# How to Choose the Double-Lumen Tube Size and Side: The Eternal Debate

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**KEYWORDS**

• Small DLT • Big DLTs • Right-sided DLTs • Left-sided DLTs • Airway damage • Lung isolation • Margin of safety

**KEY POINTS**

- Big double-lumen tubes (DLTs) are usually placed for most cases of lung isolation, leaving the small tubes for patients with short stature.
- Some controversy has been generated about the practice of using small-size DLTs for any individual independent of height, weight, and gender. Airway trauma and rupture have been proposed to be associated with this practice.
- Left-sided DLTs are commonly used for isolating the lung because of their alleged higher margin of safety.
- Proponents of the routine use of right-sided DLTs for left-sided procedures advocate this practice to increase the level of comfort of the anesthesiologist and to learn how to manage potential problems during one-lung ventilation.

## INTRODUCTION

Double-lumen tubes (DLTs) are the most commonly used devices to provide lung isolation.[1–3] DLTs are bifurcated tubes with a tracheal and a bronchial lumen, disposable, and made of polyvinyl chloride (PVC). Different sizes (28F, 32F, 37F, 39F, and 41F catheter), sides (left vs right), and manufacturers (Rusch [Teleflex Medical, Seattle, WA, USA], Mallinckrodt [Mallinckrodt Inc, St Louis, MO, USA], Sheridan [Hudson RCI, Highcombe, UK], and Portex [Smiths Medical, Dublin, OH, USA]) are available. Left-sided DLTs are used more often than right-sided.

Although disposable DLTs have been used for many years, there is still controversy regarding performance, efficiency, and outcome among thoracic and nonthoracic anesthesiologists. Strong opinions exist on the best size to use and when a right-sided DLT is indicated.

This article provides a review of the current data from the literature and opinions from experts on this topic.

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## THE CONUNDRUM OF THE SIZE

Little evidence is available in the literature on how to choose the size of a DLT. Recommendations are mainly based on old teachings, which ultimately dictate clinical practice. Most thoracic and nonthoracic anesthesiologists chose the DLT size based on patient height and gender, or on their personal experience. Measuring the tracheal or bronchial diameter has been suggested as a more precise way to determine the size of the DLT.[4–8] Tracheal diameter should be measured at the level of the clavicles on the posterior–anterior chest radiograph.[4] The bronchial diameter should be measured on the computed tomography scan within 1 to 2 mm of carina,[5,7] because the left mainstem is not clearly visible on the chest radiograph in 50% to 70% of cases. Independent of the imaging used, the measurement obtained is amplified as a result of the radiograph technique; therefore, the final value should be corrected. Several mathematical formulas have been proposed to accomplish this goal.[4,6,7] Although measuring radiograph films has a theoretical scientific background, it may not be practical. Moreover, this approach may work for most white patients, but it does not seem to be as effective in the Asian population, especially if female.[9]

The main concern of using an inappropriate size DLT is the potential of causing airway trauma and rupture. This can occur as a direct consequence of either a too big or too small DLT or indirectly, by delivering inappropriate minute ventilation during one-lung ventilation and causing auto positive end-expiratory pressure. Experts in the field remain divided between using small versus big DLTs. The supporters of using a small DLT (35F or 37F catheter) advocate the use of this size based on the assumption that it is easy to place, fits all patients, and does not seem to be associated with an increased incidence of airway damage.[10] In case of difficult airway or for small patients, a small device may be easier to use. The proponents of a bigger size (39F and 41F catheter) argue that if the DLT is too small, it will cause airway injury because of (1) the need to use high pressures in the bronchial cuff to achieve lung isolation; (2) a higher incidence of dislodgment, causing either failure to isolate the lung or ventilator-induced lung injury; (3) the inability to suction secretions; and (4) an increased resistance during mechanical ventilation, which could lead to auto positive end-expiratory pressure.[11] Airway edema and trauma, and hoarseness and sore throat have been reported with the use of DLTs and big single-lumen endotracheal tubes.[12,13]

