Review article

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SPECIFICITY OF AIRWAY MANAGEMENT IN THORACIC ANESTHESIA

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Before the advancement of anesthesia techniques in the mid-1930s, chest operations were short and difficult. Anesthesia during thoracic surgery is in itself very demanding and complicated to work with and represents a real challenge for the anesthesiologist. In order to perform the operation smoothly in patients whose respiratory reserve has already been reduced, it is necessary to exclude the lung that is being operated on and to isolate the lung that is ventilated during the surgical intervention. Double lumen tubes and endobronchial blockers are used to secure the airway and to achieve collapse and unilateral ventilation. Fiberoptic bronchoscopy is the gold standard in the world of modern thoracic anesthesia for checking the position of a double lumen tube and endobronchial blocker.

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Key words: *airway, thoracic anesthesia, double lumen tubes, endobronchial blockers*

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Introduction

The first clinical surgery on the chest was performed by Dr. Huber Block in 1882 when he performed a lung resection on his cousin with bilateral pulmonary tuberculosis, who unfortunately died soon after the operation, which caused a lot of legal problems (1). The era of modern and safe surgery followed, and the advancement of general and regional anesthesia techniques, the introduction of aseptic conditions during surgery, the introduction of new instruments and surgical techniques, which contributed to greater survival, but this was not the case with patients who were subjected to thoracic surgery. Before the advancement of anesthesia techniques in the mid-1930s, chest surgeries were short and difficult. The development of anesthesia techniques and procedures has led to thoracic surgery experiencing expansion (2). In 1928, Guedel and Waters patented an endotracheal tube with cuff, which was used for positive pressure ventilation (Figure 1) (3).

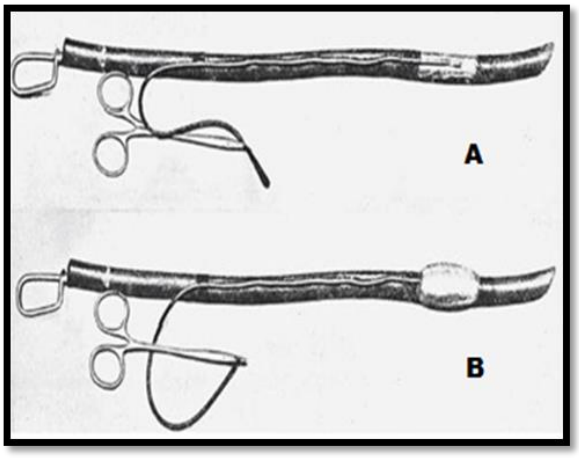

Figure 1. Guedel and Waters - Endotracheal tube with cuff, patented in 1928

A. Tracheal balloon released.
B. Inflated tracheal balloon.
Tube length 35.56cm, made of rubber.

Three years later, in 1931, Joseph W. Gale and Ralph M. Waters patented an endotracheal tube with cuff that provided unilateral lung ventilation, where the tube advanced into one bronchus and the inflated cuff closed the other bronchus isolating it, essentially serving as a bronchial blocker (4). The first successful pneumonectomy for lung cancer was performed in 1933 by Dr. Evarts Graham (5).

Isolation and one-sided pulmonary ventilation

Thoracic surgery in itself is very demanding and complicated to work with, and for the smooth performance of the operation, it is necessary to exclude the lung that is being operated on and to isolate the lung that is ventilated during the surgical intervention. This method of isolating the ventilated lung and collapsing the lung being operated on is called unilateral lung ventilation and can be reported with a double lumen endobronchial tube (left, right) or with a bronchial blocker when a double lumen tube is contraindicated (2).

Double-lumen tubes (DLT)

The design of the double lumen tube changed over the years, the first double lumen cuff tube was patented by Carlens in 1949, and it was a left double lumen tube with endotracheal and endobronchial cuff, which also had a hook that positioned itself on the carina (6). Since the hook that was placed on the carina caused damage to the carina and its rupture, 10 years later, in 1959, Brian Smith modified the left double lumen Carlens tube and removed the hook (7). A year later, in 1960, White modified the Carlens tubes and thus patented the right double lumen tube without a hook (8). In 1962, Robetshaw patented the right and left double lumen tubes with large ventilation lumens, without a hook (9).

