Published in final edited form as:
Ann Thorac Surg. 2012 December ; 94(6): 1841–1847. doi:10.1016/j.athoracsur.2012.08.006.

Obesity Increases Operating Room Time for Lobectomy in the Society of Thoracic Surgeons Database

Jamii B. St Julien, MD, MPH[1], **Melinda C. Aldrich, MPH, PhD**[1,2], **Shubin Sheng, MS**[4], **Stephen A. Deppen, MA, MS**[1,2], **William R. Burfeind Jr., MD, FACS**[5], **Joe B. Putnam, MD, FACS**[1,3], **Eric S. Lambright, MD, FACS**[1,3], **Jonathan C. Nesbitt, MD, FACS**[1], and **Eric L. Grogan, MD, MPH, FACS**[1,2,3]

[1]Department of Thoracic Surgery; Vanderbilt University Medical Center, Nashville, TN

[2]Division of Epidemiology, Institute for Medicine and Public Health, Vanderbilt University Medical Center, Nashville, TN

[3]Department of Surgery, Veterans Affairs Medical Center, Nashville, TN

[4]Outcomes Research and Assessment Group, Duke Clinical Research Institute, Durham, NC

[5]Department of Thoracic Surgery, Temple University, Philadelphia, PA

Abstract

Background—Obesity has become a major epidemic in the US. Though research suggests obesity does not increase major morbidity or mortality after thoracic operations, it likely results in greater use of healthcare resources.

Methods—We examined all patients in the Society of Thoracic Surgeons General Thoracic Surgery database with primary lung cancer who underwent lobectomy from 2006 to 2010. We investigated the impact of body mass index (BMI) on total operating room time using a linear mixed-effects regression model, and multiple imputation to account for missing data. Secondary outcomes included postoperative length of stay and 30-day mortality. Covariates included age, gender, race, forced expiratory volume, smoking status, Zubrod score, prior chemotherapy or radiation, steroid use, number of comorbidities, surgical approach, hospital lobectomy volume, hospital percent obesity, and the addition of mediastinoscopy or wedge resection.

Results—A total of 19,337 patients were included. The mean BMI was 27.3 kg/m^2, with 4,898 patients (25.3%) having a BMI ≥ 30 kg/m^2. The mean total operating room time, length of stay, and 30-day mortality were 240 minutes, 6.7 days, and 1.8%, respectively. For every 10 unit increase in BMI, mean operating room time increased by 7.2 minutes (4.8 – 8.4 minutes, $p<0.0001$). Higher hospital lobectomy volume and hospital percentage of obese patients did not affect the association between BMI and operative time. BMI was not associated with 30-day mortality or increased length of stay.

Conclusions—Increased body mass index is associated with increased total operating room time, regardless of institutional experience with obese patients.

Address for Correspondence: Eric Grogan, M.D., M.P.H., Department of Thoracic Surgery, 609 Oxford House, 1313 21st Ave. South, Nashville, TN 37232, Phone: 615-322-0064, Fax: 615-343-9194, eric.grogan@vanderbilt.edu.

Meeting Presentation: none

Disclosures: Dr. Grogan is a recipient of the Department of Veterans Affairs, Veterans Health Administration, Health Services Research and Development Service Career Development Award (10-024). Dr. St. Julien is a recipient of the Vanderbilt University Surgical Oncology T32 Training Grant (3T32CA106183-07S1). The authors had full control of the study design, methods, outcome parameters and results, data analysis, and manuscript production. The views expressed in this article are those of the authors and do not necessarily represent the views of the Department of Veterans Affairs.