Most of the data on airway rupture and the use of DLTs come from isolated case reports.[14–21] This is a rare but potentially catastrophic event, with a less than 1% incidence. It usually occurs in the membranous part of the trachea or the left mainstem bronchus. Presentation signs and symptoms include mediastinal and subcutaneous emphysema and tension pneumothorax, difficulty ventilating, and respiratory insufficiency.[11] Mediastinitis and sepsis may be later complications. The cause still remains multifactorial. Fitzmaurice and Brodsky[11] reviewed 33 case reports in 1999, and found that overinflation of the bronchial cuff was the main culprit for airway rupture in most of the cases. Airway trauma was more common with Robertshaw, Carlens, and White DLTs. For these devices, the use of a big size was mainly implicated. Airway rupture was uncommon with PVC DLTs. However, when it occurred, it seemed to be associated more with the use of small DLTs. In the latter group, most of the patients had either comorbidities that placed them at risk of airway trauma (eg, spontaneous pneumothorax[19]), or had traumatic insertions with multiple blind attempts,[14,15,18] or with the stylet left in place.[16,21] Mallinckrodt DLTs were used in most of the cases of traumatic PVC DLT injury.

Airway trauma has been reported during intubation and extubation. **Table 1** summarizes potential causes. Several factors can be implicated, other than the device

**Table 1**
**Summary of potential causes for airway trauma**

| DLT | Operator | Patient | Trachea |
|---|---|---|---|
| Inappropriate size | Inexperience | Women | Tracheomalacia |
| Bronchial cuff overinflation | Multiple attempts | Short stature | Steroid/chest radiotherapy |
| Stylet not removed | Blind technique | Obesity | Endoluminal tumors |
| Malposition | Forceful placement | Chronic obstructive pulmonary disease | |
| Memory bend | | Age >50 | |
| Use of an exchange catheter | | Coughing/moving | |

*Data from* Kim HK, et al. Left mainstem bronchial rupture during one-lung ventilation with Robertshaw double lumen endobronchial tube: a case report. Korean J Anesthesiol 2010;59(Suppl):S21–5; and Kim J, Lim T, Bahk JH. Tracheal laceration during intubation of a double-lumen tube and intraoperative fiberoptic bronchoscopic evaluation through an LMA in the lateral position: a case report. Korean J Anesthesiol 2011;60(4):285–9.

itself. Operator experience is a very important component. Other factors contributing to airway rupture include forceful insertion; multiple attempts, especially if blind and with the stylet in place; and the use of a tube exchanger. This complication seems to be more common in women, obese patients, short stature, presence of chronic obstructive pulmonary disease, age older than 50 years, and with patient movement or coughing during placement.[11,22,23] Tracheomalacia, immunosuppression, tracheal tumors, and the use of steroid or chest radiotherapy are also risk factors for tracheal rupture.

Other causes of airway trauma include pressure in the bronchial cuff, memory bend and stylet, and technique of insertion. Regarding pressure in the bronchial cuff, the higher the pressure in the cuff, the worse the damage. It seems counterintuitive to think that the more air in the bronchial cuff, the higher the pressure generated and the chance of causing damage. Cuff overinflation has been associated with airway damage in several studies.[11] Roscoe and colleagues[24] looked at the pressures generated by 1-mL increments of air in the bronchial cuff of different size DLTs and blockers in an in vitro model. A maximum volume of 6 mL for the DLTs and 10 mL for the blockers was used. Static and dynamic compliance curves were measured. Small-size DLTs required more volume in the cuff to have an underwater seal, generating higher pressures than bigger size tubes. However, the highest pressures needed to achieve a seal to 25 mm Hg pressure ranged from 12 to 24 mm Hg. This was lower than the accepted threshold for mucosal ischemia of 30 mm Hg.

