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One-lung ventilation in obese patients undergoing thoracoscopic lobectomy for lung cancer

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Abstract

Background: We evaluated the safety and feasibility of one-lung ventilation in obese patients undergoing thoracoscopic lobectomy and whether obesity affected peri- and postoperative outcomes.

Methods: This was a retrospective single center study including consecutive patients undergoing thoracoscopic lobectomy between October 2019 and February 2022. Obese patients were statistically compared to a control group to evaluate any differences in relation to one-lung ventilation and peri- and postoperative outcomes.

Results: Our study population included 111 patients; of these, 26 (23%) were included in the obese group, while 85 (77%) were included within the nonobese group. To obtain one-lung ventilation in nonobese patients, a double-lumen tube was more frequently used than a single-lumen tube with bronchial blocker (61% vs. 39%; $p = 0.02$), while in obese patients a single-lumen tube with bronchial blocker was used more than a double-lumen tube (81% vs. 19%, $p = 0.001$). Intergroup comparison showed that a double-lumen tube was the preferred method in nonobese patients, while a single-lumen tube with bronchial blockers was the strategy of choice in obese patients ($p = 0.0002$). Intubation time was longer in the obese group than in the nonobese group (94.0 ± 6.1 vs. 85.0 ± 7.0 s; $p = 0.0004$) and failure rate of first attempt at intubation was higher in the obese group (23% vs. 5%; $p = 0.01$). Obesity was not associated with increased intra-, peri- and postoperative complications and/or mortality.

Conclusions: One-lung ventilation is a feasible and safe procedure also in obese patients and obesity did not negatively affect peri- and postoperative outcomes after lung resection.

KEYWORDS
lobectomy, lung cancer, obese, one-lung ventilation, thoracoscopy

INTRODUCTION

Obesity prevalence is growing worldwide with great concern for the public health, being a risk factor for multiple diseases. Obesity-related cardiovascular and pulmonary diseases can influence and complicate anesthesiological management during surgery. Lung cancer remains one of the most common and deadly cancers in the world and lobectomy remains the

only treatment with curative intent. Video-assisted thoracoscopic surgery (VATS) is the preferred method to perform lobectomy due to the incidence of less postoperative morbidity and mortality compared to open lobectomy.

To efficiently perform a thoracoscopic lobectomy, it is mandatory that the affected lung is completely collapsed while the contralateral lung is ventilated. One-lung ventilation (OLV) can be obtained with the use of double lumen tubes (DLTs), including Carlens or Robertshaw tube, or a single-lumen tube (SLT) with bronchial blockers (BBs), such as the EZ blocker, Arndt blocker and Univent tube. Generally, DLTs are the preferred method for obtaining OLV during thoracic procedures,[1] but their use may be challenging in obese patients due to increased neck circumference, limited neck extension, anteriorization of the glottis, excess of fatty tissue in the velopalate, retropharynx and submandibular regions.[2] Furthermore, obesity may be associated with altered respiratory physiology, reduced lung volumes, low expiratory reserve, and increased airway resistance[3,4] that can affect anesthesiological management and surgical outcomes after lung resection.[5,6]

The aims of this study were to evaluate the safety and feasibility of OLV in obese patients undergoing VATS lobectomy and to determine whether obesity affected peri- and postoperative.

outcomes.

METHODS

Study design

This was a retrospective monocentric study including the data of all consecutive patients undergoing VATS lobectomy for management of lung cancer performed from October 2019 to February 2022. The clinical data of (i) patients undergoing lobectomy via VATS; and (ii) of patients with complete pre-, peri- and postoperative data were included in the analysis. We excluded the data of: (i) patients undergoing lung resection different from lobectomy (i.e., wedge resection), (ii) patients undergoing lobectomy via upfront thoracotomy and those undergoing conversion to thoracotomy during VATS, and (iii) patients with incomplete pre- and postoperative data. Obese patients were compared to a control group to determine (i) the strategy used for obtaining OLV and the safety of the procedure, and (ii) whether obesity negatively affected peri- and postoperative outcomes.

As the study was performed at academic teaching hospitals, all patients signed an informed consent for the anonymous use of their data for clinical investigations and scientific publications. The local research ethics committee approved the study design. Due to the retrospective nature of the study, no specific approval code was required because there was no modification in the standard patient care.