NIH-PA Author Manuscript
NIH-PA Author Manuscript

Keywords

Obesity; Outcomes; Lung cancer surgery; Lobectomy

Introduction

The prevalence of obesity within the US has increased to epidemic proportions.[1,2] In 2001, the prevalence was of obesity, defined as a body mass index (BMI) ≥ 30 kg/m^2, among US adults was 21%, with 2.3% being morbidly obese (BMI ≥ 40 kg/m^2)[3]. By 2008 these numbers increased to 34.2% and 5.7%, respectively.[4] Accordingly, hospital admissions of obese patients has risen substantially, and admissions of morbidly obese patients even more so.[5] The estimated annual medical costs due to obesity in 2008 were approximately $147 billion.[6] Thus, the obesity epidemic has led to a substantial increase in utilization of healthcare resources.[7–9]

Obesity is associated with increased comorbidities including diabetes, hypertension, and coronary artery disease, and has long been considered a major risk factor for poor health outcomes.[10,11] However, the data regarding obesity's influence on post-surgical outcomes have been mixed. Research has shown that obesity increases rates of wound infections and minor wound complications, but has not demonstrated a relationship between obesity and increased risk of severe complications or death.[12–18] The two largest studies of surgical populations to date show a paradoxical effect, where obesity is associated with improved post-surgical outcomes.[19,20] Within the thoracic surgery population, a multi-institutional retrospective study of 18,800 patients who underwent lung resection for lung cancer showed a significant decrease in 30-day mortality with increased BMI.[20] The counterintuitive observation that obesity does not increase peri-operative mortality, and may actually be associated with decreased mortality, raises questions as to what other factors could be involved.

Operative time is a widely used surrogate measure for resource utilization, and several studies conducted within general surgical, orthopedic, and urologic patient populations have demonstrated increased operative times among obese patients[21–25]. However, these studies had significant heterogeneity in the definitions of operative time, and it was often unclear what actual time period was assessed (e.g. total time in the operating room versus time for the procedure alone, etc.). To avoid this confusion, we specifically defined the surrogate measure for resource utilization as total operating room (OR) time, which is comprised of three component times (pre-procedure, procedure, and post-procedure time). We tested whether obesity is associated with an increase in total OR time and length of hospital stay among patients within the Society of Thoracic Surgeons General Thoracic Surgery Database who underwent lobectomy for primary lung cancer. To our knowledge, this is the first investigation of the association between obesity and OR time among patients undergoing lung resection.

Methods

Society of Thoracic Surgeons Database

The Society of Thoracic Surgeons (STS) National Database was established in 1989 to promote quality improvement and patient safety among cardiothoracic surgeons.[26] It consists of three component databases: Adult Cardiac, Congenital Heart Surgery, and the General Thoracic Surgery Database (GTSD). The first database created was the Adult Cardiac database, which has been extensively validated.[27] As of December 2010, 190 institutions were contributing to the GTSD nationwide. To prohibit selective reporting, all participating institutions are required to report all cases.

The STS GTSD utilizes a standardized data collection form to collect information for each patient undergoing a thoracic operation. During the time period of 2006 to 2010, there were two versions (v2.07 and v2.081) of the data collection form implemented by the STS. Data form v2.07 was used until 2008, and v2.081 thereafter. These two forms are very similar, but differ slightly in how some data were captured (e.g. clinical stage, comorbidities, additional procedures). Both forms are available on the STS website.[28] A sensitivity analysis showed no significant difference in associations between these two versions, so the data were combined for our analyses.

Patient Population

We examined all patients in the STS GTSD with lung cancer who underwent lobectomy as the primary procedure from 2006 to 2010 (N=19,767). For patients with multiple operations, only the first operation was included in the analysis. Only patients with complete data for age, gender, mortality at discharge, hospital identification, and OR time were included. Patients were excluded if they had both thoracoscopy and thoracotomy as the surgical approach, because the reason for conversion could not be determined. Patients were excluded if they underwent endobronchial ultrasound at the time of lobectomy because these data were only available on v2.081. Two patients with a Zubrod score of 5 were excluded as well. After excluding 430 patients (2.2%), the total number of patients included in analyses was 19,337.

Outcome Definitions

The primary outcome was total OR time, measured as the time from the patient entering the OR to the when the patient leaves the room. Secondary outcomes were pre-procedure (room entry to skin incision), procedure (skin incision to closure), and post-procedure times (skin closure to room exit), 30-day mortality, and postoperative length of stay (LOS).

