Turk J Med Sci
2012; 42 (6): 1063-1069

E-mail: medsci@tubitak.gov.tr
doi:10.3906/sag-1201-46

Original Article

Comparison of two different right-sided double-lumen tubes with different designs

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Aim: To compare usage of 2 right-sided double-lumen tubes (RDLTs) with different designs in thoracic anesthesia. Although the left-sided double-lumen tube (DLT) is preferred, the RDLT is necessary in some circumstances.

Materials and methods: A total of 40 patients undergoing left thoracotomy were divided into 2 groups receiving a Rüsch or Sheridan RDLT. The position of the RDLT was verified by clinical evaluation. It was also checked by fiberoptic bronchoscope (FOB). When malposition was detected, it was corrected using the FOB. The correct installation time of the RDLT, frequency of bronchoscopy, and left lung collapse time were recorded.

Results: According to the bronchoscopic assessment, the rates of patients with a misplaced RDLT in the supine (40% vs. 50%) and lateral decubitis position (35% vs. 30%) were similar between the groups ($P > 0.05$). Ratios of total malpositions to total bronchoscopies were similar. The most frequent malposition types were displacement of RDLTs proximally or distally. Correct RDLT installation time (262 vs. 291 s) and collapse time of the left lung (215 vs. 234 s) were comparable between the groups ($P > 0.05$).

Conclusion: With the aid of bronchoscopic evaluation, our data suggest that Rüsch and Sheridan RDLTs are not superior to each other in one-lung ventilation. They were similar in terms of malpositions.

Key words: One-lung ventilation, right-sided double-lumen tube, fiberoptic bronchoscopy

Introduction

Endobronchial intubation and one-lung ventilation (OLV) are the most important practices in thoracic anesthesia (1). Today, Robertshaw type double-lumen tubes (DLTs) are frequently used in patients undergoing thoracic surgery (2-4). The margin of safety is the margin in which the location is still correct despite the displacement of the DLT (2). Both in right and left thoracotomies, the left-sided DLTs are usually preferred to the right-sided DLTs (RDLTs), which have a lower margin of safety (5,6) and higher risk of right upper lobe collapse and obstruction (2).

In particular, anatomical features of the right upper lobe division render the use of the RDLT more difficult compared to the left-sided DLT. It is stated that the use of RDLTs only with clinical assessment, without confirming the location via fiberoptic bronchoscope (FOB), is unacceptable (7,8). All RDLTs have an additional opening, allowing ventilation of the right upper lobe, in their endobronchial lumen. Failure to fit this opening onto the bronchial lumen of the right upper lobe can lead to some complications such as atelectasis and hypoxia (9). Although the design of the RDLT has been modified many times in order to facilitate correct installation

Received: 17.01.2012 – Accepted: 15.06.2012
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and to allow ventilation of the right upper lobe, the optimal DLT design has not yet been found. Various brands of RDLTs with different bronchial balloon configurations and locations are currently available. Both the size and the place of the right upper lobe ventilation openings are also different from each other in these RDLTs (8). It has been reported that the incidence of malposition detected by FOB varies between 73% and 89%, when a right-sided RDLT is placed without the use of a FOB (10-12). In this study, we aimed to compare the effectiveness of the Rüsch and Sheridan brands of RDLTs having different configurations of endobronchial balloon and upper lobe ventilation openings. We compared their clinical usage evaluating installation into the right main bronchus, intraoperative misplacements, and collapse of the operated lung.

Materials and methods

This prospective, randomized and single-blinded study was performed with approval of the institutional human investigation ethics committee and written informed consent obtained from all patients. The study was performed in accordance with the principles of the Declaration of Helsinki. Forty adult patients (28 males, 12 females) undergoing elective left-sided thoracotomy were allocated into 2 groups. Patients with destroyed lung, emphysematous lung disease, or endobronchial lesions in the right main bronchus or intermediary bronchus were excluded from the study.

In the operating room, following pre-oxygenation, anesthesia was induced with propofol (2.5 mg/kg I.V.), fentanyl citrate (2 µg/kg I.V.), and vecuronium bromide (0.1 mg/kg I.V.). Anesthesia was maintained with isoflurane (1%-1.5%), fentanyl citrate, and vecuronium bromide. Oxygen 100% was used during OLV and a routine OLV procedure was performed throughout this study. Electrocardiography, peripheral oxygen saturation (SpO_2), invasive arterial pressure, and end-tidal carbon dioxide ($ETCO_2$) were monitored. The arterial blood gases were analyzed hourly during the operation.

