Robotic vs. Thoracoscopic Anatomic Lung Resection in Obese Patients: A Propensity Adjusted Analysis

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Running Head: Robotic lung resection in obese

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Word Count: 4498

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Abstract

Background: Minimally-invasive lung resections can be particularly challenging in obese patients. We hypothesized robotic surgery (RTS) is associated with less conversion to thoracotomy than thoracoscopic surgery (VATS) in obese populations.

Methods: The STS GTSD, Epithor French National Database, and McMaster University Database were queried for obese (BMI≥30 kg/m^2) patients who underwent VATS or RTS lobectomy or segmentectomy for clinical T1-2, N0-1 NSCLC between 2015-2019. Propensity score adjusted logistic regression analysis was used to compare the rate of conversion to thoracotomy between the VATS and RTS cohorts.

Results: Overall, 8,108 patients (STS GTSD: n=7,473; Epithor: n=572; McMaster: n=63) met inclusion criteria with a mean age of 66.6 years (SD 9 years) and BMI of 34.7 kg/m^2 (SD 4.5 kg/m^2). After propensity score adjusted multivariable analysis, patients who underwent VATS were over 5 times more likely to experience conversion to thoracotomy than those who underwent RTS (OR=5.33; 95% CI 4.14, 6.81, p<0.001). There was a linear association between degree of obesity and odds ratio of VATS conversion to thoracotomy compared to RTS. The VATS cohort had a longer mean length of stay (5.0 vs. 4.3 days, p<0.001), higher rate of respiratory failure (2.8% [168/5975] vs. 1.8% [39/2133], p=0.026), and were less likely to be discharged to their home (92.5% [5,525/5,975] vs. 94.3% [2,012/2,133]; p=0.013) compared to RTS patients.

Conclusions: In obese patients, RTS anatomic lung resection is associated with a lower rate of conversion to thoracotomy than VATS.

Abstract Word Count: 236

Obesity is one of the greatest epidemics of the 21st century. In 2017, the prevalence of adult obesity in the United States was 42.4%, up from 22.9% in 1988.[1,2] With this, the percentage of obese patients presenting for lung resection is rising and thoracic surgeons are increasingly faced with the challenge of caring for these patients.[3]

Intraoperatively, obesity poses unique technical challenges during minimally invasive lung resection due to chest wall mechanics, poor visualization, reduced range of motion, and limited depth of reach. Obesity has been associated with increased lobectomy operative times and a higher rate of conversion to thoracotomy.[4] Because conversion to thoracotomy results in longer hospital length of stay, increased respiratory complications, and higher mortality[5,6], identifying the operative approach that leads to the lowest rate of conversion in obese populations is important.

Minimally-invasive lung resections, including video-assisted thoracoscopy (VATS) and robot-assisted (RTS) approaches, have been associated with improved 30-day survival and fewer postoperative complications compared to open approaches.[7-9] However, it remains debated if RTS or VATS is superior for anatomic lung resection. Multiple meta-analyses comparing VATS to RTS anatomic lung resection have demonstrated a lower rate of conversion to thoracotomy with RTS but minimal difference in short-term morbidity or mortality. [7,10-12] However, to date, there remains a paucity of data comparing RTS to VATS anatomic lung resection in obese patients.

Given the increased comorbidities and unique intraoperative challenges associated with obesity, we sought to establish if VATS or RTS anatomic lung resection is the preferable approach in obese patients. We hypothesized that RTS anatomic lung resection is associated with a lower rate of conversion to thoracotomy than VATS lung resection in obese patients with early-stage lung cancer.

Patients and Methods

Study population and Data Source

The Society of Thoracic Surgeons General Thoracic Surgery Database (STS GTSD), Epithor French National database, and McMaster University Thoracic Surgical Database (Canada) each include demographic, operative, perioperative, and short-term outcome data for thoracic surgery patients. Records from patients with a body-mass index (BMI) ≥ 30 kg/m^2 who underwent elective VATS or RTS lobectomy or segmentectomy for clinical T1-2, N0-1, M0 NSCLC between 2015 and 2019 were identified. Exclusion criteria included age <18 years old, induction therapy, emergent or palliative operations, planned open resection, sleeve lobectomy, chest wall or diaphragm resection, or bilateral procedures.

