

## Is flexible bronchoscopy necessary to confirm the position of double-lumen tubes before thoracic surgery?<sup>☆</sup>

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### Abstract

**Objectives:** Flexible bronchoscopy is recommended to confirm correct placement of double-lumen tubes used for thoracic anesthesia. However, there is still controversy over routine bronchoscopic confirmation of their position. This study aimed to verify the usefulness of flexible bronchoscopy for confirming the position of double-lumen tubes after blind intubation. **Methods:** During a 9-month period, consecutive patients undergoing elective oncologic thoracic surgery were prospectively enrolled in the study. All patients were intubated with a left disposable polyvinyl chloride double-lumen tube. Immediately after intubation, clinical verification was made by the anesthesiologist. Then, the endoscopist performed flexible bronchoscopy with a 2.8-mm diameter Olympus<sup>®</sup> video bronchoscope, and verified the position of the double-lumen tube, before positioning the patient. The double-lumen tube was in optimal position, if the bronchial cuff was immediately below the tracheal carina, and there was a clear view of the left subcarina, with unobstructed left upper and lower bronchi. Misplacement of the double-lumen tube was diagnosed when the tube had to be moved (in or out) for more than 0.5 cm to correct its position. Critical malposition meant a double-lumen tube dislocated in the trachea or in the right bronchi, requiring immediate re-intubation under bronchoscopic guidance. **Results:** A total of 144 patients (44 women (42%) and 60 men (58%)), with a mean age of 51 years (range 25–77 years) were enrolled in the study. Surgical procedures included 37 right-sided and 31 left-sided thoracotomies, 22 video-assisted thoracoscopic surgeries (VATSs) (16 right-sided and six left-sided), one median sternotomy, six mediastinotomies, and seven miscellaneous procedures. In 66 (63%, 95% confidence interval 53.2–71.8%) cases, there was complete agreement between the anesthesiologist and the endoscopist. The latter diagnosed misplacement of the double-lumen tube in 33 (32%, 95% confidence interval 22.8–40.7%) patients and critical malposition in five (5%, 95% confidence interval 0.7–8.9%) cases. **Conclusions:** After blind intubation, 37% of double-lumen tubes required repositioning by means of flexible bronchoscopy, despite positive evaluation made by the anesthesiologist. Our data suggests that initial bronchoscopic assessment should be made with the patient still in the supine position, and confirms that flexible bronchoscopy is useful in verifying the correct position of double-lumen tubes or adjusting possible misplacements, before starting thoracic surgery.

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**Keywords:** Double-lumen tube; Flexible bronchoscopy; One-lung ventilation; Thoracic anesthesia; Thoracic surgery

### 1. Introduction

In thoracic surgery, the majority of procedures require one-lung ventilation (OLV), which is achieved by placing a double-lumen tube (DLT) in the airway of the patient [1]. The advent of video-assisted thoracoscopic surgery (VATS)

significantly increased the number of cases, which require OLV with DLT [2]. The lung should be well collapsed to allow the surgeon proper visualization of the operative field for an adequate resection during VATS, as well as during open surgery [1,2]. Therefore, precise positioning of DLT is fundamental because a misplaced tube can alter OLV and jeopardize surgery [2].

After blind intubation, the correct placement of a DLT is usually evaluated by means of clinical and instrumental controls, with the patient in both supine and lateral position, before starting surgery [1]. Appropriate inflation of the bronchial cuff, observation of chest wall movements, and auscultation of both lungs are the clinical maneuvers, which allow the anesthesiologist to verify the correct position of the

Abbreviations: DLT, double-lumen tube; OLV, one-lung ventilation; VATS, video-assisted thoracic surgery.

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DLT [3]. However, clinical evaluation does not always allow the anesthesiologist to recognize a misplaced DLT [4]. The latter can cause several problems during thoracic surgery, such as hypoxia and hypoventilation, incomplete collapse of the operative lung, contamination of the dependent lung, and an increase in postoperative lower-respiratory-tract infections [5].

In the past few decades, flexible bronchoscopy has been used to visually monitor the correct position of DLTs, and has shown a relatively high incidence of misplaced DLTs, which were not recognized by the anesthesiologist [6–13]. Despite this data, some authors believe that flexible bronchoscopy is not necessary to verify the correct position of DLTs [14–17]. In fact, a DLT should be in a satisfactory position, which means inside the appropriate bronchus, achieving selective lung collapse and isolation of the dependent lung [18]. While flexible bronchoscopy is certainly useful to confirm the exact position of DLTs, the latter can be placed in a clinically satisfactory position, without the need of subsequent bronchoscopic evaluation [19].