Regarding memory bend and stylet, all DLTs have a premade memory bend for the bronchial side that is evident after the stylet is removed. The memory bend has been implicated in causing damage during intubation[25] or extubation.[26] If the DLT is not turned in a timely fashion after passing the vocal cords, its tip may lodge on the tracheal rings and if forced cause injury. A similar mechanism has been proposed during extubation, when the tip of the tube can injure the vocal cords. This can occur with any size adult DLT, because the deflection of the bronchial tip is approximately 3 cm in most DLTs (**Fig. 1**).[25]

Technique of insertion is another cause of airway trauma. Blind insertion of the DLT can cause airway trauma or rupture, especially if forceful. A common practice is to

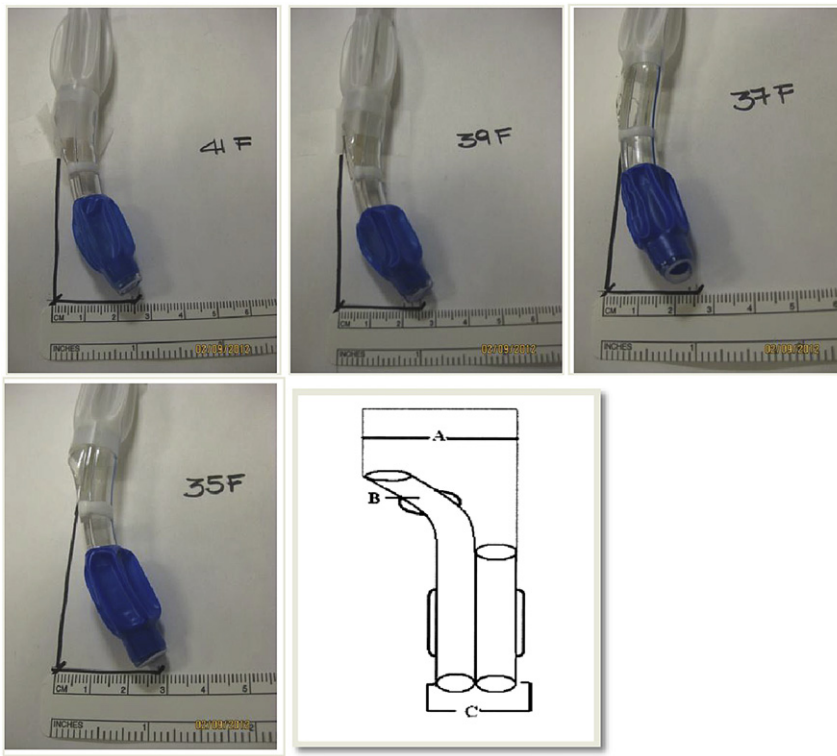


**Fig. 1.** Memory bend of a left-sided DLT (Sheridan), after removing the stylet. (*Adapted from* Lohser J, Brodsky JB. Tracheal perforation from double-lumen tubes: size may be important. Anesth Analg 2005;101(4):1243–4. [author reply: 1244–5]; with permission.)

insert the DLT by direct laryngoscopy, and after the blue cuff has passed vocal cords the stylet is removed, the tube turned depending on the side used (counterclockwise for left DLTs and clockwise for right DLTs), and pushed until it meets resistance. Inexperienced operators, leaving the stylet in place, weakened tracheal tissue, or endotracheal or endobronchial tumors can all contribute to airway damage. The use of fiberoptic bronchoscopy has decreased this potential complication, allowing confirmation of the final position after blind insertion or assisting in positioning the device under direct vision, especially in cases of endobronchial lesions. New DLTs with a built-in camera in the distal tracheal lumen are being developed to facilitate positioning during insertion and during the case.

Sore throat, hoarseness, and vocal cord and bronchial injuries have been demonstrated by Knoll and colleagues[12] to be more frequent (44% of cases) with the use of DLTs compared with endotracheal tubes and bronchial blockers. None of the patients in the study had either bronchial or vocal cord rupture. The DLT size used in this study was chosen according to Brodsky's criteria,[8] ranging from 37F to 41F. All the data were combined for the DLT group; therefore, it was not possible to discern if there was any relationship between size and severity of the damage. Amar and colleagues[10] did a prospective observational study as a result of a change in clinical practice in their institution. A small DLT (35F) was used in every patient independent of height and gender, and was compared with a bigger size (37F and 39F). There was no difference in the incidence of desaturation, tube malposition, and lung isolation

failure between the groups. Despite the presence of more females in the 35F DLT group, no differences were found between genders when data were analyzed by height. No patient had major airway complications at the end of the case or in the postoperative period. Therefore, they concluded that the use of a small DLT was feasible independent of patient size and gender.