Double lumen tubes can be left or right, depending on the bronchus they are designed to intubate (Figure 2). The difference is that the right-sided double lumen tubes have a slit called the so-called Murphy's eye, which should be placed so as to ventilate the upper right lung lobe. The installation of the right double lumen tube is technically more demanding, so that the left double lumen tubes are used more often except when there is no surgical contraindication for their installation (2).

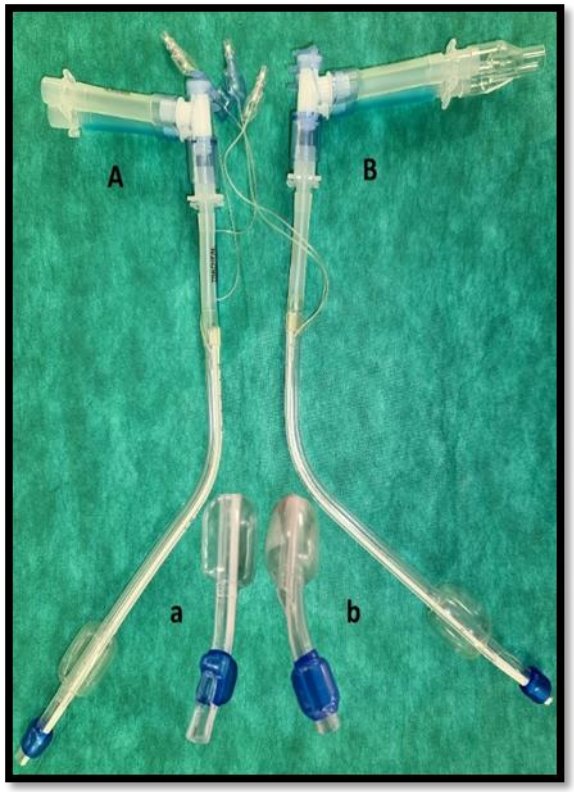

Figure 2. Double lumen tube (Rusch)

A - Rusch right double lumen tube
a - endotracheal and endobronchial (with Murphy's eye) cuff of the right double lumen tube;
B - Rusch left double lumen tube
b - endobrotracheal and endobronchial cuff of the left double lumen tube

Many anesthesiologists prefer the left double lumen tube for both right and left lung surgery to reduce the possibility of bronchial obstruction of the upper lobe of the right lung (10). The right bicuspid tube must be used if there is intrinsic (tumor, stenosis) or extrinsic (tumor, aortic aneurysm) obstruction of the left bronchus. The right double lumen tube is also used for left bronchial resections and during left lung transplantation (11).

Selection of DLT size

When choosing the size, you should choose the largest double lumen tube with a bronchial lumen that corresponds to the desired bronchus. Many problems can arise when choosing the wrong DLT size. For example, a selected smaller DLT can often be placed too deep in the bronchus, making it more likely to clog the bronchus of the upper lobe. Then, during unilateral lung ventilation, there is greater resistance to air flow through the small lumen of the tube, and this is manifested as a high level of auto peep pressure in patients with COPD (12).

There are various measurements for choosing the ideal DLT size, and some of them are:

1. Computed tomography of the chest, where the bronchus can be accurately measured, but this requires additional involvement of a radiologist (13, 14).

2. X-ray of the lungs, measuring the width of the trachea that can be used to determine the size of the left bronchus (15) (Figure 3). The width of the left bronchus is directly proportional to the size of the trachea (16). Because the trachea is visible and can be easily measured on a chest radiograph, the width of the trachea can be used to predict the size of the left bronchus. This allows the selection of the appropriate size of the left double lumen tube (17) (Table 1).

The use of DLT (39fr, 41fr) was initiated in most men, and the use of DLT (37, 39fr) was indicated for most women (18).

