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# *Role of Fiberoptic Bronchoscopy in Conjunction with the Use of Double-lumen Tubes for Thoracic Anesthesia*

## *A Prospective Study*

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***Background:*** **Fiberoptic bronchoscopy has been recommended to verify the position of double-lumen tubes (DLT), but this remains controversial. The authors studied the role of bronchoscopy for placing and monitoring right- and left-sided DLTs after blind intubation and after positioning the patient.**

***Methods:*** **Two hundred patients having thoracic surgery requiring DLT insertion were prospectively studied. "Blind" tracheal intubations were done with 163 left-sided and 37 right-sided disposable polyvinyl chloride Robertshaw tubes. Bronchoscopy was performed by a different anesthesiologist after intubation and conventional clinical verification of correct placement and after patient positioning for thoracotomy. A DLT was considered malpositioned when it had to be moved >0.5 cm to correct its position. Critical malpositions were those that might have affected patient safety or influenced the surgical procedure if left uncorrected.**

***Results:*** **After "blind" DLT intubation, clinical evidence of malpositioning was found in 28 patients. This was confirmed by fiberoptic assessment. In 172 patients in whom placement was judged correct by clinical assessment, malpositioning was detected by bronchoscopy in 79 cases, 25 of which were critical. After patient positioning, DLTs were found to be displaced in 93 patients, 48 of which were critical. Right-sided DLTs were significantly more likely to be malpositioned than were left-sided DLTs. Two complications were related to unsatisfactory lung separation in the 200 patients studied.**

***Conclusions:*** **After blind intubation and patient positioning, more than one third of DLTs required repositioning. Routine bronchoscopy is therefore recommended after intubation and after patient positioning. (Key words: Lung separation; one-lung ventilation; thoracic surgery.)**

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USE of the double-lumen tube (DLT) is the preferred lung separation method in most surgical procedures of the thoracic cavity. However, malpositioning of the DLT either during insertion or after patient positioning can occur. To avoid this, fiberoptic bronchoscopy has been recommended as a reliable method to evaluate DLT placement and lung separation.[1–4] Despite these recommendations, some authors argue that bronchoscopy is expensive, time consuming, and not universally available and thus should not be considered "routine."[5–10]

Because of the controversies concerning the routine application of fiberoptic bronchoscopy in thoracic anesthesia, we designed this prospective study to address the role of fiberoptic bronchoscopy in cases that require a DLT.

## Methods

Two hundred patients (40 women, 160 men) aged 14–78 yr (mean, 57 yr) having thoracic surgery (lung surgery: n = 187; esophageal surgery: n = 13) were studied. The surgical procedures included 70 left-sided and 114 right-sided thoracotomies and 16 median sternotomies. After preoxygenation, anesthesia was induced with thiopental or etomidate and sufentanil, and muscle relaxation was achieved with succinylcholine and vecuronium. The patients were intubated with a disposable



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polyvinyl chloride DLT (Bronchocath; Mallinckrodt, Athlone, Ireland). Following the recommendations of Brodsky *et al.*,[11] we chose 41- or 39-French tubes for men and 39-, 37-, or 35-French tubes for women. One hundred sixty-three left-sided DLTs and 37 right-sided DLTs (for planned interventions in the region of the left mainstem bronchus during left-sided thoracotomies) were used. Anesthesia was maintained with nitrous oxide and isoflurane. Continuous electric activity of the heart, arterial blood pressure, pulse oximetry, and end-tidal carbon dioxide using dual-capnography[12] (Cardiocap; Datex, Helsinki, Finland) were monitored.

The DLT with a stylet was passed through the larynx with distal curvature concave anteriorly. The stylet was removed after the endobronchial cuff had passed the vocal cords. The tube was then rotated 90 degrees and, with the head rotated slightly (to the left for right-sided tubes and to the right for left-sided tubes), the tube was advanced (typically 27–30 cm) until slight resistance was felt. After insertion, the tracheal cuff was inflated and clinical assessment of the correct intubation was made by observing chest wall expansions, checking lung compliance by manual ventilation, and by auscultation of both lungs. To assess the ability to isolate each lung, the endobronchial cuff was inflated (with about 2 ml air) and correct DLT position was assessed by auscultation after selective clamping of the bronchial and tracheal limbs. Necessary corrections were made by the same anesthesiologist. The anesthesiologist then recorded his assessment of the tube placement.