Variables and Definitions

Demographic variables, disease characteristics, treatment strategies, and outcome measures were defined by STS GTSD, Epithor, and McMaster database guidelines.[13] In cases where definitions or data fields differed between databases, harmonization was achieved or the data field was excluded from analysis. In the case of comorbidities, complications, readmission, and mortality, failure to code the presence of a variable was considered a negative response, as previously described.[14] Staging was performed in accordance with the American Joint Committee on Cancer 8th Edition staging guidelines. All data were de-identified and stored in password-protected databases.

Demographic variables collected included age, gender, BMI, cigarette smoking status (never vs. ever), chronic renal failure, cardiovascular disease (defined as either congestive heart failure or coronary artery disease in STS GTSD), chronic obstructive pulmonary disease (COPD), Zubrod score (performance status: 1, 2 or 3+), prior cardiothoracic surgery, forced expiratory volume in 1 second percent predicted (FEV1%), diffusion capacity percent predicted (DLCO%), tumor size (≤2 cm vs. 2.1-5 cm) and nodal status (N0 vs. N1). Intraoperative variables collected included operation performed (lobectomy vs. segmentectomy), technique (RTS vs. VATS), unanticipated conversion to thoracotomy, conversion reason (vascular/complication [defined as “vascular” in STS GTSD or “complications” in Epithor and McMaster databases] or anatomy/technical [defined as “anatomic”, “technical”, and “lymph nodes” in STS GTSD or “adhesions,” “disease,” and “other” in Epithor and McMaster databases]), and operative duration. Conversion was defined as initial VATS or RTS approach leading to eventual thoracotomy in the Epithor and Tmac databases. In the STS GTSD, conversion was defined by field "Surgical Approach Conversion," which specifies VATS or RTS conversion to thoracotomy. RTS to VATS conversions were not considered conversions for this analysis.

Postoperative variables that were collected included respiratory complications (air leak > 5 days, pneumonia, bronchopleural fistula, respiratory failure [defined as reintubation or requiring postoperative mechanical ventilation], empyema), cardiovascular complications (atrial or ventricular arrhythmia requiring treatment, myocardial infarction, deep vein thrombosis, pulmonary embolism), and other complications (acute renal failure, sepsis, surgical site infection, chylothorax, unexpected return to the operating room for bleeding). Discharge parameters included postoperative hospital length of hospital stay, discharge to home, in-hospital mortality, and 30-day re-admission rate.

Study Design and Statistical Analyses

Patients meeting inclusion criteria from the STS GTSD, Epithor French National Database, and McMaster University Thoracic database were pooled for analysis. The primary outcome was defined as the rate of conversion to thoracotomy, while secondary outcomes included in-hospital mortality, postoperative complications, operative duration, hospital length of stay, discharge to home, and 30-day readmission rate.

Univariable analyses of baseline characteristics by type of surgery and by conversion to thoracotomy were performed. Categorical variables were reported as counts and percentages and analyzed using Fisher's Exact or Chi-square tests. Continuous data were reported as mean with standard deviation (SD) and analyzed using independent sample t-tests. Stepwise multivariable logistic regression analysis was conducted to assess the factors predicting conversion to thoracotomy. Interaction terms between variables were assessed and reported whenever needed.