Given the fact that the controversy as to whether flexible bronchoscopy should be used or not to confirm the position of blindly placed DLTs continues, we performed a clinical prospective study to further evaluate the role of flexible bronchoscopy as a monitor for assessing the correct placement of DLTs immediately after blind intubation of patients undergoing thoracic surgery.

## 2. Materials and methods

This was a prospective study conducted at the National Cancer Institute, Pascale Foundation, in Naples, Italy, after its approval by the Institutional Ethics Committee.

During a study period of 9 months, consecutive patients undergoing elective oncologic thoracic surgery were prospectively enrolled, after obtaining written informed consent. Patients with <70% predicted forced expiratory volume in 1 s (FEV1), <80% predicted forced vital capacity, and anticipated use of right-sided DLT, single-lumen tube, or bronchial blocker were excluded from the study.

After induction of general anesthesia with 2 mg of midazolam, 0.5 mg of atropine, 1.5–2.5 mg kg<sup>-1</sup> of propofol, 1–2 µg kg<sup>-1</sup> of fentanyl, and 0.6 mg kg<sup>-1</sup> of rocuronium bromide, the patient was intubated with a left-sided Robertshaw DLT, according to current guidelines [1]. The size of DLT was chosen on the basis of both the patient's sex and height, and 35–39-Fr left-sided DLTs were used in the majority of the cases [20]. The tube was inserted blindly by a dedicated thoracic anesthesiologist (RA), using the patient's height to guide the depth of DLT insertion [3]. After successful blind intubation, the anesthesiologist performed all the conventional clinical maneuvers to verify the correct position of the DLT, with the patient in the supine position (Table 3). Then, her evaluation was recorded in the anesthesiologist's chart, without informing the endoscopist of her assessment. With the patient still in the supine position, flexible bronchoscopy was performed by one of the two endoscopists of the 'bronch team' (MdB and GBR), who entered the operating room after the anesthesiologist had completed her evaluation. Flexible bronchoscopy was

performed with an ultra-slim 2.8-mm diameter Olympus® video bronchoscope, which was inserted first into the tracheal lumen, and then into the bronchial lumen of the DLT to assess its position, according to the criteria proposed by Cohen (Table 4) [4]. After bronchoscopic assessment, the DLT was either secured in its position or repositioned according to the bronchoscopic findings, under direct visualization, inserting the video bronchoscope inside the DLT. Eventually, the assessment of the endoscopist was recorded in the anesthesiologist's chart.

Immediately before the start of surgery, the majority of the patients were turned in the lateral position, and flexible bronchoscopy was performed again to verify that the DLT was still well placed. The data obtained from this second bronchoscopic evaluation were not used for the analysis because the aim of the study was to assess both the incidence of incorrect blind insertion of DLT and the role of flexible bronchoscopy in monitoring and correcting DLT misplacement, immediately after intubation.

The statistical analysis performed was mostly descriptive. Hypotheses were tested by means of the chi-square test, and probability values <0.05 were considered significant.

Statistical analyses were performed using the statistical software package S-PLUS 6.0 Professional release 1 (Insightful Corporation, Seattle, WA, USA).

## 3. Results

From November 2008 until August 2009, 104 consecutive patients (Table 1) undergoing elective thoracic surgery (Table 2) were prospectively enrolled in the study.

After blind intubation, all 104 left-sided DLTs were considered to be in a satisfactory position by the anesthesiologist, who performed her clinical evaluation with the patient still in the supine position. However, flexible bronchoscopy showed that DLTs had been placed correctly only in 66 cases (63%), while 33 (32%) DLTs were misplaced, either proximally or distally, and a critical malposition of the DLT was detected in five other (5%) patients (Table 5).

Table 1. Patients characteristics.

Demographic data	
Age (years)	51 (25–77)
Height (cm)	140–175
Body weight (kg)	50–103
Male	60 (58%)
Female	44 (42%)
ASA II	59 (57%)
ASA III	45 (43%)

Table 2. Surgical procedures in 104 patients.

Surgical procedures	Right sided	Left sided	Bilateral and other
VATS	17 (16%)	5 (5%)	
Thoracotomy	37 (35%)	31 (30%)	
Mediastinotomy			6 (6%)
Sternotomy			1 (1%)
Other procedure			7 (7%)

Table 3. Clinical verification of correct DLT position [3].

Type of assessment
Inflation of the bronchial cuff with appropriate volume of air (2–3 ml)
Observation of chest wall movements
Auscultation of both lungs, before and after selective clamping of bronchial and tracheal lumen
Checking lung compliance by manual ventilation

Table 4. Bronchoscopic criteria for evaluating DLT position [4].