Study population

At the time of surgery, all patients were measured for bodyweight (kg) and height (meter). The BMI was obtained from Quetelet's index (weight in kg divided by the square of height in meters [kg/m^2]). According to the classification of World Health Organization (WHO), patients with BMI <18.5 were defined as underweight, patients with BMI from ≥18.5 to <25 as normal weight, patients with BMI from ≥25 to <30 as overweight, and those with BMI from ≥30 as obese.[12] Obese patients were then divided into three subcategories: obesity class I (BMI ≥30 to <35), obesity class II (BMI ≥35 to <40), and obesity class III (BMI ≥40).[7]

In all cases, the tumor was staged with whole body positron emission tomography/computed tomograpy (PET/CT) scan. Preoperative histological diagnosis was obtained in the majority of patients with CT-guided lung biopsy, or alternatively with transbronchial needle aspiration biopsy or bronchoalveolar lavage during fiberoptic bronchoscopy. When preoperative diagnosis was not possible or in case of undetermined results, the diagnosis was made through intraoperative pathological examination. Standard cardiopulmonary evaluation was performed in all cases including spirometry, diffusing capacity of the lung for carbon monoxide (DLCO), ventilation/perfusion scintigraphy, 6-min walking test (6MWT), echocardiograph and cardiopulmonary exercise testing, if needed.

An expert anesthesiologist evaluated the patient before surgery to determine their fitness for surgery, predict the operative risk and assess the airways. The strategy for obtaining OLV (DLT or SLT with BB) was decided on the assessment of the patient's airway, and in all cases the intubation and the prompt tube position was guided by fiberoptic bronchoscopy. In all cases, intubation and OLV was performed by one of the anesthesiologists assigned to the thoracic surgery unit, with at least 5 years of experience in the thoracic anesthesiology field.

All patients underwent standard lobectomy with systematic ilo-mediastinal lymphadenectomy using a standardized anterior thoracoscopic triportal approach. At the end of the procedure a single 28 Fr drainage tube was placed in the pleural cavity through the camera incision and attached to an underwater seal chest drain system. The chest drainage was removed when re-expansion of the lung was achieved in absence of air leaks and when the amount of fluid drained was less than 200–250 ml in 24 h.

Data collection

For each patient, the following data were collected:

Preoperative data: demographic data (age, gender, BMI), comorbidities, symptoms, smoking status, laboratory data, pulmonary function status including spirometry, DLCO,

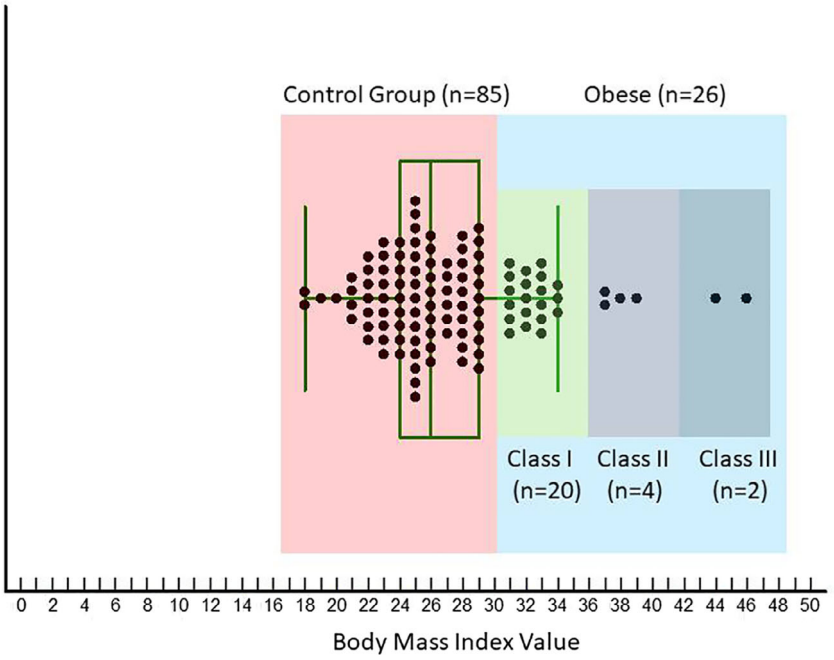

FIGURE 1 Body mass index distribution of the study population

6MWT, and tumor characteristics (tumor side, histology, and clinical stage).