Figure 3. X-ray of the lungs - measurement of tracheal diameter

Table 1. Guidelines for selecting the left DLT

MEASURED WIDTH OF THE TRACHEA (mm)	PREDICTED LEFT BRONCH WIDTH (mm)	RECOMMENDED DLT SIZE	LEFT DLT OUTER DIAMETER (mm)	DLT LUMEN INNER DIAMETER (mm)
≥ 18	≥ 12.2	41 Fr	14 – 15	10.6
≥ 16	≥ 10.9	39 Fr	13 – 14	10.1
≥ 15	≥ 10.2	37 Fr	13 – 14	10.1
≥ 14	≥ 9.5	35 Fr	12 – 13	9.5
≥ 12.5	≥ 8.5	32 Fr	10 – 11	8.3
≥ 11	≥ 7.5	28 Fr	9.4	7.4

* Tracheal width measured on an X-ray of the lungs

* Predicted left bronchial width tracheal width (mm) x 0.68

Placing DLT

Endotracheal intubation and placement of DLT before adequate preoxygenation and induction under general anesthesia and after achieving adequate relaxation can be reported using two methods:

1. *By blind technique*, so that the DLT, after passing the distal part of the tube (endobronchial cuff) through the vocal cords, rotates the whole DLT 90 degrees to the left if it is the left DLT, or rotates to the right if it is the right DLT. The recommended end point for placing DLT through the trachea is when we encounter resistance. In both men and

women, the depth of placement of the DLT is directly proportional to the height. For a man or woman 170 cm tall, the DLT should be placed in the airways up to 29 cm, and for each ± 10cm height change the DLT should be placed deeper or pulled by ± 1cm (19, 20).

2. *Fiber optic technique*, after passing the DLT through the vocal cords, the pediatric fiber-optic bronchoscope is placed through the DLT, then advances further through the trachea and enters the main left bronchus using a bronchoscope, and then through the bronchoscope that serves as a guide, the DLT is placed in the left bronchus if we place the left DLT (21, 22).

After placement of the DLT (Figure 4), the tracheal cuff is inflated first (5-10 cc) and then the bronchial (3 cc max). The position of the tube is checked by physical examination of the chest, including auscultation and observation of chest lift (23).