### *Pros and Cons of the Size Chosen*

There are specific case scenarios where a big DLT is indicated, such as lung transplantation; lung volume reduction surgery (especially in case of severe emphysema or with copious secretions); or for thoracoabdominal aneurysm repair. Big DLTs may have the advantage of allowing better suctioning of secretions, faster lung collapse, and cause less work of breathing when patients resume spontaneous ventilation at the end of the case. Small DLTs may work better for Asian females; difficult airways with cervical or carinal compression or stenosis; when an awake fiber optic (FOB) intubation is needed; or in the presence of a fresh tracheostomy (<7 days) or laryngoplasty or vocal cord medialization. In case of carinal distortion with left mainstem compression, the placement of a big size DLT may be difficult.

### *Conclusion*

The choice of which DLT size to use still remains a personal one, based on experience and comfort level. Ultimately, the size should be customized to the patient characteristics and pathology. Careful insertion of the DLT, paired with the use of the FOB as an aid for placement and positioning, removal of the stylet after the bronchial cuff passes the vocal cords, and avoiding overinflation of the bronchial cuff are all useful pointers to decrease potentially catastrophic events.

## LEFT VERSUS RIGHT: WHICH SIDE TO USE?

Left-sided DLTs are commonly used for thoracic procedures because of their reliability and alleged safety margin. This may be especially true for nonthoracic anesthesiologists with limited bronchoscopic experience. The margin of safety has been defined by Benumof and colleagues[27] as "the length of tracheobronchial tree over which the DLT may be moved or positioned without obstructing a conducting airway." Because of the length of the left mainstem bronchus (4.4–4.9 cm), left-sided DLTs are thought to have a larger margin of safety for positioning and quality of lung isolation. When the margin of safety was studied for three brands of DLT (Mallinckrodt, Sheridan, and Rusch), it was found that left-sided tubes had a safety margin of 16 to 19 mm, whereas right-sided tubes varied between 1 and 4 mm (Rusch) and 8 mm (Mallinckrodt).[27] These values were size dependent (**Fig. 2**). They concluded that left-sided DLTs were more reliable and easier to manage compared with right-sided tubes. Routine use of right-sided DLT is still frowned up on by most anesthesiologists and surgeons. Because of the variable takeoff of the right upper lobe (**Fig. 3**), right-sided DLT may be difficult to position properly and may dislodge during the case, especially with surgical manipulation of the carina. Ideally, a well-positioned right-sided DLT should allow ventilation of all three lobes of the right lung and complete isolation of the left lung. The right mainstem bronchus has a straighter angle compared with the trachea and a wider lumen (see **Fig. 3**) explaining the ease of placement, which is comparable with a right mainstem intubation. Correct positioning may be more challenging because of the anatomy of the right mainstem bronchus, especially if the right upper lobe takeoff is very close to the carina or above it (<2.3 cm distance). The presence of a porcine bronchus, which takes off above the carina, represents the only absolute contraindication for a right-sided DLT placement.