Anesthesiological data: Mallampati score, interincisor gap, thyromental distance, ASA score (ASA physical status classification system), type of endotracheal tube used, the time needed for intubation, the failure rate of first attempt at intubation of intubation, the number of repositioning attempts, cardiorespiratory data. Intubation time was recorded from the moment the tube passed the vocal cords until the anesthetist confirmed with bronchoscopy that the placement was correct. Intraoperative oxygenation was measured during the procedure through arterial blood gas tests performed immediately after intubation during two lung ventilation (T0) and after 30 min of OLV (T1). The quality of lung collapse was measured by the surgeon through a verbal scale, describing the overall satisfaction with the lung collapse throughout the surgery, ranging from 0 (no lung collapse) to 10 (complete lung collapse) as previously reported.[8]

Peri- and postoperative data: Operative time (min), blood loss (ml), transfusion rate, chest tube drainage output (ml), length of chest drainage (days), length of hospital stay (LHOS) (days), morbidity and mortality.

Statistical analysis

Values are reported as mean ± standard deviation (SD) for continuous variables or as number and percentages for categorical variables. Student's *t*-test and Chi-square test were used to evaluate intergroup difference, as appropriate. MedCalc statistical software (version 12.3) was used. A p-value < 0.05 was considered statistically significant.

RESULTS

In the study period 138 patients underwent lung resection for cancer. Of these, 27 patients were excluded from the analysis due to resections different from lobectomy ($n = 20$); conversion to thoracotomy ($n = 5$); and missing data ($n = 2$). Thus, our study population included a total of 111 patients; of these, 26 (23%) were included in the obese group (BMI ≥30) while 85 (77%) were included in the non-obese group (BMI < 30). No patient was severely underweight, one patient (1%) was underweight, 34 patients (30%) were normal weight, 50 patients (45%) were overweight, 20 patients (18%) were class I obese, four patients (4%) were class II obese and two patients (2%) were class III obese. The BMI distribution is summarized in Figure 1. As summarized in Table 1, no significant differences were found between the two study groups regarding preoperative data and tumor characteristics, but the rate of obstructive sleep apnea syndrome (OSAS) and atypical carcinoids was significantly higher in the obese compared to the nonobese group (23% vs. 1%; $p = 0.0001$, and 11% vs. 4%, $p = 0.04$, respectively).

One-lung ventilation

The data are summarized in Tables 2 and 3. Mallampati score, interincisor gap and ASA score was similar between the two study groups, while thyromental distance was significantly shorter in the obese compared to the nonobese group, with 19% of the patients having a thyromental distance <6 cm versus 5% of the patients in the nonobese group ($p = 0.02$).

