Original Article

Intubation with Vivasight Double-Lumen Tube Versus Conventional Double-Lumen Tube in Adult Patients Undergoing Lung Resection: A Retrospective Analysis

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ABSTRACT

Objectives: The present study was designed to compare outcomes in patients undergoing thoracic surgery using the VivaSight double-lumen tube (VDLT) or the conventional double-lumen tube (cDLT).

Design: A retrospective analysis of 100 patients scheduled for lung resection recruited over 21 consecutive months (January 2018–September 2019).

Setting: Single-center university teaching hospital investigation.

Participants: A randomized sample of 100 patients who underwent lung resection during this period were selected for the purpose to compare 50 patients in the VDLT group and 50 in the cDLT group.

Interventions: After institutional review board approval, patients were chosen according to inclusion and exclusion criteria and we created a general database. The 100 patients have been chosen through a random process with the Microsoft Excel program (Microsoft 2018, Version 16.16.16).

Measurements and Main Results: The primary endpoint of the study was to analyze the need to use fiberoptic bronchoscopy to confirm the correct positioning of VDLT or the cDLT used for lung isolation. Secondary endpoints were respiratory parameters, admission to the intensive care unit, length of hospitalization, postoperative complications, readmission, and 30-day mortality rate. The use of fiberoptic bronchoscopy was lower in the VDLT group, and the size of the tube was smaller. The intraoperative respiratory and hemodynamics parameters were optimal. There were no other preoperative, intraoperative, or postoperative differences between both groups.

Conclusions: The VDLT reduces the need for fiberoptic bronchoscopy, and it seems that a smaller size is needed. Finally, VDLT is cost-effective using disposable fiberscopes.

Keywords: Airway management, fiberoptic bronchoscopy, lung isolation, standard double-lumen tube, VivaSight double-lumen tube

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INTRODUCTION

Thoracic surgery requiring lung isolation is usually achieved by endobronchial intubation using a conventional double-lumen tube (DLT).[1,2] Although single-lumen tubes and bronchial blockers[3] are also used as lung separation

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techniques, DLTs are still a major and popular method. Proper insertion of DLTs is important for achieving proper anesthetic management during thoracic surgery procedures. Hypoventilation, inadequate lung collapse, and increased risk for postoperative respiratory infections are common complications of a misplaced tube.[4,5] It has been reported that blind intubation of the bronchus alone can be incorrect in 32%–48% of cases.[6] Different methods can be used to determine the correct positioning of DLTs, including auscultation, point-of-care ultrasound, or respiratory pressures, but these are insufficient to confirm the success of selective bronchial intubation.[7,8] Furthermore, the patient's lateral decubitus position during the surgical procedure can lead to bronchial extubation or pulmonary obstruction, which may seriously compromise ventilation and the success of operation. Therefore, fiberoptic bronchoscopy with a flexible fiberscope is the gold standard for guiding endobronchial lumen into position and confirm correct placement under direct vision.[7,9]

The VivaSight double-lumen tube or video double-lumen tube (VDLT) is a novel device with an integrated high-resolution camera situated at the end of the tracheal lumen, which allows obtaining real-time images of the airway during intubation of the trachea and bronchus and intraoperatively during lung surgery.[10,11] Continuous visualization of the carina is a major improvement for patient care as intraoperative displacement can be diagnosed immediately and corrected.[12] Although several studies have shown that the use of the VDLT facilitates faster insertion, high rate of correct positioning, reduction in the need for fiberoptic bronchoscopy, and repositioning when necessary,[13-17] the evidence is still limited, particularly regarding differences with conventional DLT (cDLT) in various outcome variables. Therefore, the present study was designed to provide intraoperative and immediate postoperative data in patients undergoing thoracic surgery using the VDLT or the cDLT for intubation and airway management during lung isolation procedures.