To minimize the effect of confounding factors, propensity scores were estimated using multivariable logistic regression analysis. The type of surgery was entered as the dependent variable and baseline characteristics were included as independent variables. The included variables were database, year, gender, age, BMI, smoking status, chronic renal failure, COPD, cardiovascular disease, primary procedure, Zubrod score, FEV1%, DLCO%, tumor size, nodal status, and prior cardiothoracic surgery. The propensity score is the probability of a patient receiving VATS based on his or her baseline characteristics and surgical factors, meaning a patient with the same propensity score who received RTS was equally as likely to have received VATS. The conditional predicted probability from the logistic regression model was saved as the propensity score. The c-statistics were estimated as a measure of accuracy of the propensity score prediction. The histogram of propensity score by type of surgery was plotted. The logistic regression model was then used to estimate the association between type of surgery (VATS or RTS) and conversion to open surgery. Conversion to thoracotomy was included as the dependent variable and type of surgery and propensity score were included as independent variables. The propensity-adjusted post-operative events, operative time, length of stay, and conversion rate by year were also compared between RTS and VATS using logistic regression and linear regression analyses.

Secondary analyses of association between conversion to thoracotomy and operative approach was performed in non-obese patients. For this analysis, only STS data were used with the same inclusion and exclusion criteria. Obesity was defined as BMI of 30-65 kg/m^2 and non-obese was defined as BMI of 15-29.9 kg/m^2. Propensity score analysis and estimated propensity score adjusted rate of conversion to thoracotomy between RTS and VATS was examined. The association was assessed by degree of obesity, defined as non-obese (BMI <30 kg/m^2), class I obesity (BMI = 30-34.9 kg/m^2), class II obesity (BMI = 35-39.9 kg/m^2), and class III obesity (BMI ≥ 40 kg/m^2). *P*-values were adjusted for multiple comparisons of conversion to thoracotomy between RTS and VATS by degree of obesity.

Sensitivity analysis was performed using SPSS multiple imputation command to randomly impute the missing data on certain variables. The pooled propensity score adjusted odds ratio across original data and 10 randomly imputed datasets were estimated using multivariable logistic regression analysis. Odds ratios, 95% confidence interval (CI) and *p*-values are reported. A *p*-value of 0.05 was used for statistical significance. SPSS (Armonk, New York) and STATA (College Station, Texas) statistical software were used for data analyses.

Results

A total of 13,412 obese patients (STS GTSD: n=11,910; Epithor: n=1,430; McMaster: n=72) met inclusion criteria with a mean age of 66.7 years (SD 9.1 years) and BMI of 34.6 kg/m^2 (SD 4.5 kg/m^2). A VATS approach was used in 69.5% (9,346/13,412) and RTS approach in 30.5% (4,066/13,412) of cases. Baseline demographic and intraoperative characteristics differed between the VATS and RTS cohorts for BMI, smoking status, COPD, primary procedure performed (lobectomy or segmentectomy), and DLCO% (**Supplemental Table 1**). The overall rate of conversion to thoracotomy in 13,412 was 11.4% (VATS 15% (1,403/9,346) vs. RTS 3%. (122/4,66); OR=5.7 [95%CI 4.72, 6.89] $p<0.001$).

Of the 13,412 patients identified, 5,304 were excluded due to having incomplete datasets. The baseline characteristics of 8,108 patients with complete datasets were used in the primary analysis and are shown in **Table 1**. BMI, smoking status, and DLCO% significantly differed between patients who underwent RTS and VATS. The proportion of RTS was significantly higher in TMac and STS GTSD than in Epithor. **Table 2** compares the baseline characteristics of 8,108 patients with complete datasets who were converted to thoracotomy to those who were not converted. Patients who were converted were more likely to be male, have a higher BMI, VATS surgery, lobectomy, >2-5 cm tumor, N1 disease, lower FEV1% and DLCO%, and more comorbidities. Patient characteristics associated with conversion to thoracotomy on multivariable logistic regression are reported in **Supplemental Table 2**. VATS approach, male gender, higher BMI, history of cardiothoracic surgery, lobectomy, larger tumor size, node positivity, higher Zubrod score, and lower FEV1% were associated with conversion to thoracotomy.