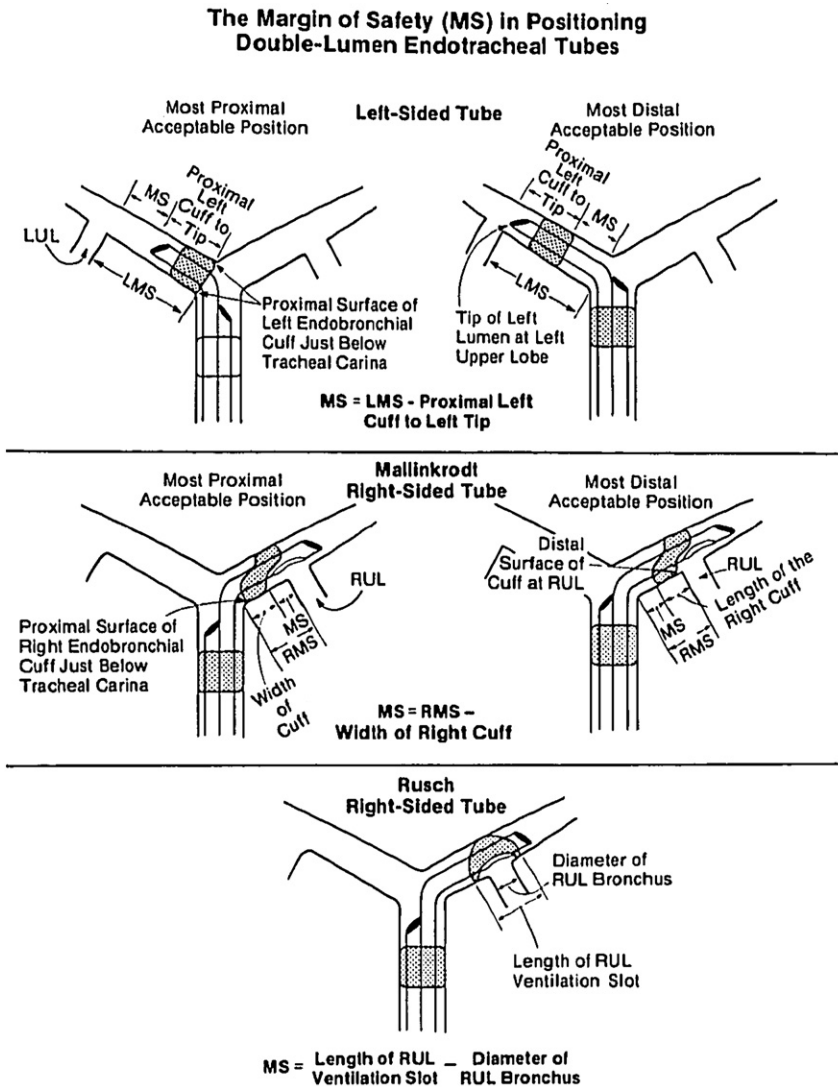


**Fig. 2.** Margin of safety for left and right DLT placement and the most proximal and most distal acceptable position for the DLT. (*Top*) Left-sided DLTs. (*Middle*) Mallinckrodt right-sided DLT. (*Lower*) Rusch right-sided DLT. LMS, length of the left mainstem bronchus; MS, margin of safety in positioning the DLT; RMS, length of the right mainstem bronchus; RUL, right upper lobe. (*From* Benumof JL, Partridge BL, Salvatierra C, et al. Margin of safety in positioning modern double-lumen endotracheal tubes. Anesthesiology 1987;67(5):729–38; with permission.)

Several brands of right-sided DLTs are commercially available, with different bronchial cuff configurations and length (**Fig. 4**). Mallinckrodt has the more forgiving shape to accommodate the DLT in the proper position because of the shape of the bronchial cuff in relation to the side orifice for the right upper lobe. Broncho-Cath tubes by Mallinckrodt have been modified to increase their safety margin, by widening the opening of the right upper lobe orifice.[28] The Cliny (Create Medic, Yokohama, Japan) has