TABLE 1 Characteristics of study population

Variables	Total ($n = 111$)	Obese ($n = 26$)	Non-obese ($n = 85$)	p-value
Age (years)	66.3 ± 7.7	64.5 ± 7.4	66.8 ± 7.8	0.17
Gender (male)	68 (61%)	12 (46%)	56 (65%)	0.07
Smokers	87 (78%)	17 (65%)	70 (82%)	0.06
BMI, kg/m^2	27.0 ± 4.3	32.8 ± 3.1	25.2 ± 2.7	0.0001
Comorbidities				
• Diabetes	16 (14%)	5 (19%)	11 (12%)	0.42
• COPD	33 (30%)	6 (23%)	27 (31%)	0.39
• Cardiac	23 (21%)	4 (15%)	19 (22%)	0.44
• OSAS	7 (%)	6 (23%)	1 (1%)	0.0001
Laboratory data				
• White blood cells (/ul)	6739 ± 3090	6888 ± 3223	6693 ± 3067	0.78
• Hemoglobin (g/dl)	13.7 ± 1.5	13.7 ± 1.2	13.7 ± 1.6	0.92
• Albumin (g/dl)	4.2 ± 0.4	4.0 ± 0.3	4.1 ± 0.4	0.94
• Total protein (g/dl)	6.9 ± 0.6	7.0± 0.5	6.9 ± 0.6	0.38
Symptoms				
• Cough	42 (38%)	9 (35%)	33 (39%)	0.69
• Thoracic pain	11 (10%)	1 (4%)	10 (12%)	0.24
• Dyspnea	29 (26%)	10 (38%)	19 (22%)	0.10
• Weight loss	8 (7%)	3 (11%)	5 (6%)	0.33
Pulmonary function				
• FEV1 %	94 ± 20	96 ± 17	93 ± 20	0.41
• DLCO %	90 ± 18	94 ± 20	88 ± 18	0.22
• ppoFEV1 %	74 ± 16	76 ± 17	73 ± 16	0.35
• ppoDLCO %	71 ± 17	71 ± 20	71 ± 15	0.88
• 6MWT, meters	479 ± 165	475 ± 209	480 ± 148	0.91
Pathological stage				
• IA	47 (42%)	11 (42%)	36 (42%)	0.99
• IB	21 (18%)	4 (11%)	17 (20%)	0.96
• IIA	6 (5%)	2 (8%)	4 (5%)	0.55
• IIB	15 (13%)	1 (4%)	14 (16%)	0.09
• IIIA	11 (10%)	5 (19%)	6 (7%)	0.06
Histology				
• Adenocarcinoma	65 (56%)	14 (54%)	51 (60%)	0.57
• Squamous cell carcinoma	29 (26%)	4 (15%)	25 (30%)	0.15
• Typical carcinoid	2 (2%)	1 (4%)	1 (1%)	0.37
• Atypical carcinoid	5 (4%)	3 (11.5%)	2 (2%)	0.04
• LCNEC	3 (3%)	1 (4%)	2 (2%)	0.68
• Others	7 (8%)	3 (11.5%)	4 (5%)	0.32

Abbreviations: 6MWT, six minutes walking test; BMI, body mass index; COPD, chronic obstructive pulmonary disease; DLCO, diffusing capacity of the; lung for carbon monoxide; FEV1, forced expiratory volume in 1 second; LCNEC, large cell neuroendocrine carcinoma; OSAS, obstructive sleep; apnea syndrome; ppoDLCO, predicted postoperative DLCO; ppoFEV1, predicted postoperative predictive FEV1.

Nonobese group: In 52 (61%) patients, a Carlens ($n = 50$; 59%) and Robertshaw ($n = 2$; 2%) DLT was used for OLV, while in 33 (39%) patients a SLT was used as EZ blocker ($n = 18$; 21%) and Univent ($n = 15$; 18%). The Carlens tube sizes were 35 Fr ($n = 15$), 37 Fr ($n = 33$), 39 Fr ($n = 2$); the Robertshaw tube sizes were: 37 Fr ($n = 1$) and 39 fr ($n = 1$); the SLT for the EZ blocker were 6.5 mm inner diameter (ID) ($n = 1$), 7 mm ID ($n = 3$), 7.5 mm ID ($n = 7$), 8 mm ID ($n = 3$), 8.5 mm ID ($n = 1$); the Univent tube sizes were 6.5 mm ID ($n = 1$), 7 mm ID ($n = 3$), 7.5 mm ID ($n = 8$), 8 mm ID ($n = 5$), 8.5 mm ID ($n = 1$). The DLT compared to a SLT with BB was more frequently used (61% vs. 39%; $p = 0.02$). The mean intubation time was 85.0 ± 7.0 s. The failure rate of first attempt at