Immediately after this procedure, a second anesthesiologist, unaware of the first anesthesiologist's assessment, performed fiberoptic bronchoscopy (fiberbronchoscopes LF-1 or 3 C 20; Olympus Optical Co., Tokyo, Japan) and made the final assessment of DLT placement and corrected any tube malposition. Bronchoscopic criteria for correct DLT position were defined as follows: For the left-sided tube, unobstructed view into the left upper and lower lobe bronchus through the endobronchial lumen with the bronchial cuff immediately below the carina and just visible in the main left bronchus through the tracheal lumen. For the right-sided tube, unobstructed view into the right upper lobe bronchus through the eye of the right endobronchial lumen with the same position of the cuff in the right main bronchus, as described for the left-sided tube.[13] To provide a quantitative measure, malpositioning was diagnosed when the tube had to be moved (in or out) by more than 0.5 cm to correct its position. Critical malpositions were defined as follows: left endobronchial limb compromising (allowing no clear view of) left upper or left lower lobe bronchus, right endobronchial limb allowing no clear view of the right upper lobe; and intratracheal dislocation of more than one half of the endobronchial cuff. These malpositions were considered critical because they might have affected patient safety or influenced surgery.

A second bronchoscopy with correction of the tube's position if necessary was undertaken after positioning the patient for thoracotomy (lateral decubitus) or sternotomy (neck hyperextension) in all patients. The initial intubation and the fiberoptic management of all 200 DLTs were performed by five anesthesiologists during a period of 18 months.

Statistical analysis: Analysis of the results of DLT position and the indications for further bronchoscopies was done using descriptive statistics. The odds of developing a certain outcome in the presence of a risk factor against not having this factor (odds ratio) and its standard error of the mean were calculated. Hypothesis testing was done using the chi-square test. Probability values $<0.05$ were considered significant. The kappa-test of interrater (interobserver) agreement was used to test the agreement between the clinical and bronchoscopic assessment (malposition was described as a deviation of 0.5 cm from the correct position) of DLT placement.

## Results

Tables 1 and 2 summarize the main results. After intubation (and attempted correction of tube position), clinical findings alone detected tube malposition in 28 of the 200 patients (14%). Subsequent fiberoptic examination not only confirmed clinical findings but also provided an exact diagnosis of the malposition. Intubation of the "wrong" main stem bronchus was a frequent malposition (n = 13) that was corrected using the fiberscope as a guide. Proximal (n = 6) and distal malpositions (n = 6) also occurred frequently. Airway obstruction due to secretion without malposition was found in three patients.

Despite normal findings on auscultation and inspection, fiberoptic assessment revealed DLT malposition (0.5 cm deviation from correct position) in 79 additional patients (39.5%), with distal DLT malposition (n = 52) occurring more frequently than proximal malpositioning (n = 18). The interobserver agreement test between clinical and the fiberoptic assessment showed a



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**Table 1. Bronchoscopic Findings after Intubation and after Patient Positioning in 200 Patients Undergoing Thoracic Surgery**

| Time point | Patients (n/%) | FOB Findings | n |
|---|---|---|---|
| After intubation | | | |
| Abnormal clinical findings | 28/14.0 | Intubation of the "wrong" mainstem bronchus (12 × left DLT/1 × right-DLT | 13 |
| Abnormal FOB findings | | DLT too distal | 6 |
| | | DLT too proximal | 6 |
| | | Secretion | 3 |
| Normal clinical findings | 79/39.5† | DLT too distal | 52 |
| Abnormal FOB findings* | | DLT too proximal | 18 |
| | | Overinflated bronchial cuff | 7 |
| | | Underinflated bronchial cuff | 2 |
| After positioning | | | |
| Abnormal FOB findings* (no clinical evaluation) | 93/46.5‡ | DLT too proximal | 59 |
| | | Tracheal DLT disolocation | 17 |
| | | DLT too distal | 15 |
| | | DLT dislocation into the opposite mainstem bronchus | 2 |

Fiberoptic bronchoscopy (FOB) was carried out in all patients following "blind" double lumen tube (DLT) placement and clinical verification, and after positioning the patient for surgery.