All patients were intubated with a Robertshaw type, disposable RDLT using the conventional method by the same thoracic anesthesia specialist. Rüsch (Rüschelit®, Bronchopart®, Willy Rüsch AG, Kernen, Germany) and Sheridan (Sher-i-bronch®, Hudson Respiratory Care Inc., Temecula, CA, USA) brand of RDLTs were placed in Group R (n = 20) and Group S (n = 20), respectively. The size of the DLT was 35-37 French (Fr) in females, while it was 39-41 Fr in males. In the conventional intubation method, the endobronchial cuff passed the vocal cords with direct laryngoscopy, as the distal concave angle of DLT faced the anterior. The RDLT was installed by pushing the tube with a 90° rotation towards the right side. The stylet was pulled as soon as the endobronchial cuff passed the vocal cords. The tracheal and endobronchial cuffs were inflated consecutively until no leak was observed. The placement of the DLT was assessed clinically with manual ventilation, inspection, and auscultation of the chest by clamping the lumens of the DLT individually. The position of the DLT was recorded as “appropriate” or “inappropriate” based on a clinical evaluation. In the supine position, correct placement of the DLT was verified using a FOB (Olympus® LF–DP, Olympus Medical System Corp., Tokyo, Japan) by another anesthetist. Inappropriately located DLTs were positioned in the expected place via the FOB. After bronchoscopic evaluation, if the DLT had to be moved more than 0.5 cm to correct its position, this condition was defined as “malposition”.

The bronchoscopic criteria of correct RDLT installation were described as follows: observation of the carina and direction of the endobronchial lumen towards the right when examining from the tracheal lumen, and observation of the right upper lobe bronchus orifice at the level of right upper lobe ventilation opening when checking from the bronchial lumen of the DLT. When the right upper lobe ventilation opening of the DLT was not placed at the level of right upper lobe bronchus orifice, the position of the DLT was corrected by turning and pushing or pulling it along by FOB. The correct installation time was regarded as the time beginning from the passage of the endobronchial cuff between the vocal cords to the moment that the DLT’s position was decided to be appropriate using a FOB.

The position of the DLT was also assessed via FOB in the lateral decubitis position and throughout the operation every 30 min. In the event of DLT malposition it was corrected immediately. Additional bronchoscopies were performed whenever a difficulty existed in the operated lung collapse or dependent lung ventilation. Total number of bronchoscopies, and the number and types of malpositions were recorded. The malposition types are defined in Table 1. The surgeon was asked to evaluate the left lung collapse as “good surgical view”, “partial collapse”, or “no collapse”. The time beginning from the initiation of OLV to complete collapse of the operated lung was recorded as “lung collapse time”.

The descriptive statistics were defined as mean and standard deviation for continuous variables. Categorical variables were defined as numbers and percentages. The Pearson chi-square test and Fisher’s exact test were used for determination of the relationships between categorical variables.

Results

The groups were similar with respect to patient characteristics (P > 0.05) (Table 2). In clinical assessment, DLT malpositions were significantly lower in Group R compared to Group S (P = 0.05) in the patients in the supine position. However, there was no significant difference between the groups in the assessment of DLT placement via FOB (Table 3). No significant difference was found between the groups in terms of malposition types determined using FOB in the patients in the supine and lateral decubitis positions (Table 4). During the operation, including additional bronchoscopies, DLTs were found to be displaced proximally in 8 and 7 patients in Group R and Group S, respectively. DLTs were observed to be displaced distally in 3 patients in each group. This difference was not statistically significant (P > 0.05).

Table 1. Description of malposition types.

Malposition types	
Type 1	Protrusion of the bronchial balloon into the carina and inadequate visualization of the right upper lobe orifice from the upper lobe ventilation opening in the bronchial lumen (proximal displacement of DLT)
Type 2	Nonvisualization of the upper margin of the bronchial balloon at the entrance of the main bronchus and inadequate visualization of the right upper lobe orifice from the upper lobe ventilation opening in the bronchial lumen (distal displacement of DLT)
Type 3	Both lumens of DLT are in the trachea
Type 4	Intubation of the left main bronchus

DLT: double-lumen tube.

Table 2. Patient characteristics.

	Group R (n = 20)	Group S (n = 20)	P
Age (year)	50.5 ± 12.8	48.8 ± 17.9	0.74
Weight (kg)	68.40 ± 9.70	66.80 ± 12.80	0.65
Height (cm)	166.9 ± 5.4	168.4 ± 7.6	0.30
Female/Male	6/14	6/14	1.00
Operation time (min)	177.15 ± 56.62	177.15 ± 34.40	1.00
Surgical procedures			0.251
Pneumonectomy	7	3	
Lobectomy	6	12	
Wedge resection	5	3	
Cystotomy	2	2	

Table 3. Clinical assessment and bronchoscopic evaluation of the tube placement in the patient in supine position.