TABLE 2 Surgical characteristics and anesthesiological evaluation parameters

Variables	Total ($n = 111$)	Obese ($n = 26$)	Non-obese ($n = 85$)	p-value
Mallampati score:				
• I	22 (20%)	2 (8%)	20 (24%)	0.07
• II	69 (62%)	18 (69%)	51 (60%)	0.39
• III	16 (14%)	4 (15%)	12 (14%)	0.87
• IV	4 (4%)	2 (8%)	2 (2%)	0.20
Interincisor gap:				
• <3 cm	3 (3%)	2 (8%)	1 (1%)	0.07
• 3 cm	5 (4%)	2 (8%)	3 (4%)	0.37
• >3 cm	103 (93%)	22 (84%)	81 (95%)	0.06
Thyromental distance:				
• <6 cm	9 (8%)	5 (19%)	4 (5%)	0.02
• 6 cm	7 (6%)	2 (8%)	5 (6%)	0.74
• >6 cm	95 (86%)	19 (73%)	76 (89%)	0.04
ASA score:				
• I	/	/	/	/
• II	33 (30%)	7 (27%)	26 (30%)	0.72
• III	73 (66%)	18 (69%)	55 (65%)	0.67
• IV	5 (4%)	1 (4%)	4 (5%)	0.85
Type of endotracheal tube used:				
DLT				
• Carlens (left-sided)	54 (48%)	4 (15%)	50 (59%)	<0.0001
• Robertshaw (left-sided)	3 (3%)	1 (4%)	2 (2%)	0.68
SLT with BB				
☐ Univent	23 (21%)	5 (19%)	18 (21%)	0.83
☐ EZ blocker	31 (28%)	16 (62%)	15 (18%)	<0.0001
Lung collapse score (mean ± SD):	7.6 ± 1.1	7.2 ± 1.1	7.6 ± 1.0	0.06

intubation was 5%, with five patients that needed repositioning to achieve correct placement of the tube (4 patients required one attempt at repositioning, 1 patient required 2 attempts).

Obese group: In 21 (81%) patients, a SLT was used including EZ blocker ($n = 16$; 62%) and Univent ($n = 5$; 19%), while in five (19%) cases a DLT was used as Carlens ($n = 5$; 15%) and Robertshaw ($n = 1$; 4%). The Carlens tube sizes were 35 Fr ($n = 2$), 37 Fr ($n = 2$); Robertshaw size was 37 ($n = 1$); the SLT tube sizes for the EZ blocker were 6.5 mm ID ($n = 2$), 7 mm ID ($n = 4$), 7.5 mm ID ($n = 8$), and 8 mm ID ($n = 2$); the Univent tube sizes were 6.5 mm ID ($n = 1$), 7 mm ID ($n = 2$), and 7.5 mm ID ($n = 2$). A SLT with BB was used more than a DLT (81% vs. 19%, $p = 0.001$). The mean intubation time was 94.0 ± 6.1 s; the failure rate of first attempt at intubation was 23%, with six patients that needed repositioning (4 patients required one attempt at repositioning, 2 patients required 2 attempts).

Obese versus nonobese comparison: The failure rate of first attempt at intubation was higher in the obese compared to the nonobese group (23% vs. 5%; $p = 0.01$). There were no cases of operations not performed due to failure to obtain OLV in either group. The intubation time was longer in the obese than in the nonobese group (94.0 ± 6.1 vs. 85.0 ± 7.0 s; $p = 0.0004$). A DLT was used more in nonobese compared to obese patients (61% vs. 19%; $p = 0.0002$), while a SLT with BB was used more in obese compared to nonobese patients (81% vs. 39%; $p = 0.0002$). No significant difference was found regarding the lung exclusion score (7.2 ± 1.1 vs. 7.6 ± 1.0; $p = 0.06$), neither in the oxygenation parameters measured during the operation, as summarized in Table 3.

Peri- and postoperative outcomes

The data are summarized in Table 4. No significant differences between both groups were found regarding operative times ($p = 0.92$), blood loss ($p = 0.21$), conversion ($n = 0.12$), and transfusion rate ($p = 0.06$). The chest drainage output ($p = 0.39$), length of chest drainage ($p = 0.71$), and LHOS ($p = 0.67$) were also similar. No significant difference was found regarding postoperative morbidity. The obese compared to the nonobese group had a higher incidence of hypoxemia (35% vs. 20%, $p = 0.12$) while the nonobese compared to the obese group had a higher incidence