METHODS

This was a single-center retrospective analysis of patients undergoing pulmonary resection from January 2018 to September 2019. During this period, 100 patients were chosen through a random process with the Microsoft Excel program (Microsoft 2018, Version 16.16.16) out of about 150 surgeries pertaining to this study, the complete data of which were recovered from the patients' medical records in the electronic database of the hospital. Inclusion criteria were adult patients (≥18 years of age) undergoing lung resection, including wedge resection, transegmentary resection, lobectomy, bilobectomy, and pneumonectomy, who had been intubated by anesthesiologists with wide experience in thoracic surgery using direct laryngoscopy to insert a VDLT or cDLT with caliber adjusted to biometric patient criteria (sex, weight, and height) and their own experience using both devices.

Patients in whom other techniques of lung isolation were used or who underwent other thoracic surgical procedures (e.g., bullectomy and sympathectomy) were excluded from the study as well as patients with predicted or unexpected difficult airway.

The study was approved by the Clinical Research Ethics Committee of the Consorci Hospital General Universitari de València that complies with standards of good clinical practice (CPMP/ICH/135/95) with the identification code "VivaSight Valencia 2020." Preoperatively, all patients gave written informed consent for the surgical and anesthetic procedure.

The primary endpoint of the study was to analyze the need to use fiberoptic bronchoscopy to confirm the correct positioning of the tube during induction and throughout the surgical procedure when either the VDLT or the cDLT was used for lung isolation. Secondary endpoints were respiratory parameters, admission to the intensive care unit (ICU), length of hospitalization, postoperative complications, readmission, and 30-day mortality rate.

For each patient, the following data were recorded: sex, age, height, weight, body mass index (BMI), American Society of Anesthesiologists (ASA) physical status classification, preoperative forced expiratory volume in one second (FEV_1), preoperative forced vital capacity (FVC), preoperative FEV_1/FVC ratio, primary diagnosis, surgical procedure, surgical approach, total duration of operation, type of analgesia, Mallampati score and Cormack–Lehane grade, use of fiberoptic bronchoscopy, VDLT and DLT size, tidal volume, positive end-expiratory pressure (PEEP), peripheral capillary oxygen saturation (SpO_2), fraction of inspired oxygen (FiO_2), end-tidal carbon dioxide ($EtCO_2$), peak inspiratory pressure (PIP), need of continuous positive airway pressure (CPAP), ICU admission, ICU readmission, length of hospital stay, hospital readmission, postoperative complications (respiratory, hemodynamic, airway damage, and others), and mortality. Intraoperative variables were collected during three stages: initial two-lung ventilation, during one-lung ventilation, and during the final two-lung ventilation at the end of surgery. The postoperative observation period was 30 days from the

date of surgery. In addition, direct costs including the devices, fiberoptic bronchoscopy, and days of stay in the ICU and in the hospital were calculated for the two study groups according to 2017 official data of the autonomous community of Valencia.

After institutional review board approval, patients were chosen according to inclusion and exclusion criteria and we created a general database. During this period, 100 patients were chosen through a random process with the Microsoft Excel program (Microsoft 2018, Version 16.16.16) out of about 150 surgeries pertaining this study.

Our objective was to determine the percentage of cases in which the use of a fiberoptic bronchoscope was not required to verify the correct positioning of the endobronchial tube when a VDLT camera was used (main hypothesis: the use of VDLT reduces the use of fiberoptic bronchoscope).

Using the G * Power program, it was estimated that the sample size necessary to carry out the project was 100 patients (50 per group), considering an effect size of 87% according to the study by Heir *et al.* 2018, α error = 5%, and statistical power = 99% (1-beta error probability).

Categorical variables are expressed as frequencies and percentages and quantitative variables as mean and standard deviation (SD). The Chi-square test with Yate's correction for independent samples was used for the comparison of categorical variables between the VDLT and the cDLT groups, and the Student's *t*-test or the Mann–Whitney *U*-test for continuous variables. The effect size of the differences associated with the use of the VDLT and the cDLT was assessed with the Rosenthal correlation coefficient (*r*). Statistical significance was set at $P < 0.05$. The R statistical program (version 3.5.2) was used for the analysis of data. The R Studio statistical program (version 1.1.383) was used for the analysis of data.