Statistical Analysis

We used the National Institute of Health categorizations of obesity, where a BMI ≥ 30 kg/$m^2$is classified as obese. [29] Variables were selected from the data collection forms prior to analyses. Potential confounders included in regression models were selected based on *a priori* knowledge, exploratory analyses, and a causal model using directed acyclic graphs[30] to evaluate for confounding and effect modification. The variables included in our models were age, gender, race, Zubrod score[31], smoking status, preoperative chemotherapy, preoperative chest radiation therapy, steroid use, % predicted forced expiratory volume in one second (FEV_1), surgical approach, total number of comorbidities, and additional procedures performed at the time of lobectomy (mediastinoscopy and wedge resection). Data on annual hospital lobectomy volume, annual hospital percentage of obese patients, and clinical tumor stage were also collected. A smoking status of “current” was defined as actively smoking or quit within 1 month pre-operatively, and “former” was defined as having quit >1 month pre-operatively and smoked over 100 cigarettes total. Comorbidities included hypertension, congestive heart failure, coronary artery disease, diabetes, peripheral vascular disease, and end-stage renal disease on dialysis.

Univariate comparisons were performed using the Pearson chi-square test for categorical variables, and Wilcoxon rank-sum test for continuous variables. We created linear mixed effects multivariable regression models to investigate the relationship between BMI and operating room times. The risk ratios generated were multiplied by the mean OR time to generate each covariate’s average impact (in minutes) on OR time. The regression models for LOS generated an odds ratio which was similarly multiplied by the mean LOS to estimate the average impact (in days) on LOS. LOS was not normally distributed, so was log-transformed for analyses, then back-transformed for result interpretation. Missing variable data was imputed using 10-fold multiple imputation by chained equations.[32] A secondary analysis to determine the influence of institutional experience on the relationship between BMI and operative time was performed by including interaction terms between BMI and annual hospital volume, and between BMI and hospital percentage of obese patients. We also developed models examining the interaction between clinical tumor stage and race and gender. Due to the large sample size and multiple comparisons, associations having a p-value <0.01 were considered statistically significant. All analyses were performed with R (www.r-project.org) and SAS® 9 (SAS Institute Inc.; Cary, NC) statistical software packages. This study was approved by the Vanderbilt University Institutional Review Board.

Results

A total of 19,337 patients were included (11,566 from v2.07; 7,771 from v2.08). The mean BMI was 27.3 kg/m^2, with 13,222 patients (68.4%) having a BMI < 30 kg/m^2, 4,898 patients (25.3%) having a BMI ≥ 30 kg/m^2, and 1,217 patients (6.3%) having no BMI data (this data was imputed for analysis). Of the 4,898 patients with a BMI ≥30 kg/m_2, there were 625 patients who were morbidly obese (BMI ≥ 40 kg/m^2). Patient characteristics are detailed in Table 1. Mean total OR time was 240.1 (standard deviation (s.d.) = 93.4) minutes. Mean pre-procedure, procedure, and post-procedure times were 48.4 (s.d. = 34.4), 174.1 (s.d. = 87.3), and 17.4 (s.d. = 37.4) minutes, respectively. The mean LOS was 6.9 days (s.d. = 7.8), and the overall mean 30-day mortality was 1.8%.

Obese patients were more likely to be younger, black, former smokers with more comorbidities than non-obese patients. They were less likely to undergo preoperative chemotherapy, radiation, or mediastinoscopy, and more likely to undergo thoracotomy (Table 1). Multivariable regression analysis demonstrated that for every 10 unit increase in BMI there was an increase in the mean total OR time of 7.2 minutes (p<0.0001). For example, a lobectomy in a patient with a BMI of 45 kg/m^2 takes approximately 15 minutes longer than for a patient with a BMI of 25 kg/m^2. Factors associated with longer total operating time were black race (7.2 minutes; p=0.0001), male gender (19.2 minutes; p<0.0001), preoperative chemotherapy (12 minutes; p<0.0001), and preoperative chest radiation therapy (16.8 minutes; p<0.0001) (Table 2). Wedge resection and mediastinoscopy added an additional 12 minutes (p<0.0001) and 53 minutes (p<0.0001), respectively. BMI and mediastinoscopy were the only factors significantly impacting all three components of total OR time (Table 3).