TABLE 3 Anesthesiological data

Variables	Total ($n = 111$)	Obese ($n = 26$)		Non-obese ($n = 85$)		p-value
		Right-sided surgery (15)	Left-sided surgery (11)	Right sided surgery (49)	Left sided surgery (36)	
Intubation time (s)	90.0 ± 6.2	95.0 ± 7.0	93.0 ± 7.2	87.0 ± 8.1	83.0 ± 6.4	0.0004
		94.0 ± 6.1		85.0 ± 7.0		
Failure of first attempt at intubation	11 (10%)	4 (14%)	2 (7%)	3 (3 %)	2 (2%)	0.01
		6 (23%)		5 (5%)		
Repositioning attempts:						
• 1	8 (7%)	3 (11%)	1 (3%)	2 (2%)	2 (2%)	0.62
• 2	3 (3%)	1 (3%)	1 (3%)	1 (1%)	0	
PaO2 (mmHg)						
• T0	233 ± 76	225 ± 60		241 ± 68		0.29
• T1	132 ± 61	129 ± 43		138 ± 50		0.13
PaCO2 (mmHg)						
• T0	41 ± 1.3	40.4 ± 1.6		42.1 ± 1.0		0.13
• T1	43 ± 1.0	44.3 ± 0.9		43.0 ± 0.8		0.10
SpO2, %						
• T0	99.5 ± 0.5	99.3 ± 0.5		99.6 ± 0.4		0.13
• T1	99.1 ± 1.5	99.1 ± 1.3		99.2 ± 1.4		0.14

Abbreviations: PaO2, partial pressure of oxygen; PaCO2, partial pressure of carbon dioxide; SpO2, oxygen saturation; T0, immediately after intubation during two lung ventilation; T1, after 30 min of one-lung ventilation.

TABLE 4 Peri- and postoperative outcomes

Variables	Total ($n = 111$)	Obese ($n = 26$)	Non-obese ($n = 85$)	p-value
Operative time (min)	297 ± 76	296 ± 69	297 ± 78	0.92
Blood loss (ml)	283 ± 65	277 ± 60	290 ± 56	0.21
Conversion	14 (13%)	1 (4%)	13 (15%)	0.12
Transfusion	17 (15%)	1 (4%)	16 (19%)	0.06
Chest drainage (ml)	132 ± 68	143 ± 91	129 ± 61	0.39
Chest tube duration (days)	6.3 ± 4.6	6.0 ± 4.1	6.4 ± 4.7	0.71
LHOS (days)	7.5 ± 4.2	7.2 ± 4.1	7.6 ± 4.2	0.67
Respiratory complications				
• Reintubation/prolonged intubation	5 (5%)	1 (4%)	4 (5%)	0.85
• Postoperative hypoxemia	26 (23%)	9 (35%)	17 (20%)	0.12
• Airway injury	0	0	0	-
• Empyema	1 (1%)	1 (4%)	0	0.07
• Atelectasis	16 (14%)	3 (12%)	13 (15%)	0.63
• Respiratory failure	2 (2%)	1 (4%)	1 (1%)	0.37
• Pneumonia	9 (8%)	3 (11%)	6 (7%)	0.46
• Bronchopleural fistula	0	0	0	-
• Prolonged air leaks	21 (19%)	2 (8%)	19 (22%)	0.09
Cardiac complications, n (%):				
• Arrhythmias	5 (5%)	2 (8%)	3 (4%)	0.37
• Myocardial infarction	2 (2%)	0	2	0.43
☐ ICU stay >12 h	15 (13%)	3 (11%)	12 (14%)	0.73
☐ 30–day mortality, n (%)	3 (3%)	1 (4%)	2 (2%)	0.68

Abbreviations: ICU, intensive care unit; LHOS, length of hospital stay.

of prolonged air leaks (22% vs. 8%; $p = 0.09$), but the differences were not statistically significant. Postoperative hypoxemia was generally moderate and in the first two postoperative days. It was managed with Venturi mask oxygen therapy or high-flow nasal cannula when needed in both groups.

DISCUSSION

General anesthesia in obese patients is challenging. Excessive oropharyngeal adiposity, limited neck extension, increase in neck circumference, and large base of the tongue are predictors of difficult intubation. Furthermore, the OSAS, decreased chest wall compliance, increased airway resistance, decreased lung capacities and increased breathing effort may increase the risk of complications during and after surgery.[9–11] These factors become particularly relevant in obese patients scheduled for lung resection. Despite this, there is a paucity of data in the literature regarding the effects of obesity on surgical outcomes after lung resection, and to date no study has evaluated the relationship between OLV and obesity in patients undergoing VATS resection. In a prospective randomized study, Campos et al.[12] found that DLT and SLT were feasible strategies to obtain OLV in obese patients undergoing elective thoracic or esophageal surgery via thoracoscopy or thoracotomy.