To minimize the effect of confounding factors on conversion to open surgery, a propensity score was estimated for each patient. The area under the receiver operator curve (ROC) for the predicted propensity score was 0.59 (95% CI 0.58-0.60; **Supplemental Figure 1**). The distribution of propensity score was similar between RTS and VATS (**Supplemental Figure 2**) with mean score of 0.74 (SD 0.06) for VATS and 0.72 (SD 0.06) for RTS. The propensity adjusted odds ratio of conversion to thoracotomy was 5 times greater in obese patients who received VATS than those who received RTS (OR=5.33; 95% CI 4.14, 6.81, p<0.001). **Supplemental Table 3** demonstrates the reason for thoracotomy in patients that underwent conversion.

Supplemental Table 4 shows the propensity score adjusted analysis of conversion to thoracotomy by year. The odds ratio of VATS conversion to thoracotomy compared to RTS, increased from 2015 to 2016-2017 (OR=1.32 [95% CI 1.06-1.62], p=0.010) and to 2018-2019 (OR=1.55 [95% CI 1.16-2.06], p=0.003).

Comparing propensity score adjusted postoperative outcomes of the 8,108 obese patients with complete datasets, VATS patients had a longer mean length of stay (5.0 vs. 4.3 days, p<0.001), higher rate of respiratory failure (2.8% [168/5975] vs. 1.8% [39/2133], p=0.026), and were less likely to be discharged to their home (92.5% [5,525/5,975] vs. 94.3% [2,012/2,133]; p=0.013) compared to RTS patients (**Table 3**). **Supplemental Table 5** demonstrates postoperative outcomes in patients that were converted to thoracotomy compared to those not converted.

As a sensitivity analysis, multiple imputation method was applied to impute missing data for the original 13,412 patients. The pooled propensity score adjusted odds ratio of conversion to thoracotomy for VATS compared to RTS was 5.64 (95% CI: 4.67, 6.82, p<0.001), consistent with findings of the propensity score adjusted analysis on 8,108 patients with complete datasets.

In a secondary analysis of the STS GTSD, 12,197 non-obese patients with complete dataset were compared to the 7,473 obese patients with complete datasets. The baseline characteristics between the RTS and VATS cohorts are presented in **Supplementary Table 6.** Patients who underwent RTS were more likely to be never smokers, have COPD, cardiovascular disease, prior cardiothoracic surgery, undergo segmentectomy, and have a higher DLCO%. To minimize the effect of group differences on conversion to thoracotomy, a propensity score was estimated for each patient. The propensity score adjusted risk of conversion to thoracotomy was 2.5 times higher in obese patients than in non-obese patients (OR 2.5 [95% CI 2.10-2.66], p<0.001). There was a linear association between BMI and rate of conversion to thoracotomy. The propensity score adjusted odds of conversion to thoracotomy in VATS compared to RTS, increased for Class I (OR=2.37 [95% CI 2.10-2.66], p< 0.001), Class 2 (OR=2.37 [95% CI 2.00-2.80], p<0.001) and Class 3 (OR=3.33 [95% CI 2.71-4.10], p<0.001) obesity compared to non-obese (BMI<30) patients as shown in **Supplemental Table 7.**

Comment

Considering the increasing prevalence of obesity and use of minimally-invasive lung resections, understanding if a VATS or RTS approach is associated with a lower conversion to thoracotomy in obese patients is important. In the absence of a randomized, controlled trial comparing VATS and RTS anatomic lung resection in obese patients, the current intercontinental, propensity score adjusted analysis provides a good surrogate. These data demonstrate that obese patients who underwent VATS anatomic lung resection for early-stage NSCLC were over 5 times more likely to experience conversion to thoracotomy than those who underwent RTS. In addition, patients in the VATS cohort had a longer hospital length of stay and a higher rate of postoperative respiratory failure, and were less likely to be discharged home than RTS patients.