DLT placement		Group R (n = 20)	Group S (n = 20)	P
Clinically correct		11 (55%)	5 (25%)	0.05
	Malposition with FOB	3 (27%)	0 (0%)	0.228
	No malposition with FOB	8 (73%)	5 (100%)	0.638
Clinically incorrect		9 (45%)	15 (75%)	0.05
	Malposition with FOB	5 (56%)	10 (67%)	0.678
	No malposition with FOB	4 (44%)	5 (33%)	0.678

DLT: double-lumen tube, FOB: fiberoptic bronchoscope.

Table 4. Malposition types by bronchoscopic evaluation in the patient in supine and lateral decubitis position.

		Group R (n = 20)	Group S (*n* = 20)	P
Supine	No	8	10	0.523
	Type 1	3	4	0.677
	Type 2	4	6	0.462
	Type 3	1	0	0.305
	Type 4	0	0	1.000
LDP[a]	No	7	6	0.735
	Type 1	2	5	0.203
	Type 2	5	1	0.065
	Type 3	0	0	1.000
	Type 4	0	0	1.000

[a] When the patient turned to the lateral decubitis position (LDP)

The data for DLT placement by bronchoscopic evaluation are given in Table 5. There was no significant difference between the groups in terms of correct installation time or left lung collapse time ($P > 0.05$). The ratios of total malpositions to total bronchoscopies were 26/152 (17.1%) and 26/146 (17.8%) in Group R and Group S, respectively ($P > 0.05$). The number of patients without DLT malpositions was 8 (40%) and 9 (45%) in Group R and Group S, respectively, in all bronchoscopic checks (Table 5).

The surgeon evaluated the left lung collapse as "good" in 18 and 17 patients in Group R and Group S, respectively, whereas it was defined as "partial" in 2 and 3 patients in Group R and Group S, respectively. There was no statistically significant difference between the groups with regard to surgical assessment of the left lung collapse ($P > 0.05$). The installation of the DLT and FOB handling were managed uneventfully in the present study. Arterial blood gases and $ETCO_2$ values were within the normal physiological ranges. Hypoxemia ($SaO_2 < 90\%$) was not seen at any stage of our study.

Table 5. Data of DLT placement by bronchoscopic evaluation.

	Group R (n = 20)	Group S (n = 20)	P
Patients with DLT malposition in supine position	8 (40%)	10 (50%)	0.523
Patients with DLT malposition in LDP[a]	7 (35%)	6 (30%)	0.735
Patients with intraoperative DLT malposition/with DLT malposition in LDP[a]	5/7 (71.4%)	4/6 (66.7%)	0.853
Patients with intraoperative DLT malposition/without DLT malposition in LDP[a]	3/13 (23%)	3/14 (21.4%)	0.918
Patients without DLT malposition	8 (40%)	9 (45%)	0.749
Malpositions in routine bronchoscopy during operation	9 (45%)	6 (30%)	0.080
Total malpositions	26	26	0.635
Routine bronchoscopies	150	142	
Additional bronchoscopies	2	4	0.36
Correct installation time (s)	262.25 ± 108.62	291.5 ± 126.75	0.270
Lung collapse time (s)	215.1 ± 127.89	234 ± 69.83	0.537

DLT: double-lumen tube, FOB: fiberoptic bronchoscope.
[a] When the patient turned to the lateral decubitis position (LDP)

Discussion

Although a left-sided DLT is usually preferred during OLV in patients undergoing right or left thoracotomy, the placement of a RDLT might be mandatory in some conditions. Benumof (2) summarized these conditions as follows: the presence of a lesion in the left main bronchus, torsion of the left main bronchus due to external pressure, destruction of the trachea-bronchial tree, and special operations such as sleeve resections. In fact, in many studies, a RDLT has been found to be as safe and effective as a left-sided DLT in the presence of FOB (4,6). Ehrenfeld et al. (13) stated that the idea that a left-sided DLT is safer than RDLT is not true when hypoxemia, hypercapnia, and high airway pressure are considered as criteria. However, blind (without FOB) installation of the RDLT might lead to significant problems such as atelectasis in the upper lobe, shunt, and hypoxia. When the RDLT is placed blindly, the incidence of malposition is high with the guidance of a FOB. In previous studies, when checked by FOB, the rates of DLT malpositions were 89%, 83%, and 73% (10-12). Interestingly, the positions were thought to be correct with auscultation.

In one case, Van Dyck and Astiz (14) reported that the bronchial lumen of the Sheridan RDLT caused an acute ventilation problem by twisting during the intubation and entering the right upper lobe bronchus. They concluded that with the Sheridan RDLT the right upper lobe ventilation opening is placed between the 2 bronchial balloons, and is longer and wider than the Rüsch. These factors might have contributed to the bronchial lumen's kink in the Sheridan RDLT. In a prospective study, Hurford et al. (15) found that the incidence of malposition leading to insufficient lung isolation was higher with the Sheridan RDLT than with the Rüsch.