RESULTS

The study population included 100 patients (50 in each study group), with a total of 69 men and 31 women, with a mean (SD) age of 64.1 (1.6) years and BMI of 26.1 (0.6) kg/m^2. Overweight (BMI: 25–29.9 kg/m^2) was recorded in 50% of patients of the VDLT group and in 52% of the cDLT group. As shown in Table 1, there were no statistically significant differences between patients in the VDLT and DLT groups regarding demographics, pulmonary function tests, and preoperative data (e.g., 95% of the patients included were ASA II and III). Moreover, there were no differences regarding the surgical procedures, surgery time, or type of analgesia applied [Table 2]. The most relevant surgical characteristics and analgesia results were tumors as the most common indication for surgery (90%), wedge resection (44%) or lobectomy (52%) as the most frequent surgical procedures, open thoracotomy approach in 61% of cases, and epidural and paravertebral

Table 1: Demographic and anthropometric data. Preoperative lung function assessment

	Group 1: VDLT	Group 2: cDLT	*P*
Sex n (%)			0.66
Men	33 (66%)	36 (72%)	
Women	17 (34%)	14 (28%)	
Age (years) Mean±SE	64.64±1.45	63.58±1.83	0.65
Height (cm) Mean±SE	166.00±1.31	168.08±1.21	0.24
Weight (kg) Mean±SE	72.83±2.19	75.88±1.85	0.29
BMI (kg/m^2) *n* (%) Mean±SE	25.84±0.57	26.42±0.66	0.51
Underweight (<18.5)	1 (2%)	0 (0%)	
Normal range (18.5-24.9)	15 (30%)	18 (36%)	
Overweight (25-29.9)	25 (50%)	26 (52%)	
Obese class I (30-34.9)	9 (18%)	3 (6%)	
Obese class II (35-39.9)	0 (0%)	0 (0%)	
Obese class III (>40)	0 (0%)	3 (6%)	
A. S. A. risk *n* (%)			0.89
I	1 (2%)	1 (2%)	
II	25 (50%)	23 (46%)	
III	22 (44%)	25 (50%)	
IV	2 (4%)	1 (2%)	
V	0 (0%)	0 (0%)	
FEV1/FVC (%) Mean±SE	70.26±2.06	68.30±1.58	0.45
FEV1 (ml/s) Mean±SE	97.09±3.08	91.13±2.81	0.16
FVC (ml/s) Mean±SE	111.30±2.77	106.93±2.93	0.60

VDLT, Video double-lumen tubes/VivaSight-DL; cDLT, Conventional Double-lumen tubes; *n*, number; SE, Standard error; cm, Centimeters; kg, kilograms; ASA, American Society of Anesthesiologists physical status; FEV1, Forced expiratory volume in the first second; FVC, Forced vital capacity

Table 2: Surgical characteristics and analgesia

	Group 1: VDLT	Group 2: cDLT	*P*
Patient primary pathology *n* (%)			0.50
Tumor	46 (92%)	44 (88%)	
Others	4 (8%)	6 (12%)	
Surgery procedure *n* (%)			0.30
Wedge	24 (48%)	20 (40%)	
Lobectomy	23 (46%)	29 (58%)	
Bilobectomy	2 (4%)	0 (0%)	
Pneumonectomy	1 (2%)	1 (2%)	
Surgical approach *n* (%)			0.53
Minimally invasive	21 (42%)	18 (36%)	
Open	29 (58%)	32 (64%)	
Duration of Surgery per patient (min)	148.80±9.08	154.26±8.34	0.66
Analgesia *n* (%)			0.37
Epidural	24 (48%)	30 (60%)	
Paravertebral	16 (32%)	13 (26%)	
Intravenous	10 (20%)	7 (14%)	
Surgical resection side *n* (%)			0.33
Right	27 (54%)	32 (64%)	
Left	23 (46%)	18 (36%)	

VDLT, Video double-lumen tubes/VivaSight-DL; cDLT, Conventional double-lumen tubes; *n*, number; min, minutes

analgesia in 54% and 29% of patients, respectively. The surgical lung resection side was mostly the right for both groups. The mean duration of surgery was 151.2 (8.7) min.