* The tube had to be moved (in or out) by more than 0.5 cm to correct its position.

† Of these, 25 were critical malpositions.

‡ Of these, 48 were critical malpositions.

small but significant agreement (kappa = 0.248 ± 0.047; $P < 0.001$). Critical malpositions were detected in 25 of these 79 patients: 8 right endobronchial tubes did not allow clear view of the right upper lobe, and 9 left endobronchial tubes allowed no clear view into the left upper or left lower lower lobe bronchus. In 8 patients, one half or more of the endobronchial cuff was displaced in the trachea.

After positioning, bronchoscopy revealed malpositioning (0.5 cm deviation from correct position; see Methods) in 93 patients. Proximal malpositions; with the cuff partially bulging into the trachea, occurred more often (n = 59) than did distal malpositions (n = 15). Critical malpositions were detected in 48 of these 93 patients: In two patients, the endobronchial cuff was located in the "wrong" mainstem bronchus, in 17

**Table 2. Fiberoptic Bronchoscopy for DLT Correction in Relation to the Type of the Tube and to the Surgical Intervention in 200 Patients**

| Intervention | DLT Type | Number of Patients | DLT Correction after Intubation* | | DLT Correction after Positioning of the Patient | |
|---|---|---|---|---|---|---|
| | | | n | % | n | % |
| Median sternotomy | Left | 16 | 8 | 50.0 | 3 | 18.8 |
| Right-sided thoracotomy | Left | 114 | 57 | 50.0 | 49 | 43.0 |
| Left-sided thoracotomy | Left | 33 | 15 | 45.5 | 14 | 42.4 |
| Left-sided thoracotomy | Right | 37 | 27 | 73.0 | 27 | 73.0 |

DLT = double lumen tube.

* Includes those detected after clinical or fiberoptic assessment.



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patients the endobronchial cuff had completely moved into the trachea, in 19 patients one half or more of the endobronchial cuff was dislocated into the trachea, and 10 tubes (5 left, 5 right) were too far in allowing no clear view of the left upper or left lower lobe bronchus (left DLT) or right upper lobe bronchus (right DLT).

Positioning the patient for sternotomy produced a lower rate of (left-sided) DLT malpositions (3 of 16, or 18.8%) than did positioning the patient for lateral thoracotomy (63 of 147, or 42.9%). However, this difference was not significant ($P$ = 0.05). The frequency of DLT malpositions after patient positioning was not different from that after intubation ($\chi^2 = 1.96$; $P$ = ns).

Distal displacement occurred more frequently after intubation than after patient positioning (58 of 200 *vs.* 15 of 200, respectively; $\chi^2 = 30.98$, $P < 0.001$; odds ratio, 5.6 ± 1.6), whereas proximal malpositioning occurred more frequently after patient positioning than after intubation (76 of 200 *vs.* 24 of 200, respectively; $\chi^2 = 36.5$, $P < 0.001$; odd ratio, 4.5 ± 1.2). Right-sided DLT malpositioning occurred more often than left-sided after intubation (27 of 37 right sided *vs.* 80 of 163 left-sided, $\chi^2 = 6.92$; $P < 0.01$; odds ratio, 2.8 ± 1.1) and after positioning (27 of 37 right-sided *vs.* 66 of 163 left-sided, $\chi^2 = 12.79$; $P < 0.002$; odds ratio, 4 ± 1.6).

## Discussion

This study addresses the role of fiberoptic bronchoscopy during thoracic anesthesia in cases that require the use of DLT. Most thoracic interventions require DLTs, and incorrect positioning of the DLT may lead to complications such as hypoxia, atelectasis, high airway pressure, accumulation of secretion, and high incidence of infections after surgery.[3,7,14,15] Fiberoptic bronchoscopy is now an important tool in avoiding or correcting DLT malposition. Before the introduction of the bronchoscopy, assessment of tube position depended on clinical examination, which consisted of inspection, auscultation, and assessment of ventilation pressure with and without unilateral clamping of DLT limbs.[5,6,10,14,16]