In our study, we found a significant difference between the groups in terms of clinical malpositions in the supine position of 45% in Group R and 75% in Group S. We suggest that this can arise from incorrect auscultation findings (reflected sound), displacement of the tube during bronchoscopy, or insufficient inflation of the bronchial cuff.

The mean margin of safety, which explains the vulnerability of the RDLT to malposition, is one third that of the left-sided DLT (5,7,12). It has been stated that the use of RDLTs with only clinical assessment, without confirmation using FOB, is not appropriate (7,8). In our study, the groups were similar in terms of the number of malpositions found in the first assessment with FOB. The malpositions were detected with FOB in approximately one fifth of all DLTs whose position was clinically assessed as correct. This shows the necessity of bronchoscopy during the installation of a RDLT.

An optimal RDLT design facilitating the correct installation towards the right main bronchus and allowing ventilation of the right upper lobe has not been found yet. Failure to fit the upper lobe ventilation opening to the right upper lobe bronchus lumen during right endobronchial intubation leads to serious complications. It is stated that this problem is rarely encountered if the ventilation opening is wider and longer (9). The endobronchial balloons of the Rüsch and Sheridan RDLTs are in different forms and locations despite having similar basic features (7,8). The Rüsch RDLT has a single bronchial balloon and the upper lobe ventilation opening is placed in that area (Figure 1), whereas the Sheridan RDLT has 2 bronchial balloons and the upper lobe ventilation opening is between them (Figure 2).

Campos et al. (6) reported that DLT malpositions often occurred when the patient was turned to the lateral decubitis position from the supine position. The DLT can be displaced distally or proximally by head and neck movements of the patient (16). The tolerance of RDLTs to head movements is lower than that of left-sided DLTs. When a small tube is used, the DLT could be pushed cephalad with a high volume of the endobronchial cuff (2).

When the patient turned to the lateral decubitis position from the supine position, we observed malpositions in approximately one third of the patients in both groups. The probability of malposition during OLV was found to be higher in patients having DLT malposition when turned to the lateral decubitis position (17). In our study, the ratio of patients with intraoperative DLT malposition to the patients having DLT malposition when turned to the lateral decubitis position was 71.4% in Group R and 66.7% in Group S. Moreover, the ratio of the patients with intraoperative DLT malposition to the patients not having DLT malposition when turned to the lateral decubitis position was 23% and 21.4% in Group R and Group S, respectively.

In the present study, displacement of the DLT proximally or distally was the most common malposition type in both groups. Surgeons did not define any insufficient collapse of the left lung during OLV.

The use of a RDLT with assessment of its placement via FOB is recommended in the anesthesia

Figure 1. Endobronchial segment of Rüsch right-sided double-lumen tube.

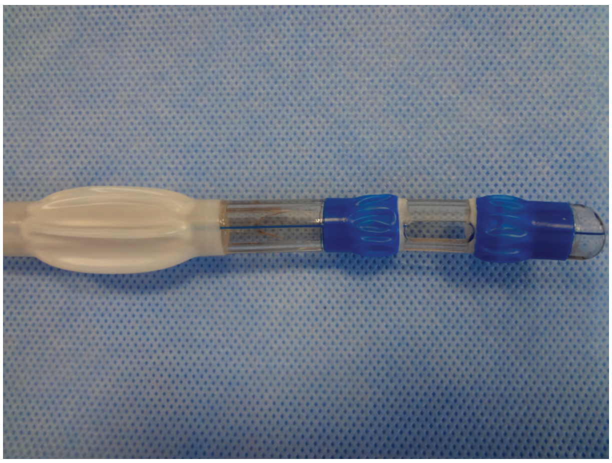

Figure 2. Endobronchial segment of Sheridan right-sided double-lumen tube.

curriculum (7,8,18). In a previous study, which was performed on anesthetists with limited experience in thoracic surgery, the endobronchial intubation time was long and the malposition rates were high. Consequently, that result was attributed to insufficient knowledge of FOB usage (19). Routine FOB use provides anesthesiologists increased expertise in positioning DLTs (20). We think that training on RDLT usage with the aid of a FOB is essential as a part of the residency program in thoracic anesthesiology in order to provide the skills for conditions requiring a RDLT. We agree with previous authors (21,22) on the point that the clinician should be familiar with the available devices to provide OLV and safe management of patients.

In conclusion, with the aid of bronchoscopic evaluation, the present study indicates that Rüsch and Sheridan RDLTs are not superior to each other in OLV. Despite their different bronchial structures, both Rüsch and Sheridan RDLTs were safe and similar in terms of malpositions during thoracic surgery. Handling the RDLT and FOB is a challenging issue in thoracic anesthesia practice. Therefore, experienced anesthesia staff should be available in such a center performing thoracic surgery and OLV.

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