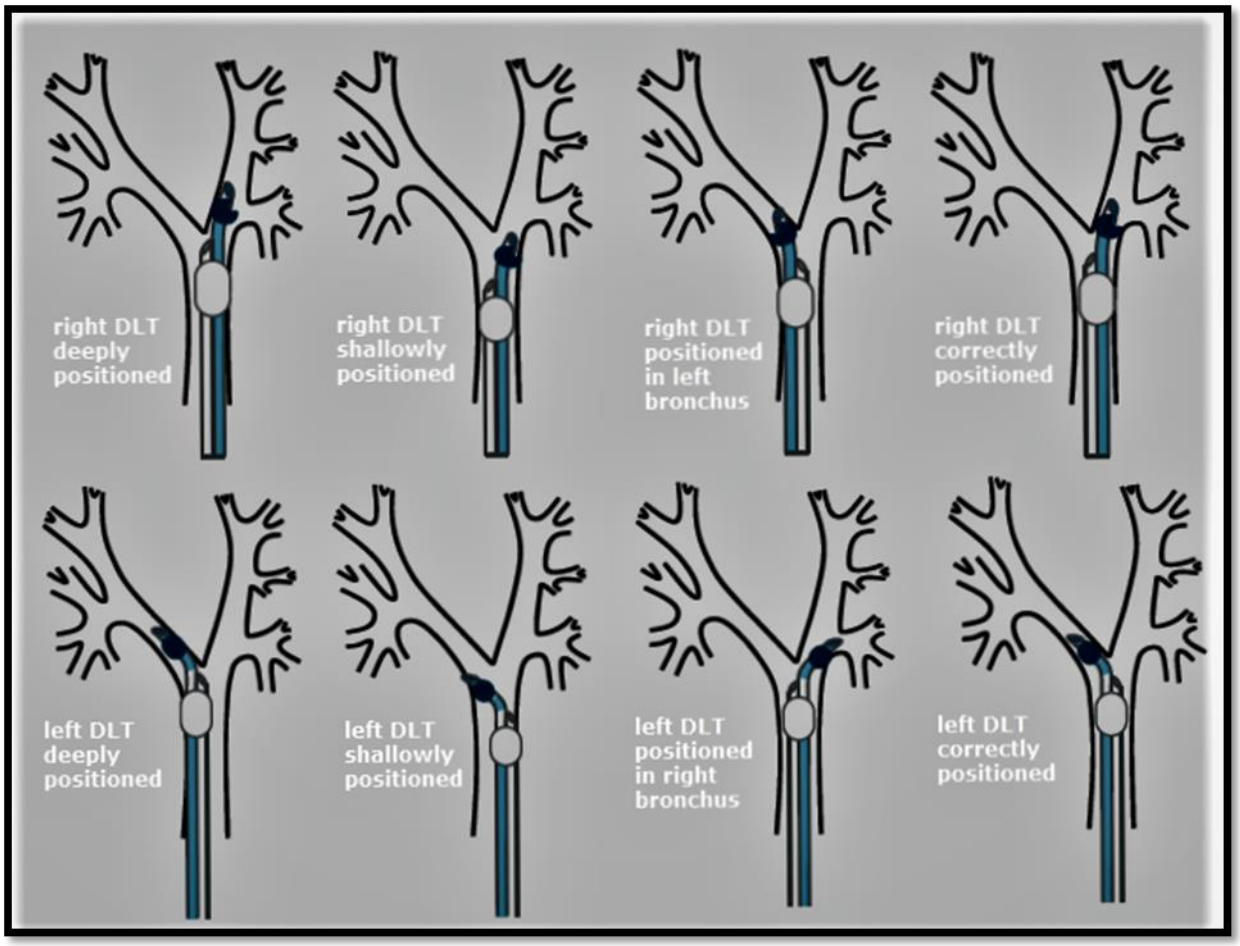

Figure 4. Position of the left and right DLT in relation to the carina

In the world of modern thoracic anesthesia, bronchoscopy is the gold standard for checking the position of the DLT, both in the supine and lateral position, and at the same time the safest method of checking the position of the DLT (24) (Figure 5, 6 and 7).

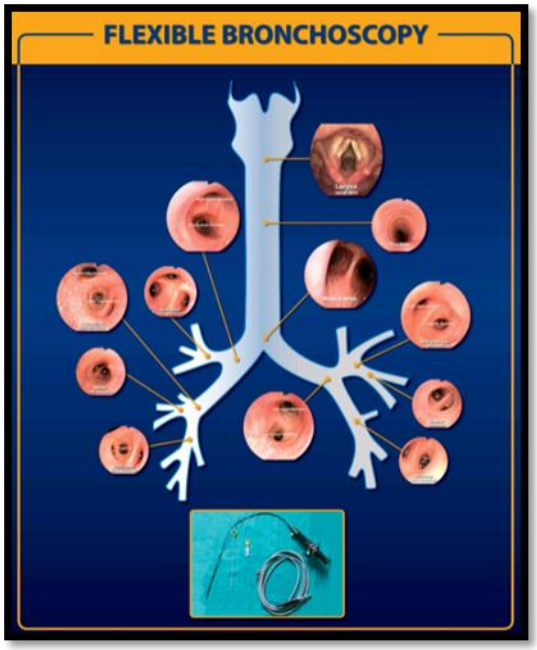

Figure 5. Visualization of anatomical structures using flexible bronchoscopy

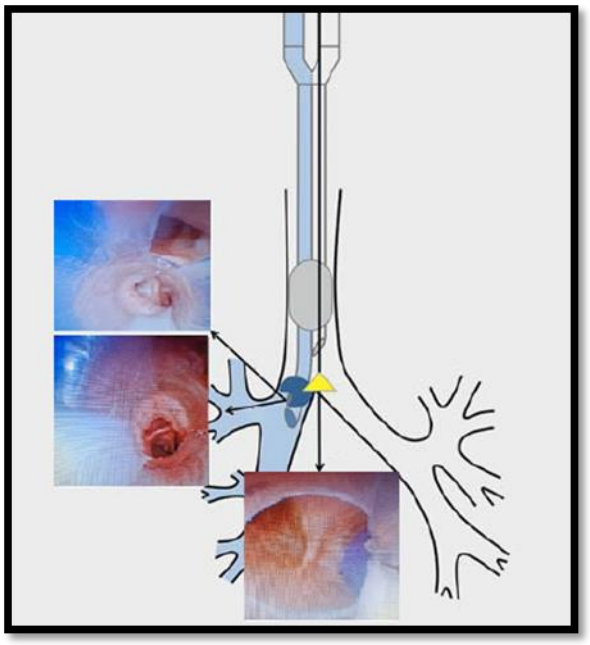

Figure 6. Right-sided intubation with right DLT - fiberoptic presentation of anatomical structures