In our study, clinical examination alone (without bronchoscopy) identified malpositioning in only 28 of 200 patients; in one half of these cases, correct positioning required use of the bronchoscope as a guide. Despite satisfactory clinical (auscultation and inspection) evaluation, fiberoptic assessment revealed DLT malpositioning in a further 79 of the 200 patients. In 25 patients, the malposition was critical and might have affected patient safety or influenced surgery. Previous studies have also shown that 15.5–24% of left-sided DLTs could not be positioned using clinical signs alone, necessitating fiberoptic bronchoscopy.[2,3] However, the findings of our study indicate that limiting the use of bronchoscopy to failed positioning (as diagnosed by clinical criteria) may lead to a high rate of undetected malpositions.[1–4] In agreement with some previous studies, our study thus supports the use of bronchoscopy for DLT placement. However, in contrast to our study, previous studies had some limitations, such as small sample size[1,4] and no regular fiberoptic assessment after patient positioning.[2]

Double-lumen tube malpositioning also occurs frequently when patients are positioned for thoracotomy. In our study, DLTs were malpositioned as often after positioning the patient (>46%) as after intubation (>53%). Whereas distal malpositions occurred more frequently after intubation, proximal malpositions were more frequent after positioning. We could speculate that not repositioning distally malpositioned tubes after intubation may have lead to less proximally malpositioned tubes after patient positioning. Two points, however, must be remembered. First, not only proximal but also distal malpositions occur after patient positioning. Second, there is no reason to believe that the same tubes that are malpositioned distally after intubation are those predestined to be malpositioned proximally after patient positioning. A distally malpositioned tube left undisturbed after intubation may cause serious injury if it moves distally during patient positioning. These findings highlight the importance of bronchoscopy in excluding and correcting tube malposition after intubation and after patient positioning.

Exact placement of right-sided DLTs caused more problems than placement of left-sided DLTs. This was most likely due to the low margin of safety in positioning a right rather than a left-sided DLT.[17] Small proximal or distal deviations may cause either obstruction of the right upper lobe bronchus or insufficient separation of the lungs. The latter was responsible for spilling of secretions from the upper into the lower lung in two patients. Because of the low margin of safety and high incidence of malposition associated with "blind" positioning of a right-sided tube, routine bronchoscopy is recommended these tubes are used.[3]

Malposition may be defined as tube placement that may lead to clinical problems if not corrected. Malposition can also be defined as any deviation (0.5 cm in this study) from an optimal placement. (The average margin

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of safety in positioning is 19 mm for a left-sided Mallinckrodt tube and 8 mm for a right-sided tube.[17,18]) Our rather stringent fiberoptic definitions of tube malposition may be partly responsible for the high rate of clinically undetected malpositions that we report. This might, on the other hand, explain the low malposition rates and satisfactory clinical results in some reports in which DLTs were placed blindly.[6,14] We recognize that deviations from our definitions of malpositioning (*i.e.*, partial obstruction of the upper lobe bronchus or a small tracheal dislocation with a partial herniation of the endobronchial cuff) might not be noticed clinically and might not cause problems during one-lung ventilation. However, accepting such borderline tube placements carries the potential danger of subsequent dislocation, obstruction, insufficient lung separation, or all of these. Using the bronchoscope may help prevent such mishaps.

We also found that bronchoscopy is frequently necessary during surgery to correct malpositions (n = 26, often caused by surgical manipulations) and to clear blood or secretions from the bronchial tree (n = 27). During surgery, abnormal finding on auscultation or difficult ventilation may not always be due to tube malposition but may also be caused by secretions and bronchospasms. Without bronchoscopy, correction would be attempted by maneuvers such as probing with a suction catheter, changing the tube's position, or both, combined with repeated auscultation to achieve a satisfactory result. This is time consuming and eventually may require a fiberoptic examination. With primary fiberoptic assessment, clarification of the cause of inadequate ventilation and its treatment are immediately possible.

In conclusion, the results of our study support the routine use of bronchoscopy as a diagnostic and therapeutic tool in placing DLT tubes, correcting tube malposition, and removing secretions or blood occluding the airway during thoracic anesthesia. The potential benefits of bronchoscopy as outlined in this study outweigh its potential drawbacks, such as mucosal lesions, danger of infections, and increased costs.

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