Position	Bronchoscopic findings
Optimal	The bronchial cuff of DLT is immediately below the tracheal carina and there is a clear view of the left subcarina with unobstructed left upper and lower bronchi
Misplacement	Partial dislocation of DLT either proximally or distally. DLT has to be moved (in or out) for more than 0.5 cm to correct its position
Critical malposition	DLT dislocated in the trachea or in the right bronchi. Immediate re-intubation under bronchoscopic guidance is mandatory

Therefore, there was complete agreement between the anesthesiologist and the endoscopist in 63% (95% confidence interval: 53.2–71.8%) of patients whose DLT had been correctly placed, as confirmed by flexible bronchoscopy. In 33 cases (32%, 95% confidence interval 22.8–40.7%), there was partial disagreement between the two observers, due to the fact that flexible bronchoscopy detected a fine malposition of DLTs, which had to be moved in or out for more than 5 mm under bronchoscopic guidance. Finally, five DLTs were found to be critically malpositioned by flexible bronchoscopy, despite positive assessment of the anesthesiologist. In these cases of complete inter-observer disagreement (5%, 95% confidence interval 0.7–8.9%), the tube was immediately repositioned under bronchoscopic guidance.

The inter-observer agreement was not influenced by the sex of the patients and/or experience of the anesthesiologist. There was no significant difference ( $p = 0.48$ ) between males and females (Table 6), and the incidence of DLTs misplacement did not change over the time during the study period. The number of malpositioned DLTs was similar ( $p = 0.11$ ) between the first and the second half of the study (Table 7).

Table 5. Bronchoscopic findings after blind intubation with patient in supine position.

Number of DLT	Bronchoscopic findings
66 (63%)	Optimal position
24 (23%)	Distally misplaced
9 (9%)	Proximally misplaced
5 (5%)	Dislocation in the trachea

Table 6. Interobserver agreement about correct placement of DLT according patients sex.

Interobserver agreement	Males	Females
Complete agreement	36 (60%)	29 (66%)
Partial disagreement	22 (37%)	12 (27%)
Complete disagreement	2 (3%)	3 (7%)

No significant statistical difference between the 2 groups ( $p = 0.48$ ).

Table 7. Interobserver agreement about correct placement of DLT according the two different time frames of the study.

Interobserver agreement	1st part of the study (patients #1–52)	2nd part of the study (patients #53–104)
Complete agreement	37 (71%)	28 (54%)
Partial disagreement	12 (23%)	22 (42%)
Complete disagreement	3 (6%)	2 (4%)

No significant statistical difference between the 2 groups ( $p = 0.11$ ).

#### 4. Discussion

In the era of VATS, which requires mandatory OLV, it is crucial to confirm the correct position of DLTs after blind intubation and before the start of surgery [1,2]. Unknown malposition of a DLT can lead to both intra-operative and postoperative complications, which can affect the surgical outcome [5]. Despite the positive clinical evaluation performed by the anesthesiologist, a DLT can be either misplaced or critically malpositioned, requiring slight, but clinically important, adjustments of its position or complete repositioning under bronchoscopic guidance [6–13]. The latter was necessary to reposition 48% of DLTs after blind intubation of 23 patients undergoing thoracotomy, despite satisfactory positioning as assessed by clinical criteria [6]. In another series, flexible bronchoscopy revealed that left-sided DLTs had been incorrectly placed in 78% of patients undergoing thoracic anesthesia [7]. Similar data were reported by a study, which related the high rate (83%) of misplaced left-sided DLTs to the fact that the stylet was removed immediately after the bronchial cuff had passed the vocal cords of the patient [11]. Other authors reported lower rates of DLT misplacement (32–44%) detected by flexible bronchoscopy after blind intubation; however, also in these series, clinical confirmation was still unreliable and missed a significant number of malpositioned DLTs [8,9,13].

Flexible bronchoscopy should be performed immediately after blind intubation, with the patient still in the supine position, as suggested by two studies reporting that DLTs are malpositioned in 40% of patients before turning them to the lateral position, despite positive confirmation of the anesthesiologist [10,12]. This observation was the rationale of our study, which had the objectives of assessing both the incidence of malpositioned DLTs after blind intubation and the role of flexible bronchoscopy in monitoring and correcting DLT misplacement, with the patient still in supine position.