Details of intraoperative airway management are shown in Table 3. Intubation difficulties according to Mallampati score and Cormack–Lehane grade were similar in patients assigned to the VDLT or cDLT groups. In this study, we included 100 cases using a left cDLT o VivaSight-DL (this device has only a left model) who underwent lung resection (right side in 54% of cases in the VDLT group and 64% in the cDLT group) shown in Table 1. The number of patients in whom fiberoptic bronchoscopy was required to assess the positioning of the tube was significantly lower in the VDLT group (9/50 [18%]) than in the cDLT group (26/50 [52%]) ($P = 0.0008$). Also, in a higher percentage of patients in the VDLT group than in the cDLT, smaller tube diameters were used ($P = 0.04$). In this study, we analyzed the clinical course and postoperative imaging tests routinely performed looking for airway damages related to the airway management but any tracheobronchial or vocal cord injuries were found in any group after reviewing carefully the postoperative evolution.

Respiratory parameters during initial two-lung ventilation, during one-lung ventilation, and during the final two-lung ventilation at the end of surgery were optimal in the two study groups [Table 4]. The mean PEEP used during one-lung ventilation was 7.03 (1.29) cm H_2O in the VDLT group and 6.25 (0.24) cm H_2O in the cDLT group ($P = 0.01$; $r = 0.29$). Additionally, the mean SpO_2 during initial one-lung ventilation was 98.25% (0.28) in the VDLT group and 99% (0.13) in the cDLT group ($P = 0.04$; $r = 0.20$).

CPAP was used in 1 patient in the VDLT group who had preoperatively and intraoperatively persistent SpO_2 of 89% despite intensive maneuvers to correct hypoxemia. CPAP of 5 cm H_2O was applied in the surgical lung with an increase in SpO2 to 97%. In the cDLT group, 3 patients undergoing pneumonectomy, bilobectomy, and lobectomy, respectively, poorly tolerated one-lung ventilation and required CPAP therapy.

Table 5 shows postoperative clinical results. There were no differences in the ICU readmission rate, length of hospital stay, and respiratory and hemodynamic complications. None of the patients died.

Based on costs per day of hospitalization (341 €), days of ICU stay (1365.29 €), and intubation devices (26 € for conventional DTL, 210 € for Ambu disposable bronchoscope, and 165 € for a VDLT tube), the total direct costs were 4466.92 € in the VDLT group and 4801.88 € in the cDLT group ($P = 0.58$; $r = 0.60$).

DISCUSSION

The main finding of the study is that patients undergoing lung resection intubated using the VDLT device showed a lower requirement of fiberoptic bronchoscopy to assess tube positioning during surgery as compared with patients

Table 3: Airway management results

	Group 1: VDLT	Group 2: cDLT	*P*
Mallampati *n* (%)			0.82
I	20 (40%)	16 (32%)	
II	20 (40%)	21 (42%)	
III	9 (18%)	12 (24%)	
IV	1 (2%)	1 (2%)	
Cormack-Lehane *n* (%)			0.35
I	35 (70%)	29 (58%)	
IIA	9 (18%)	15 (30%)	
IIB	5 (10%)	5 (10%)	
IIIA	0 (0%)	1 (2%)	
IIIB	1 (2%)	0 (0%)	
IV	0 (0%)	0 (0%)	
FOB *n* (%)			0.0008
Yes	9 (18%)	26 (52%)	
No	41 (82%)	24 (48%)	
Tube Size *n* (%)/men (%)/women (%)			0.05
35 Fr	10 (20%)/1 (2%)/9 (18%)	3 (6%)/1 (2%)/2 (4%)	
37 Fr	38 (76%)/30 (60%)/8 (16%)	41 (82%)/29 (58%)/12 (24%)	
39 Fr	2 (4%)/2 (4%)/0 (0%)	6 (12%)/6 (12%)/0 (0%)	
41 Fr	0 (0%)	0 (0%)	
Airway damage *n* (%)			1
Tracheobronchial injury	0 (0%)	0 (0%)	
Vocal cord injury	0 (0%)	0 (0%)	

VDLT, Video double-lumen tubes/VivaSight-DL; cDLT, Conventional double-lumen tubes; *n*, number; FOB, Flexible bronchoscopy; Fr, french