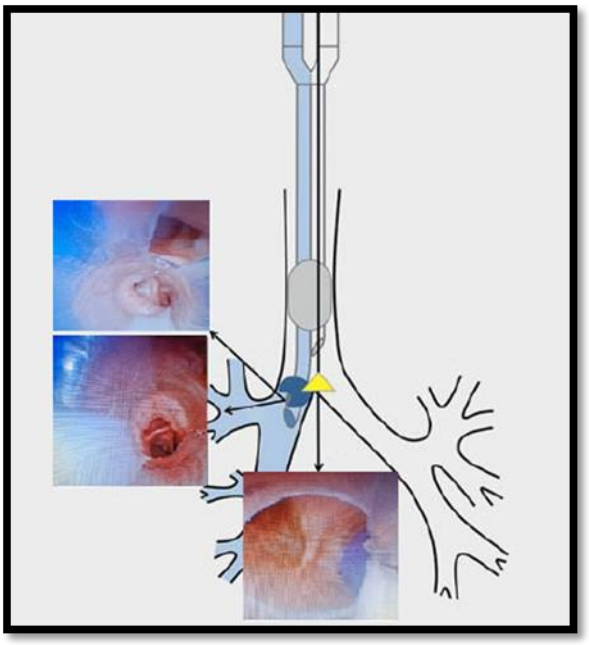

Figure 7. Left-sided intubation with left DLT - fiberoptic presentation of anatomical structures

Complications due to intubation with DLT

In general, DLTs are safe and easy to use, but complications can certainly occur (Table 2). The most common problems are related to the position of DLT. Poorly placed DLT can lead to airway damage, hypoxemia, or compromise surgery if adequate lung collapse does not occur (23).

Table 2. Complications due to intubation of DLT

INTUBATION	TRAUMA	PROBLEMS RELATED TO DLT POSITION
✓ carinal hook cannot pass through epiglottis (Carlens DLT) ✓ inability to place DLT in the bronchi due to excessive airway obstruction (intrinsic, extinct)	✓ tracheobronchial rupture ✓ rupture of thoracic aneurysm ✓ tooth trauma ✓ airway injury ✓ laryngeal mucosal injury ✓ vocal cord injury ✓ arytenoid dislocation	✓change of DLT position when positioning the patient in the lateral position ✓Flexion or extension of the head leads to a change in DLT position ✓shallowly placed DLT, bronchial cuff in front of the carina ✓deep placed DLT ✓change of DLT position during surgical manipulation

To avoid any complication related to DLT placement, the following recommendations should be followed (23):

1. Choose the largest plastic DLT that will fit in the airways,
2. Remove the intruder as soon as the DLT passes behind the vocal cords,
3. Caution in patients with pathologically altered tracheobronchial wall, leukemia, on corticosteroid therapy,
4. Slowly inflate tracheal and bronchial cuff, never over-inflate cuff,
5. If it is necessary to inflate the cuff further, check the position of the DLT and perform bronchoscopy and auscultation,
6. Do not use nitric oxide, and if you use it, inflate the cuff with saline,
7. Be sure to measure the pressure in the cuff (Figure 8),
8. When moving patients, be sure to drain both cuffs, dispense bronchial cuff when isolation or selective ventilation is no longer required,
9. After the operation, be sure to do a bronchoscopy to determine if the injury occurred, its location and extent of the injury.

Figure 8. Checking the pressure in cuffs (endobronchial, endotracheal) using a cuff pressure control device (Mallinckrodt)

Endobronchial blockers

Historically, bronchial blockade has been achieved with gauze tampons, urinary catheters, and kits used for embolectomy (25, 26).

Nowadays, endobronchial blockers (Figure 9) are used exclusively to block the bronchi, and there are several types:
EZ blocker, ARNDT blocker, COHEN blocker, FUJI blocker, COOPDEH blocker.