Some have hypothesized that an advantage is afforded by the 3-dimensional visualization, maintenance of the hand-eye-target axis, ability to singularly control retraction and camera movement, and wristed instruments used in RTS compared to VATS operations.[4,15,16] A recent propensity score matched analysis of the National Cancer Database (NCDB) showed that the odds of conversion to thoracotomy in all patients is higher in VATS compared to RTS lobectomy (14% vs. 9%, p<0.0001).[17] However, the analysis did not take patient BMI into account as a risk factor for conversion to thoracotomy. Similarly, the Premier Healthcare Database was used to compare propensity score matched cohorts of open, VATS, and RTS lobectomy.[9] This administrative database analysis also revealed a higher rate of conversion to thoracotomy (13.1% vs. 6.3%, p<0.0001), postoperative complications, non-home discharge, and a longer length of stay with VATS compared to RTS lobectomy, despite having a shorter mean operative time. Again, data on patient BMI were not included in the analysis.

It is plausible that any technical advantage provided by a RTS approach over a VATS approach may be amplified in obese patients, given the increased chest wall thickness and reduced intrathoracic working space. Indeed, in a secondary analysis of the current data, the odds ratio of conversion to thoracotomy with VATS compared to RTS in obese patients was over double that observed in the non-obese patients.

It has been shown that anatomic lung resections can be performed safely and effectively with both VATS and RTS, with outcomes that are better than with an open approach.[7-9] However, in certain subsets, such as obese patients, one approach may provide advantages that warrant its preferential use. Given the increased treatment effect observed with RTS over VATS for anatomic lung resection in obese patients compared to non-obese populations, perhaps RTS should be preferentially considered in obese patients. This is supported by the current data suggesting that nearly every postoperative complication was more common in patients that underwent conversion to thoracotomy compared to those who did not.

A greater odds ratio for conversion to thoracotomy was observed in patients with class III obesity compared to those with class I or II obesity. This may reflect the increasing technical challenges posed by patients with a higher degree of adiposity that can be compensated for with RTS technology. Since BMI cannot differentiate lean mass from fat mass nor visceral from peripheral adiposity, it is conceivable that some patients with class I or II obesity had a body habitus similar to non-obese patients, minimizing the treatment effect observed with RTS.

The current study has certain limitations. Despite our attempts to account for imbalances between groups, the current administrative dataset cannot account for surgeon experience or preference, difficulty of dissection, histology, hospital setting, tumor location, specific segment resected, or other reported risk factors for conversion to thoracotomy.[6,16] For example, it is possible that surgeons preferentially used RTS for patients with complete fissures, no previous pneumonias, and lower lobe tumors, accounting for the lower conversion rate. However, beyond the earliest part of the learning curve, most RTS surgeons broaden their selection criteria and begin to perform more “difficult” cases. This observation is supported by the equivalent rates of prior cardiothoracic surgery, large tumors, and node positive disease in the VATS and RTS cohorts. In addition, the conversion rate for VATS lung resection may be artificially high due to cases in which a surgeon did a VATS wedge resection to confirm cancer then proceeded with a planned thoracotomy. From our experience, this is more often performed during VATS than RTS anatomic lung resections. However, the VATS conversion rate of 15% in the current propensity-adjusted model is similar to that reported in the literature, suggesting this scenario represents a small fraction of VATS conversions. Finally, since the proportion of surgeons performing >20 RTS lobectomies annually is rising compared to VATS lobectomies, it is possible that the lower rate of conversion with RTS reflects increased surgeon experience with this platform. Despite these potential limitations, the current study represents the first propensity-adjusted analysis to date comparing VATS to RTS anatomic lung resection in obese patients. In addition, it is the first to pool contemporary, international, patient-level data, increasing the applicability and external validity of the findings. Overall, these data suggest that obese patients with early-stage NSCLC undergoing minimally invasive anatomic lung resection with VATS have a higher rate of conversion to thoracotomy when compared to patients undergoing anatomic lung resection with RTS.

There are no potential conflicts of interest related to this work

Classifications: Lung cancer, Outcomes, Robotic surgery, Obesity

Acknowledgements: The data for this research were provided by The Society of Thoracic Surgeons' National Database Participant User File Research Program. Data analysis was performed at the investigators' institutions.