Table 4: Respiratory parameters

	Group 1:VDLT	Group 2:cDLT	*P*
Tidal volume (ml/kg) Mean±SE			
TLV 1	8.07±0.14	8.44±0.12	0.06
OLV	6.66±0.13	6.70±0.12	0.82
TLV 2	7.99±0.16	8.19±0.15	0.43
PEEP (cm H_2O) Mean±SE			
TLV 1	5.70±1.48	5.27±0.17	0.21
OLV	7.03±1.29	6.25±0.24	0.01
TLV 2	6.68±1.81	6.31±0.35	0.51
SpO_2 (%) Mean±SE			
TLV 1	98.25±0.28	99.00±0.13	0.04
OLV	96.80±0.34	96.95±0.32	0.93
TLV 2	98.42±0.30	98.89±0.15	0.57
FiO_2 (%) Mean±SE			
TLV 1	55.16±1.14	55.51±1.65	0.75
OLV	63.75±1.64	64.33±1.79	0.79
TLV 2	57.91±1.52	61.92±3.90	0.61
$EtCO_2$ (%) Mean±SE			
TLV 1	36.60±1.17	37.08±0.45	0.47
OLV	36.25±0.63	36.67±0.54	0.61
TLV 2	35.10±0.65	35.79±0.63	0.48
PIP (cmH_2O) Mean±SE			
TLV 1	17.74±0.53	17.27±0.48	0.64
OLV	21.52±0.65	21.68±0.68	0.87
TLV 2	19.12±0.82	19.47±1.35	0.93
CPAP *n* (%)			0.77
Yes	1 (2%)	3 (6%)	
No	49 (98%)	47 (94%)	

VDLT, Video double-lumen tubes/VivaSight-DL; cDLT, Conventional double-lumen tubes; SE, Standard error; TLV1: initial two-lung ventilation; OLV, One-lung ventilation; TLV2, final two-lung ventilation; SpO_2, peripheral capillary oxygen saturation; FiO2, Fraction of inspired oxygen; $EtCO_2$, End-tidal carbon dioxide; PIP, airway peak inspiratory pressure; CPAP, Continuous positive airway pressure; *n*, number

Table 5: Postoperative clinical results

	Group 1: VDLT	Group 2: cDLT	*P*
ICU (days)			0.44
Mean±SE	1.26±0.24	1.40±0.42	
Total	63	70	
Hospitalization (days)			0.76
Mean±SE	7.46±0.57	8.08±0.79	
Total	373	404	
ICU readmission *n* (%)			1
yes	1 (2%)	2 (4%)	
no	49 (98%)	48 (96%)	
Rehospitalization *n* (%)			1
yes	4 (8%)	3 (6%)	
no	46 (92%)	47 (94%)	
Respiratory complications *n* (%)			0.36
yes	11 (22%)	15 (30%)	
Air leak	7 (14%)	11 (22%)	
Hypoxemia	1 (2%)	4 (8%)	
Air chamber	2 (4%)	0 (0%)	
Pneumonia	1 (2%)	0 (0%)	
no	39 (78%)	35 (70%)	
Hemodynamic complications *n* (%)			0.18
yes	3 (6%)	7 (14%)	
AF	1 (2%)	2 (4%)	
HF	0 (0%)	1 (1%)	
Bleeding	3 (6%)	4 (8%)	
no	47 (94%)	43 (86%)	
Other types of complications *n* (%)			
yes	1 (2%)	2 (4%)	1
no	49 (98%)	48 (96%)	
Mortality *n* (%)	0 (0%)	0 (0%)	1

VDLT, Video double-lumen tubes/VivaSight-DL; cDLT, Conventional double-lumen tubes; SE, standard error; *n*, number; ICU, Intensive care unit; *n*, Number; AF: Atrial fibrillation; HF, Heart failure

intubated with the cDLT device (9 patients [18%] vs. 26 patients [52%), and this difference was statistically significant. Our results are in agreement with data of a prospective study of 2,127 patients requiring one-lung ventilation during thoracic surgery reported by Langiano *et al*.[18] in which bronchoscopy was used in 54% of cases to check the correct positioning of the DLT. These results are consistent with a 20%–40% rate of DLT malpositioning verified by fiberoptic bronchoscopy.[19]