In our series, anesthesiological assessment was able to confirm the correct position of DLTs in 66 (63%) patients, while flexible bronchoscopy demonstrated a misplaced DLT that had to be repositioned in 38 (37%) cases. In five (5%) patients, the unrecognized misplacement of DLT was critical and could have seriously affected both patient's safety and surgical outcomes. Indeed, 30% of deaths reported in a series of British patients undergoing major thoracic surgery were related to DLT malfunctioning, which caused prolonged periods of hypoxemia and hypoventilation, and often required tube exchange [5]. Critical malposition of left-sided DLTs either in the trachea or in the main right bronchus occurred in 18 out of 132 (14%) patients undergoing thoracic

surgery [9]. Usually, a gross malposition of the DLT is detected by the anesthesiologist, without the need of bronchoscopic monitoring, especially when instrumental evaluation is used [3,10,16]. However, flexible bronchoscopy revealed that 25 out of 172 (14.5%) DLTs had been critically malpositioned, despite a satisfactory evaluation made by the anesthesiologist in a series of 200 patients, who underwent endoscopic control before lateral positioning [12]. Accordingly, in our series, five DLTs critically malpositioned would have been undetected without bronchoscopic monitoring. This information confirms that inadvertent endobronchial intubation is a possible complication of DLTs placement, and can be unrecognized by the clinical evaluation of the anesthesiologist [21]. In 33 (32%) patients, flexible bronchoscopy showed that the DLT was either proximally (9), or distally (24) dislocated for more than 5 mm. According to Brodsky, this slight misplacement is clinically not significant, and the tube can function properly, without affecting both anesthesia and surgery [19]. Therefore, some authors suggest that flexible bronchoscopy should not be routinely used for monitoring DLT position after blind intubation of the patient [14–17]. In a series of 1170 patients undergoing thoracic anesthesia, the reported incidence of complications was lower when anesthesiological assessment was used, compared with bronchoscopic monitoring (13% vs 21%) [16]. Similar data were reported by a British audit of double-lumen endobronchial intubation, which showed that checking DLTs with flexible bronchoscopy did not affect the incidence of intra-operative problems (19% vs 17%) between patients who underwent flexible bronchoscopy and those in whom endoscopy was not used [17]. In another clinical audit, endoscopic control confirmed that all DLTs were in a satisfactory position after blind intubation [15].

Despite the anesthesiologist's assessment, a satisfactorily placed DLT is often slightly malpositioned (5–10 mm) [12,14,15]. A fine malposition could impair the correct functioning of the DLT, which does not seal properly the airway, and, therefore, cannot adequately protect the dependent lung from contamination of blood, water, or pus during surgery [4,5]. Slight endobronchial cuff displacements of DLTs may alter the regional distribution of the ventilation and determine hypoxemic episodes during OLV [22]. Without a well-collapsed lung, the operative field is not well visualized, and the risk of postoperative air leaks is increased [4]. The occlusion of the left upper-lobe bronchus, which is often undetected by clinical assessment, induces intra-operative lobar collapse in the dependent lung, and increases the risk of postoperative infections [5]. Finally, a distally misplaced DLT may seriously injure the bronchial tree of the patient during his/her positioning before the start of surgery [12]. Therefore, after blind insertion of a DLT, flexible bronchoscopy is required to exclude fine malpositions, such as a bronchial cuff bulging in the trachea or the bronchial lumen too far in the left main bronchus [10].

Bronchoscopic monitoring of DLT position should be performed immediately after blind intubation, with the patient still in the supine position [24]. When the patient is supine, access to DLT is optimal, orientation of flexible bronchoscopy is certain, correlation of clinical signs with bronchoscopic findings is relatively easy, and the upper lobe obstruction can be surely ruled out [23,24]. In fact, if flexible

bronchoscopy is not used to verify the optimal position of DLT immediately after blind intubation, it will be difficult to precisely reposition it, with the patient in the lateral position during surgery [4].

In our series, the incidence of misplaced DLTs did not change between males and females patients (Table 6), probably because only one dedicated anesthesiologist performed all DLT placements, and the guidelines for DLT insertion were strictly followed [3,20]. Similarly, there was no improvement of DLT placement during the study period (Table 7), probably due to the fact that the anesthesiologist was already an expert in thoracic anesthesia and the results were not affected by a hypothetical learning curve [20].

Flexible bronchoscopy requires a specific training period for the thoracic anesthesiologist [20]. Expertise in bronchial endoscopy reduces the risk of misinterpreting the bronchial findings due to the lack of recognition of tracheobronchial anatomy during endoscopic control of DLTs [25]. Indeed, among patients, there are significant anatomical variations in the tracheobronchial tree, which can be further distorted by tumor masses, effusions, or previous surgery [5]. At our Institution, bronchoscopic monitoring after blind insertion of DLTs is routinely performed by the endoscopists of the 'bronch team', who are part of our multidisciplinary lung cancer group. During thoracic surgery, the endoscopists are on call, available to perform bronchoscopic control of the DLT when required, alternating two ultra-slim 2.8-mm diameter Olympus® video bronchoscopes, dedicated for thoracic surgery. This approach facilitates the detection of DLT misplacement, reducing the risk of misinterpretation during flexible bronchoscopy, and does not require that the anesthesiologist undergoes specific training. However, it is costly, time-consuming, and requires both a specific organization of the Endoscopy Unit and collaborative teamwork among different specialists, which is not always possible in other Institutions.