Funding: This study was funded by a grant from the Boris Family Centre for Robotic Surgery, McMaster University

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Table 1: Characteristics of 8,108 obese patients who underwent anatomic lung resection

Demographics	**RTS=2,133 N(%)**	**VATS=5,975 N(%)**	***p*-value**
Database			
STS GTSD, n=7473	2016(94.5)	5457(91.3)	
Epithor, n=572	88(4.1)	484(8.1)	<0.001
TMac, n=63	29(1.4)	34(0.6)	
Gender			
Male	911(42.7)	2598(43.5)	0.537
Female	1222(57.3)	3377(56.5)	
Mean age (SD)	66.62(9.1)	66.65(8.9)	0.887
Mean BMI (SD)	34.9(4.6)	34.6(4.5)	0.036
BMI Class 1–<30.0–34.9	1320(61.9)	3896(65.2)	
BMI Class 2–35.0–39.9	548(25.7)	1397(23.4)	0.023
BMI Class 3–≥40.0	265(12.4)	682(11.4)	
Cigarette Smokers			
Ever	1678(78.7)	4560(76.3)	0.027
Never	455(21.3)	1415(23.7)	
Chronic Renal Failure	446(20.9)	1210(20.3)	0.517
COPD	798(37.4)	2111(35.3)	0.085
Cardiovascular Disease	597(28)	1660(27.8)	0.855
Prior Cardiothoracic Surgery	246(11.5)	610(10.2)	0.088
Primary Procedure			
Lobectomy	1881(88.2)	5344(89.4)	0.111
Segmentectomy	252(11.8)	631(10.6)	
Tumor Size			
≤ 2cm	1082(50.7)	3073(51.4)	0.576
2.1-5cm	1051(49.3)	2902(48.6)	
Nodal Status			
N0	2035(95.4)	5680(95.1)	0.527
N1	98(4.6)	295(4.9)	
Zubrod Score			
0	1006(47.2)	2883(48.3)	
1	1031(48.3)	2839(47.5)	
2	84(3.9)	226(3.8)	0.775
3+	12(0.6)	27(0.5)	
Mean FEV1% (SD)	83.9(19.0)	83.1(19.3)	0.106
Mean DLCO% (SD)	77.8(20.2)	76.2(20.0)	0.002
Surgery Year			
2015-2016	824(38.5)	3069(51.5)	<0.001
2017-2019	1309(61.5)	2906(48.5)	

All data are presented as n(%), unless otherwise specified. BMI, body mass index; COPD, chronic obstructive pulmonary disease; DLCO%, percent predicted diffusion capacity of carbon monoxide; FEV1%, percent predicted forced expiratory volume in 1 second; RTS, robot-assisted thoracoscopic surgery; SD, standard deviation; STS GTSD, Society of Thoracic Surgeons General Thoracic Surgery Database; TMac, McMaster University Thoracic Surgical Database; VATS, video-assisted thoracoscopic surgery.

Table 2: Characteristics of 8,108 obese patients by conversion to thoracotomy

Demographics	**Conversion to Open Surgery**		***p*-value**
	No=7151 (%)	**Yes=957 (%)**	
Type of Surgery			
RTS	2064(96.8)	69(3.2)	<0.001
VATS	5087(85.1)	888(14.9)	
Gender			
Male	3040(86.6)	469(13.4)	<0.001
Female	4111(89.4)	488(10.6)	
Age - Mean (SD)	66.7(9.1)	66.4(8.8)	0.379
BMI - Mean (SD)	34.6(4.5)	35.1(4.7)	0.006
BMI Class 1–30.0–34.9	4617(88.5)	599(11.5)	
BMI Class 2–35.0–39.9	1726(88.7)	219(11.3)	0.014
BMI Class 3–≥40.0	808(85.3)	139(14.7)	
Cigarette Smoking			
Never	1644(87.9)	226(12.1)	0.666
Ever	5507(88.3)	731(11.7)	
Chronic Renal Failure	1453(87.7)	203(12.3)	0.520
COPD	2527(86.9)	382(13.1)	0.006
Cardiovascular Disease	1945(86.2)	312(13.8)	<0.001
Prior Cardiothoracic Surgery	717(83.8)	139(16.2)	<0.001
Primary Procedure			
Lobectomy	6236(87.6)	899(12.4)	<0.001
Segmentectomy	825(93.4)	58(6.6)	
FEV1% Mean (SD)	83.8(19.1)	79.9(18.9)	<0.001
DLCO% Mean (SD)	76.9(20.1)	74.3(20.1)	<0.001
Tumor Size			
≤2cm	3709(89.3)	446(10.7)	0.002
2.1-5cm	3442(87.1)	511(12.9)	
Nodal Status			
N0	6830(88.5)	885(11.5)	<0.001
N1	321(81.7)	72(18.3)	
Zubrod Score			
0	3483(89.6)	406(10.4)	0.002
1	3368(87.0)	502(13.0)	
2	268(86.5)	42(13.5)	
3+	32(82.1)	7(17.9)	
Surgery Year			