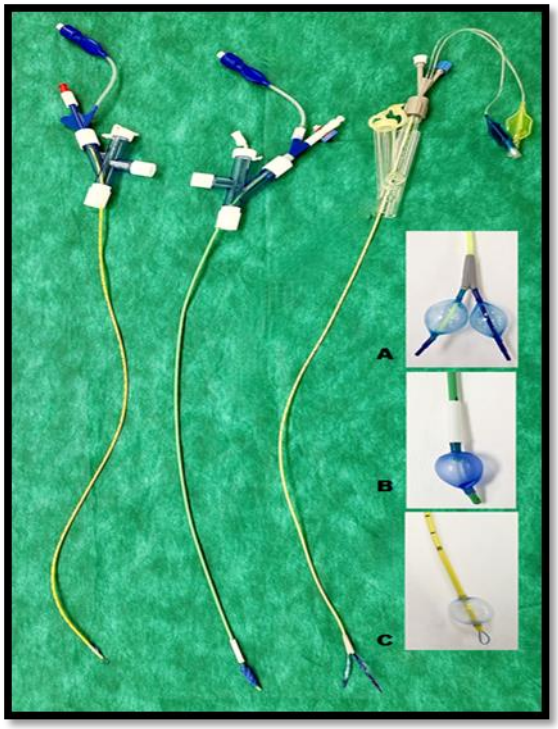

Figure 9. Endobronchial blockers

A. EC blocker,
B. Cohen blocker,
C. Arnd blocker

In thoracic anesthesia, double lumen tubes are mainly used for lung isolation and unilateral ventilation. Some endobronchial blockers should be used in certain groups of patients, such as patients with limited mouth opening, patients with previous laryngectomy, patients with permanent tracheostomy when the stoma is too small to place a double lumen tube (27, 28). In children and pediatric patients, bronchial blockers should be the first choice, because even the smallest DLT may be too large (29).

After endotracheal intubation, and placement of the one-lumen tube in the trachea, an endobronchial blocker can be placed in the appropriate bronchus to achieve lung collapse (23). The procedure of placing endobronchial blockers is performed under the control of bronchoscopy, except for urgent conditions when lung collapse is necessary, EZ blocker can be placed blindly (30).

Although they are more practical and easier to use than DLT, they also have their drawbacks: they can be easily moved when changing the patient's position or during surgical manipulation, the lung cannot collapse and expand again during surgery, and CPAP ventilation cannot be applied to the collapsed lung if the patient becomes hypoxemic during unilateral ventilation (23).

Conclusion

The use of a double lumen endobronchial tube is the standard of isolation and unilateral lung ventilation during thoracic surgery. The use of endobronchial blockers may be an alternative in special cases when the use of a double lumen tube is contraindicated. In order to avoid complications that occur during the airway management and after the placement of the double lumen tube, it is necessary to follow the recommendations and choose the appropriate size of the double lumen tube. Fiberoptic bronchoscopy is the gold standard of modern thoracic anesthesia and it is necessary for: insight into the anatomy of the bronchial tree, positioning of the endobronchial tube, lung isolation and unilateral ventilation as well as the toilet of the bronchial tree.

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SPECIFIČNOST OBEZBEĐIVANJA DISAJNOG PUTA U GRUDNOJ ANESTEZIJI

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Sve dok tehnike anestezije nisu napredovale sredinom tridesetih godina dvadesetog veka operacije na grudnom košu bile su kratke i teške. Anestezija tokom torakohirurških intervencija, sama po sebi jako je zahtevna i komplikovana za izvođenje i predstavlja pravi izazov za anesteziologa. Za nesmetano izvođenje operacije kod bolesnika kod kojih je respiratorna rezerva već snižena, potrebno je isključiti plućno krilo koje se operiše i izolovati plućno krilo koje se ventilira tokom hirurške intervnecije. Za obezbeđivanje disajnog puta i za postizanje kolapsa i jednostrane ventilacije, koriste se dvolumenski tubusi i endobronhijalni blokeri. Fiberoptička bronhoskopija je u svetu moderne grudne anestezije zlatni standard za proveru pozicije dvolumenskog tubusa i endobronhijalnog blokera.

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Ključne reči: *disajni put, grudna anestezija, dvolumenski tubusi, endobronhijalni blokeri*