However, there has not been a comparative study for evaluation of the results of OLV and the surgical outcomes in relation to the obesity. To overcome these limits, in this study we compared obese patients with a control group undergoing the same operation as lobectomy. Furthermore, the data of patients undergoing upfront thoracotomy lobectomy or converted VATS lobectomy as an open approach was excluded from the analysis as this could affect the outcome compared to VATS.

First, we found that a DLT was the preferred strategy in nonobese patients, while the SLT with BB was the most used device in obese patients to obtain SLV. Generally, a DLT is considered the gold standard for lung exclusion as it allows rapid and effective lung isolation and permits easy deflation and reinflation of both lungs at any moment during surgery. Furthermore, DLTs are also less likely to become displaced than bronchial blockers.[13–15] On the other hand, DLTs are more challenging to place in patients with a difficult airway compared to SLT. This easily explained the more frequent use of SLT rather than DLT in our obese patients who presented with difficult airways due to neck and airway anatomy as demonstrated by higher rate of failure attempt and longer intubation time compared to the control group. Despite the disadvantages of BBs which included higher risk of malpositioning or displacement during the surgery due to the smaller lumen size,[16] no significant differences were found between DLT and SLT, and in all cases a satisfactory OLV was obtained. Anesthetists during the entire procedure checked the prompt position of the BB with fiber bronchoscopy and it probably explained these results.

Second, obesity was not associated with higher rates of intra- and postoperative morbidity and mortality compared to the nonobese groups. These results are in line with the paradoxical protective effect of obesity after lung resection, as several studies observed slightly better outcomes, reduced rate of perioperative complications, morbidity and mortality.[17,18] An additional explanation of our results could be the selection of obese patients scheduled for surgery. The risk of postoperative complications appeared to increase at both the extremes of BMI values, with increased risk for patients underweight or severely overweight (obesity class III).[19] However, in our study population, no significant differences were found regarding preoperative comorbidities in obese patients compared to the control group.

Third, our results highlighted that OLV was a feasible and safe procedure in obese patients and obesity did not negatively affect postoperative outcomes of lung resection. However, it was important to perform an accurate preoperative evaluation of patients. The choice of strategy to obtain OLV (DLT or SLT with BB) should not only depend on the BMI of patients but other factors such as neck and airway anatomy must be considered. The BMI >30 did not correspond automatically to a difficult airway while other recognized factors that could predict a difficult intubation were Mallampati class of III or greater, OSAS, neck circumference and neck impaired mobility.[20] Thus, in obese patients with an oropharyngeal distribution of fat that reduces the airway caliber, a difficult airway should be expected. In these cases, a SLT with BB could be the first choice for obtaining OLV as it is easier to place compared to larger DLTs. In order to choose the most appropriate lung exclusion strategy and to prevent unsuccessful intubation, we encourage careful evaluation of the anatomy of the patient's airway to search for recognized factors predictive of difficult intubation, the assessment of airway diameters via CT scan of the neck and thorax and a preoperative bronchoscopy to be performed, when needed.

Our study had several limitations and no definitive conclusions could be drawn. The main limitations were its retrospective nature and the small sample size. There was no standardized protocol for intubation and in most patients a SLT with BB was used after a failed attempt to obtain OLV with DLT, while in other cases it was used as the first choice. Furthermore, obese patients undergoing lung resection were highly selected which could affect the surgical results.

In conclusion, our study showed that OLV was safely performed in obese patients, and obesity did not increase the risk of postoperative morbidity and mortality. The preoperative evaluation of patients remains crucial in order to choose the best strategy for obtaining OLV. Due to the retrospective nature of the study and the small sample size, our results should be corroborated by prospective and larger studies in the future.

AUTHOR CONTRIBUTION

Conceptualization: A.F., and B.L. Data curation: S.F. *Methodology*: G.N. and G.M; *Investigation*: A.M., G.O., M.P.,

Formal analysis: M.G, and M.M. Resources: L.F, R.F, F.M, snf G.L. *Writing – original draft*: B.L., and A.F., *Writing – review and editing*: A.F. F.F. C.P. and A. M. *Visualization*: F. R., L.F., M. F. *Supervision*: A.F. and G.V. *Funding acquisition*: S.F.

CONFLICT OF INTEREST

The authors disclose no conflict of interest and no funding for this study.

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