2015-2016	3459(48.5)	434(45.5)	0.085
2017-19	3692(51.5)	523(54.5)	

All data are presented as n (%), unless otherwise specified. BMI, body mass index; COPD, chronic obstructive pulmonary disease; DLCO%, percent predicted diffusion capacity of carbon monoxide; FEV1%, percent predicted forced expiratory volume in 1 second; RTS, robot-assisted thoracoscopic surgery; SD, standard deviation; VATS, video-assisted thoracoscopic surgery.

Table 3: Outcomes of 8,108 obese patients that underwent anatomic lung resection

Secondary Outcomes	Type of Surgery		Mean difference (95%CI)	*p*-value
	RTS=2,133 N (%)	VATS=5,975 N (%)		
Mean OR duration (minutes) (SD)	266.4(95.0)	244.5(88.3)	-19.5(-24.0, -15.0)	<0.001
Mean length of stay (days) (SD)	4.3(3.8)	5.1(8.0)	0.7(0.3, 1.0)	<0.001
			Odds ratio (95% CI)	
Post-op events	668(31.3)	1961(32.8)	1.05(0.94–1.17)	0.351
Prolonged air leak	154(7.2)	40(6.8)	0.94(0.77–1.14)	0.537
Pneumonia	49(2.3)	182(3.0)	1.30(0.94–1.80)	0.108
Bronchopleural Fistula	2(0.1)	6(0.1)	1.05(0.21–5.32)	0.947
Deep vein thrombosis	10(0.5)	31(0.5)	1.12(0.54–2.31)	0.752
Pulmonary Embolus	16(0.8)	39(0.7)	0.86(0.47–1.54)	0.610
Atrial or Ventricular Arrhythmia	200(9.4)	546(9.1)	0.97(0.82–1.15)	0.749
Myocardial Infarction	7(0.3)	15(0.3)	0.81(0.33–2.02)	0.661
Bleeding	0(0.0)	2(0.03)	--	0.985
Empyema	8(0.4)	16(0.3)	0.65(0.27–1.53)	0.327
Sepsis	11(0.5)	40(0.7)	1.16(0.60–2.27)	0.668
Kidney Injury or failure	3(0.1)	3(0.1)	0.26(0.05–1.30)	0.101
Chyle Leak	11(0.5)	22(0.4)	0.67(0.3–1.40)	0.294
Respiratory failure	39(1.8)	168(2.8)	1.50(1.05–2.13)	0.026
Surgical site infection	127(6.0)	520(8.7)	1.15(0.93–1.42)	0.179
Mortality at discharge	10(0.5)	44(0.7)	1.48(0.74–2.96)	0.270
Discharge with a chest tube* (n=7,473)	258(4.7)	136(6.7)	0.69(0.55-0.86)	<0.001
Readmission within 30 days	140(6.6)	418(7.0)	1.07(0.87–1.31)	0.502
Discharged to home	2012(94.3)	5525(92.5)	0.77(0.62–0.94)	0.013

All data are presented as n (%), unless otherwise specified. OR, operating room; RTS, robot-assisted thoracoscopic surgery; SD, standard deviation; VATS, video-assisted thoracoscopic surgery. *Data from STS GTSD only.