The evidence of the use of VDLT is still limited. The percentage of patients requiring fiberoptic bronchoscopy was 18%, which is similar to the data reported in previous studies. In the randomized study of Heir *et al*.[14] of 38 patients allocated to the VDLT, fiberoptic bronchoscopy was necessary in 13.2% of patients for verification of the final position of the tube, in 7.7% to correct dislodgement, and in 9% to aspirate secretions that prevented an adequate view of the carina and correct one-lung ventilation. However, a systematic review of randomized controlled trials of VivaSight single and DLTs with conventional tubes during normal airway and expected difficult airway management indicated that studies were not conclusive regarding the need for fiberoptic bronchoscopy.[10] The present study provides additional evidence of a lower percentage of patients requiring bronchoscopy when using the VDLT device, although fiberoptic bronchoscopy remains the gold standard to verify correct tube positioning.[7,9] On the contrary, adequate visualization and continuous monitoring of the airway provided by the high-resolution camera allows prompt correction and prevention of complications of a poorly positioned tube, including lobar collapse, hypoxemia, and/or postoperative pulmonary infections.[20] Studies comparing VDLT with standard DLT reported a faster tracheal intubation rate and higher success rate at the first attempt for VivaSight.[10] Also, in many studies, VDLT has shown to achieve intubation faster and higher successful intubation rates as compared to cDLT checked by fiberscope in normal and difficult airway scenarios.[21,22]

Regarding appropriate left-sided DLT, most adult female and male patients can be intubated with DLT size 35Fr and 39Fr, respectively. Inadequate selection of the size of DLT may cause airway complications, including severe tracheobronchial injury.[23] In our study, the most common sizes in both groups were 37Fr, although in patients in the VDLT, the average sizes were smaller than those in the cDLT

group. Complications related to intubation using either the VDLT or the cDLT did not occur. In a systematic review, soft tissue trauma, dysphonia, sore throat, hematoma, and bleeding have been reported as complications of VivaSight, and due to the outer thickness, a smaller-sized DLT may be necessary.[10] In 1 out of 8 patients reported by Dean *et al*.,[11] tracheal intubation with size of the VDLT calculated according to biometric criteria (sex, weight, and height) was unsuccessful after two attempts to pass below the subglottis and a conventional 35Fr DLT was easily passed into the correct bronchus. Other authors have also referred unsuccessful intubations and the need to use VivaSight- DL of smaller sizes than 35Fr; thus, cDLT of 32Fr have been used.[15] In the study by Dean *et al*.,[11] a comparison of the VDLT 37Fr tube with a Mallinckrodt 37Fr DLT showed that the external diameter of the VDLT was 36% greater than the Mallinckrodt 37Fr DLT (15 vs. 11 mm), owing to the profile of the camera, and it was speculated that this may have impeded the passage of the tube into the trachea. When we started using the VDLT in our hospital, we had a similar experience with respect to the need to use a lower VDLT caliber as the previous authors informed.[11,15] In our study, there were significant differences in the size of the devices in a homogeneous population, with smaller sizes in the VDLT group, without any tracheobronchial or vocal cord injuries in either group after reviewing the clinical course and postoperative imaging tests routinely performed. These results indicate that the optimal size of the VDLT may be slightly smaller than the corresponding size of the cDLT in order to avoid complications that in other studies have been associated with the use of DLTs with an integrated camera[10]; however, this would require a future verification through a prospective study.

Regarding the ventilatory parameters used, a difference was observed in SpO2 during the initial two-lung ventilation, although it was optimal (>98%) in both groups. Regarding the PEEP used during OLV, it was slightly higher in the VDLT group, with an average PEEP between 6 and 7 cmH2O in both groups, which coincides with the opinion of other authors who published that protective lung ventilation includes a PEEP between 5 and 8 cmH2O.[24]

Total duration of the surgical procedure was slightly shorter in the VDLT group as compared to patients in the cDLT, but differences were not significant. Other studies have shown that the median duration of intubation with visual confirmation of tube position was significantly reduced using the VivaSight-DL (VDLT) compared with the cDLT[16,17] because of the lower need for fiberoptic bronchoscopy during intubation or surgery.[16] In our retrospective study, it was not possible to measure the intubation time in each group, but we did observe a significant reduction in the need to use the fiberscope in the VDLT group, which may justify the reduction in total operative time; however, this should be confirmed with a prospective study in which intubation time is also evaluated. Moreover, a higher rate of successful intubation at the first attempt with the VivaSight- DL has also been reported.[10]