Some limitations of this study should be acknowledged. The exclusion from the study group of patients with FEV1 <70% may not entirely reflect the current practice in thoracic surgery. However, the rationale of the study was to assess the efficacy of DLT placement in the absence of confounding factors, such as impeding respiratory distress due to minimal malposition of the DLT in patients with less than normal cardiopulmonary reserve (Reviewer #1.A). Similarly, the exclusion of patients with an anticipated use of right-sided DLT and/or bronchial blocker had the intention to analyze the results of blind intubation of DLT in a homogeneous group of patients. In fact, left-sided DLTs are preferred for both left- and right-sided procedures in routine thoracic surgery, due to the high risk of upper lobe obstruction with a right-sided DLT [1,3,4]. The practice of choosing the size of DLT on the basis of both the patient's sex and height could have negatively affected the results due to the possibility of an incorrect choice because of larger trachea or bronchi, as in patients with chronic obstructive pulmonary disease. This could be avoided using radiological patterns to guide the choice of the correct size of the DLT [16]. Clinical evaluation can misdiagnose a critical malposition of DLT, such as proximal dislocation in the trachea, which was not detected in five patients in our series. This could have probably been recognized either by means of measurement of peak

inspiratory pressures during both two-lung ventilation and OLV or by dual capnography [1,3]. Indeed, instrumental monitoring of DLTs can supply useful information to the clinical evaluation and correctly assess gross malposition of DLTs [22]. The latter was not relevant for the purpose of our study, whose main objective was to assess the incidence of DLTs' fine malpositions. These are not usually detected by the standard instrumental monitoring available in the operative room [4]. Another drawback is the relatively low number (104) of patients enrolled in the study, which could affect the results obtained. These are similar to those reported by the largest prospective clinical study published [12]. The final answer could arrive from a randomized controlled trial. However, according to Slinger, the controversy as to whether flexible bronchoscopy must be used to monitor DLT placement after blind intubation is over, and flexible bronchoscopy should be used routinely in thoracic anesthesia [20]. Ideally, the proper evaluation of DLT after its insertion should be performed by a bronchial endoscopist. However, we acknowledge that an anesthesiologist dedicated to thoracic surgery should be proficient in bronchoscopy and adequately trained to perform the bronchoscopic control of the DLT. Finally, our decision to include in the analysis only the data regarding DLT assessment immediately after blind intubation with the patient in supine position could be criticized. Indeed, we did not analyze the data obtained from the second bronchoscopic control, which was always performed after turning the patient to the lateral position. The aim of the study was to assess both the incidence of incorrect blind insertion of DLT and the role of flexible bronchoscopy in monitoring and correcting DLT misplacement, immediately after intubation, with the patient still in the supine position. Some authors believe that flexible bronchoscopy is either unnecessary or should be reserved for those patients showing anesthesiological problems, when already positioned for surgery [14–17]. However, the observation that a relatively high percentage (40%) of DLTs was misplaced at the time of blind intubation indicated the importance in evaluating the incidence of primary malpositioning of DLTs [10,12]. Eventually, the results of our study confirmed that a relatively high number (37%) of DLTs are misplaced immediately after intubation, as shown by bronchoscopic assessment with the patient still in the supine position.

In conclusion, our data support the routine use of flexible bronchoscopy in thoracic anesthesia, as an efficacious monitor for checking the correct position of DLT after blind intubation. Bronchoscopic confirmation of correct DLT placement or its appropriate repositioning under bronchoscopic guidance should be initially made with the patient still in the supine position. This first step facilitates the second and more important confirmation of DLT position after positioning the patient before the start of surgery, and subsequent intra-operative controls, if required. These data could be used for credentialing or revalidating the credentials of a thoracic surgical unit to identify the basic process needed to ensure the quality of practice in thoracic surgery. However, there is a need to confirm that systematic flexible bronchoscopic monitoring of DLTs reduces intra-operative and postoperative morbidity and/or mortality of patients

undergoing thoracic surgery, thanks to a prompt recognition of fine DLT malpositions. The latter could be the objective of a prospective, multicenter, randomized study.

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