediate confirmation of tube placement with continuous visualization.[13] Incorrect placement of the DLT can lead to problems with deflating the lung or with ventilating the non-operative lung sufficiently. Therefore, visual confirmation of correct tube placement after intubation and after placing the patient in the lateral surgical position has become mandatory. In a study by Onifade *et al*.,[14] it was demonstrated a significantly lower rate of FOB use when using a VivaSight-DLT compared to a conventional DLT and the need for FOB guidance for confirming proper LDLT placement may be eliminated with the novel VivaSight-DLT. Moreover, placement of the VivaSight-DLT was significantly quicker and malposition during surgery occurred significantly less than with the conventional DLT. Moreover, because the VivaSight-LDLT provides continuous surveillance, migration

of a LDLT during surgery would be rapidly recognized and corrected without the need for FOB and may prevent complications associated with conventional LDLT.

Triple-Cuffed DLT

A novel DLT was developed to facilitate DLT positioning via the addition of a carinal cuff between the bronchial cuff and the tracheal lumen.[15] The ANKOR-DLT (Insung Medical, Wonjou, Republic of Korea) may facilitate superior DLT positioning and reduce tracheobronchial injury, but its effectiveness remains to be conclusively elucidated. Although FOB has facilitated improved visualization of the tracheobronchial anatomy and is considered the gold standard for confirming the position of the DLT, in a previous study, 39% of anesthesiologists with limited thoracic anesthesia experience were unable to achieve lung isolation successfully irrespective of the type of device used, due to poor knowledge of endoscopic bronchial anatomy.[16] The inflated carinal cuff of the ANKOR-DLT that expands toward the right side of the main body of the DLT is subject to being captured by the carinal ridge as the tube is advanced alongside the tracheobronchial tree. The point at which the ANKOR-DLT is unable to advance further is considered the proper depth for lung isolation, and the inflated carinal cuff is assumed to affect the direction of ANKOR-DLT insertion into an intended left mainstem bronchus. Compared with conventional DLT, ANKOR-DLT was more optimally positioned before FOB guidance. In one study, it was shown that lung isolation using ANKOR-DLT can be accomplished regardless of using FOB. Using ANKOR-DLT can reduce the need for multiple attempts of DLT placement for lung isolation, which entails inevitable risks of airway trauma, hypoxemia, and hypercapnia, particularly when non-thoracic anesthesiologists or trainees are conducting the procedure.[17] It is also notable that given this feature of ANKOR-DLT, their use may be considered in situations in which FOB is not feasible, such as in cases of massive pulmonary secretion or bleeding. Moreover, in one study it was shown that the incidence of inadvertent placement of the LDLT into the right main bronchus was 4.2%,[18] that unlikely can happen with the use of ANKOR-DLT. Furthermore, given that there are substantial costs associated with the use of either single-use or reusable FOB, the use of ANKOR-DLT may have some cost/benefit advantages with respect to reducing the use of FOB resources in developing countries or small-volume institutions.

In conclusion, we advocate that using our novel formula would add another supporting evidence to the correct position of LDLT besides the use of FOB. Moreover, we think that using our formula may reduce the time spent to verify the LDLT placement. However, there is a need of a large multicenter study to conclusively validate our formula. Also, the use of the novel VivaSight-DLT provided continuous surveillance during surgery with the possible correction of the DLT position if needed without the use of FOB. Moreover, the use of ANKOR-DLT added a new insight into the proper insertion depth of LDLT without the use of FOB. We believe that those three modalities do not preclude the use of FOB but may reduce the dependence on it for checking the insertion depth of LDLT.

Acknowledgement

The authors would like to thank Mr. Sayed Anis Ahmed, anesthesia technician at King Saud University Medical City, for his continuing support and efforts in maintaining the devices required for lung isolation and for his help in conducting the thoracic anesthesia workshops.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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