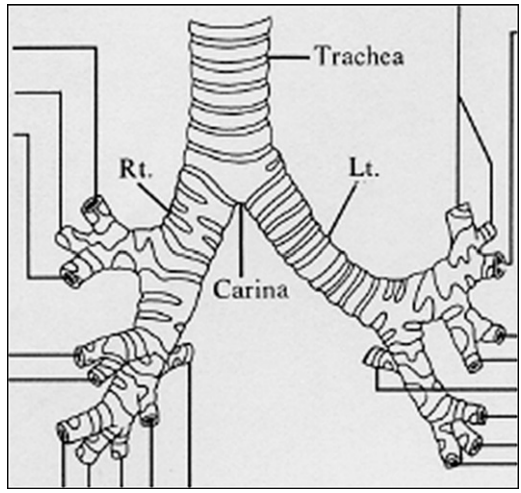


**Fig. 3.** Tracheobronchial tree anatomy.

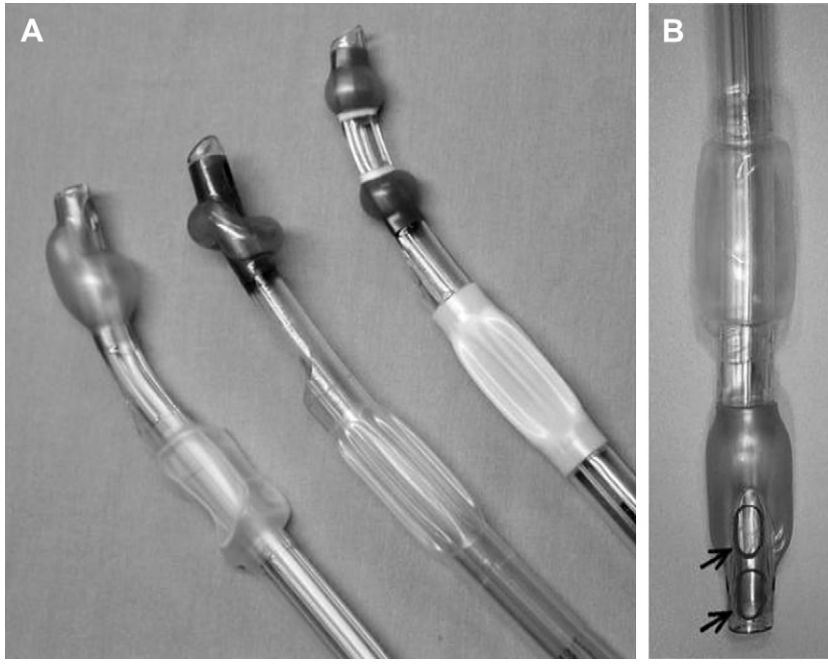


**Fig. 4.** Different brands of commercially available right-sided DLTs. From left to right, manufacturers are Portex, Mallinckrodt, and Sheridan (*A*), and Cliny (*B*). ([*A*] *From* Ehrenfeld JM, Walsh JL, Sandberg WS. Right- and left-sided Mallinckrodt double-lumen tubes have identical clinical performance. Anesth Analg 2008;106(6):1847–52; with permission; and [*B*] *From* Hagihira S, Takashina M, Mashimo T. Application of a newly designed right-sided, double-lumen endobronchial tube in patients with a very short right mainstem bronchus. Anesthesiology 2008;109(3): 565–8; with permission.)

created a new right-sided DLT with a long oblique bronchial cuff and two orifices for the right upper lobe, which increases the success rate for placement and positioning in patients with a short right mainstem bronchus.[29] To increase the success rate for proper positioning, the fiberoptic bronchoscope should be used.

Indications for right-sided DLT placement are listed in **Box 1**. For these cases, blockers or left-sided DLT may not be suitable because they would be positioned on the surgical site. Possible bronchial injury, trauma to the tumor with bleeding, and difficulty in the surgical dissection or repair may represent potential problems. In case of extrinsic bronchial compression or distortion, it may be difficult to place a left-sided DLT or a blocker. Furthermore, the device chosen may need to be periodically withdrawn to check the site of surgical repair. In case of left bronchial sleeve resection, the presence of a left-sided DLT requires withdrawal from the airway to allow suturing the anastomosis, making ventilation of the right lung difficult after the airway is opened.

Some centers routinely use right-sided DLTs for left-sided procedures with good results. This was demonstrated by Erhenfeld and colleagues.[1] This group conducted a retrospective review on the performance of right- versus left-sided DLTs when used for contralateral thoracic procedures. No difference in hypoxia, hypercapnia, or high airway pressures was found. The same group also demonstrated that there was no difference in incidence of these complications when frequent and infrequent DLT users were compared.[30] However, when these events occurred, they were more severe and prolonged among the infrequent users.