In a cost-effectiveness analysis conducted from a healthcare sector perspective in Denmark, the cost of using VDLT was 299.96 US$ per procedure versus 347.61 US$ for a cDLT with a reusable bronchoscope and the incremental cost-effectiveness ratio was 51.06 US$ per bronchoscopy avoided.[25] In our study, the mean direct costs per patient associated with the use of the VDLT or cDLT, disposable fiberoptic bronchoscopies, and days of ICU and hospital stay was somewhat lower in the VDLT group, but without statistically significant differences. Therefore, we can indicate that the use of VDLT is cost-effective, both when using disposable or reusable fiberscopes to check the correct position of the DLT.

On the contrary, differences in other intraoperative and ventilatory variables as well as in postoperative outcomes were not registered and surgical procedures were completed successfully in all patients. None of the patients died at 30 days after surgery.

In this study, the use of VDLT as compared with cDLT reduced the need of fiberoptic bronchoscopy to check correct tube positioning in patients undergoing lung resection surgery. Smaller sizes appear to be adequate when using VDLT devices as compared with cDLTs, but more studies are needed in the future to confirm this result.

In our opinion, this study is of great interest because it is a usual clinical practice study comparing conventional double-lumen tubes vs. VDLT that analyzes the real need to use a fiberscope to verify the correct lung isolation.

Regarding the limitations of the present study, it should be noted that it consists of a single-center and retrospective study; the latter aspect may require adjustment of the parameters that could be evaluated in the future.

The conclusions of this study are that the use of VDLT reduces the need to check lung isolation by fiberscope with respect to the use of standard DLT; furthermore, it is proven that the use of smaller VDLT calibers with respect to the cDLT group is a safe clinical practice from the point of view of airway management, ventilation, and incidence of complications. Finally, we can indicate that the use of VDLT is cost-effective,

both when using disposable or reusable fiberscopes to check the correct position of the double-lumen tube.