### *How to Avoid Placing a Right-Sided DLT if Absolutely Indicated*

Several options have been proposed to avoid the use of a right-sided DLT when there is an absolute indication. Right mainstem intubations with a single-lumen tube, placing a left-sided DLT very close to the carina, or careful placement of a blocker have been suggested. However, they all have some downsides that may contraindicate their use. Right mainstem intubation has been suggested as an alternative to the use of a right-sided DLT. As shown in **Fig. 5**, the length and size of the cuff of a regular endotracheal tube may not be appropriate for ventilating the right lung and to properly isolate the left. Specifically, the total length of the endotracheal tube may not be sufficient to reach the mainstem bronchus; the cuff may be too big to fit completely in the right mainstem, with possible herniation above the carina or occlusion of the take-off of the right upper lobe; and finally the tip of the endotracheal tube beyond the cuff is longer, causing lobar ventilation. Indications for mainstem intubation include pediatric airway (below the limits of commercially available DLT size); critical airway in patients

**Box 1**
**Indications for right-sided DLT placement**

- Left bronchial disease or damage
  - Left endobronchial tumors
  - Penetrating or blunt trauma to left mainstem bronchus
  - Prior left mainstem reconstruction (transplantation or sleeve resection)
  - Kinking of the left bronchus after left upper lobectomy
- Left bronchial compression
  - Thoracic aortic aneurysm

**Fig. 5.** Comparison between the cuff of a Rusch 7.0 I.D. single-lumen endotracheal tube and a right double-lumen tube (Mallinkrodt Broncho-Cath 39F). The cuff starts are aligned. The single-lumen endotracheal tube extends far beyond the distal end of the right-sided DLT cuff.

already intubated (where changing the DLT would be problematic, such as unstable neck or difficult airway); and in case of distorted or damaged trachea.

In the case of careful insertion of a left-sided DLT in the left mainstem, the DLT is placed in the contraindicated area. Careful positioning away from the lesion with the aid of a fiberoptic bronchoscope can be done. However, the DLT is positioned in the proximity of the lesion and potentially can cause damage or be damaged during surgery. The left-sided DLT may need to be withdrawn in case of bronchial resection or repair, potentially causing the inability to ventilate the contralateral side. It also needs to be readvanced in case lung isolation is still required (ie, sleeve resection, lung transplantation), with the potential of injuring the anastomosis.

The use of a blocker may not be a safe practice because it needs to be placed in the operative side. Placement may be difficult because of airway pathology or distortion, with potential injury of the bronchus, tumor, or existing anastomosis. Moreover, the blocker may periodically require being withdrawn to check for the surgical repair and prevent being stapled in the specimen. In case of extrinsic compression, blockers may be difficult to insert and do not seal properly.

## *Conclusion*

The routine use of a right-sided DLT for left-sided procedures is a standard of practice in some institutions. It requires (1) a patient with the appropriate right bronchial anatomy, (2) experience with the use of the fiberoptic bronchoscope and a bronchoscopic knowledge of the airway anatomy, (3) a familiarity with the technique, and (4) an open-minded surgeon. Elective use of this device has the advantage of helping the anesthesiologist to build the confidence and skills to use and troubleshoot right-sided tubes when absolutely indicated. It also helps to demonstrate to surgical colleagues that the device works. Key points for successful right-sided DLT placement are as follows:

1. The choice an appropriate size and brand
2. Identification of the carina with the bronchoscope through the tracheal lumen
3. Identification of the bronchial cuff in the right mainstem bronchus
4. Matching of the opening of the bronchial side of the DLT and the right upper lobe take-off
5. Secure “taping job” after the right-sided DLT is properly positioned to avoid dislodgment

6. Holding the head and the tube in place during positioning in the lateral decubitus, avoiding flexion and extension
7. Reconfirm positioning with the fiberoptic scope once in the lateral decubitus, and resecure the tape if needed to avoid dislodgment after surgery has started

Despite all the evidence that right- and left-sided DLTs have similar performance, left-sided DLTs are still the most commonly used devices for lung isolation. Ultimately, successful use of a right-sided DLT remains in convincing skeptical surgeons and anesthesiologists that it functions satisfactorily.

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