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Declaration of patient consent
The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Cohen E. Recommendations for airway control and difficult airway management in thoracic anesthesia and lung separation procedures. Are we ready for the challenge? Minerva Anestesiol 2009;75:3-5.
2. Granell M, Parra MJ, Jimenez MJ, Gallart L, Villalonga A, Valencia O, *et al*. Review of difficult airway management in thoracic surgery. Rev Esp Anestesiol Reanim (Engl Ed) 2018;65:31-40.
3. Kosarek L, Busch E, Abbas A, Falterman J, Nossaman BD. Effective use of bronchial blockers in lung isolation surgery: An analysis of 130 cases. Oschner J 2013;13:389-93.
4. Seo JH, Bae JY, Kim HJ, Hong DM, Jeon Y, Bahk JH. Misplacement of left-sided double lumen tubes into the right mainstem bronchus: Incidence, risk factors and blind repositioning techniques. BMC Anesthesiol 2015;15:157.
5. Taguchi H, Yamada K, Matsumoto H, Kato A, Imanishi T, Shingu K. Airway troubles related to the double lumen endobronchial tube in thoracic surgery. J Anesth 1997;11:173-8.
6. Klein U, Karzai W, Bloos F, Wohlfarth M, Gottschall R, Fritz H, *et al*. Role of fibreoptic bronchoscopy in conjunction with the use of double lumen tubes for thoracic anaesthesia. Anesthesiology 1998;88:346-50.
7. Hu WC, Xu L, Zhang Q, Wei L, Zhang W. Point-of-care ultrasound versus auscultation in determining the position of double lumen tube. Medicine (Baltimore) 2018;97:e9311. doi: 10.1097/MD.0000000000009311.
8. Bussières JS, Somma J, Del Castillo JL, Lemieux J, Conti M, Ugalde PA, *et al*. Bronchial blocker versus left double lumen endotracheal tube in video-assisted thoracoscopic surgery: A randomized controlled trial examining time and quality of lung deflation. Can J Anaesth 2016;63:818-27.
9. Lu Y, Dai W, Zong Z, Xiao Y, Wu D, Liu X, *et al*. Bronchial blocker versus left double lumen endotracheal tube for one lung ventilation in right video-assisted thoracoscopic surgery. J Cardiothorac Vasc Anesth 2018;32:297-301.
10. Saracoglu A, Saracoglu KT. VivaSight: A new era in the evolution of tracheal tubes. J Clin Anesth 2016;33:442-9.
11. Dean D, Dragnea D, Anwar S, Ong C. The VDLT double lumen tube with integrated camera. Eur J Anaesthesiol 2016;33:305-8.
12. Massot J, Dumand-Nizard V, Fischler M, Le Guen M. Evaluation of the double lumen tube VDLT (DLT-ETView): A prospective single-center study. J Cardiothorac Vasc Anesth 2015;29:1544-9.
13. Heir JS, Purugganan R, Jackson TA, Norman PH, Cata JP, Kosturakis A, *et al*. A retrospective evaluation of the use of video-capable double lumen endotracheal tubes in thoracic surgery. J Cardiothorac Vasc Anesth 2014;28:870-2.
14. Heir JS, Guo SL, Purugganan R, Jackson TA, Sekhon AK, Mirza K, *et al*. A randomized controlled study of the use of video double lumen endobronchial tubes versus double lumen endobronchial tubes in thoracic surgery. J Cardiothorac Vasc Anesth 2018;32:267-74.
15. Rapchuk IL, Kunju S, Smith IJ, Faulke DJ. A six-month evaluation of the VivaSight™ video double lumen endotracheal tube after introduction into thoracic anaesthetic practice at a single institution. Anaesth Intensive Care 2017;45:189-95.
16. Levy-Faber D, Malyanker Y, Nir RR, Best LA, Barak M. Comparison of VivaSight double lumen tube with a conventional double lumen tube in adult patients undergoing video-assisted thoracoscopic surgery. Anaesthesia 2015;70:1259-63.
17. Schuepbach R, Grande B, Camen G, Schmidt AR, Fischer H, Sessler DI, *et al*. Intubation with VivaSight or conventional left-sided double lumen tubes: A randomized trial. Can J Anaesth 2015;62:762-9.
18. Langiano N, Fiorelli S, Deana C, Baroselli A, Bignami EG, Matellon C, *et al*. Airway management in anesthesia for thoracic surgery: A "real life" observational study. J Thorac Dis 2019;11:3257-69.
19. Brodsky JB. Fiberoptic bronchoscopy need not be a routine part of double lumen tube placement. Curr Opin Anaesthesiol 2004;17:7-11.
20. Pennefather SH, Russell GN. Placement of double lumen tubes--time to shed light on an old problem. Br J Anaesth 2000;84:308-10.
21. Truszewski Z, Szarpak L, Czyzewski L, Ervin T, Kurowski A, Majer J, *et al*. A comparison of the ETView VivaSight SL against a fiberoptic bronchoscope for nasotracheal intubation of multitrauma patients during resuscitation. A randomized, crossover, manikin study. Am J Emerg Med 2015;33:1097-9.
22. Szarpak L, Kurowski A, Zaśko P, Karczewska K, Czyzewski L, Bogdanski L, *et al*. Double lumen tube tracheal intubation in a manikin model using the VivaSight Double Lumen: A randomized controlled comparison with the Macintosh laryngoscope. Am J Emerg Med 2016;34:103-4.
23. Brodsky JB, Lemmens HJ. Tracheal width and left double lumen tube size: A formula to estimate left-bronchial width. J Clin Anesth 2005;17:267-70.
24. Kaufmann K, Heinrich S. Minimizing postoperative pulmonary complications in thoracic surgery patients. Curr Opin Anaesthesiol 2021;34:13-9.
25. Larsen S, Holm JH, Sauer TN, Andersen C. A cost-effectiveness analysis comparing the VivaSight double lumen tube and a conventional double lumen tube in adult patients undergoing thoracic surgery involving one lung ventilation. Pharmacoecon Open 2020;4:159-69.