BMI had an inverse association with length of stay, such that for every 10 unit increase in BMI there was a decrease of 0.3 days (95% confidence interval (CI) 0.23 –0.38, p<0.0001). Similarly, every 10% increase in FEV_1 decreased LOS by 0.2 days (95% CI 0.18 – 0.23, p<0.0001). Underweight patients (N=583) had a disproportionately longer LOS (mean = 9.34 days) than all other BMI categories of patients (normal weight = 6.98 days, overweight = 6.39 days, obese = 6.33 days, and morbidly obese 6.54 days). Increasing age, male gender, steroid use, smoking status, increasing number of comorbidities, thoracotomy, and Zubrod scores above zero were all significantly associated with increased LOS (p<0.0001). Of these, a Zubrod score ≥ 3 had the largest impact on LOS (+2.9 days; 95% CI 2.3 – 3.6; p<0.0001), followed by thoracotomy (+1.9 days; 95% CI 1.7 – 2.0; p<0.0001).

BMI was not significantly associatedwith 30 -day mortality (odds ratio = 0.82; p=0.063). A higher $FEV_1$was the only factor significantly associated with decreased mortality (odds ratio

NIH-PA Author Manuscript

NIH-PA Author Manuscript

= 0.88; $p<0.0001$). Age, male gender, preoperative radiation therapy, total number of comorbidities, thoracotomy, and a Zubrod score ≥ 2 were all significantly associated with increased mortality (Table 4).

Interaction terms (hospital lobectomy volume*BMI; obesity percentage*BMI) were found to be non-significant when added to the total OR time model ($p>0.01$), and did not affect BMI's association with total OR time. Similarly, interaction terms (clinical tumor stage*race; clinical tumor stage*gender) were found to be non-significant and did not affect the associations between race and operative time, or between gender and operative time.

Discussion

Obesity has become a major health problem in the US, and has long been thought to have a detrimental effect on health outcomes.[10,11] In this multi-institutional, retrospective study of adults undergoing lobectomy for primary lung cancer we tested whether obesity was associated with increased operating room times, which we consider a surrogate measure of perioperative resource utilization.

BMI increased total OR time by impacting every component of time spent in the operating room, predominantly the procedure time. Every ten unit increase in BMI increased total OR time by an average of 7.2 minutes, which could represent a major source of the healthcare costs that are already known to be higher for obese patients in the US.[7,9] There are no published data on true operating room costs, but an estimated average patient charge of $62 per minute[33] has been reported. If we consider this cost estimate, then every 10 unit increase in BMI costs approximately an additional $446. This likely underestimates the true cost because it does not take into account that most hospitals charge OR time in blocks of 15 or 60 minutes, and many will round up to the next 15 minutes.[33] In 46% of hospitals participating in the STS GTSD, almost a third (21–30%) of patients were obese, implying that we can expect significant increases in hospital expenses due to increased OR time alone.

The single largest patient characteristic influencing total OR time was male gender. Black patients, while only comprising 8.2% of this population, had significantly increased OR times as compared to whites. The reason for this is unclear, but implies that there are other factors associated with race and gender that still need to be elucidated. Neither gender nor race's effect on total OR time was explained by clinical tumor stage. BMI surprisingly had an inverse relationship with LOS. This is likely explained by the prolonged LOS experienced by underweight patients when compared to obese patients. Nonetheless, such a small impact on LOS is not likely to be clinically significant.

The mean mortality of the STS population (1.8%) is comparable to reported mortality after lung resections of 1.4 – 2.2%.[20,34] We found no significant association between BMI and 30-day mortality, which differs from the findings of Kozower and colleagues[20] showing that higher BMI was associated with decreased 30-day mortality. Although we examined a similar population to that of Kozower, our regression model included the additional covariates of mediastinoscopy, wedge resection, and pre-operative chest radiation, possibly accounting for the difference in results. In our model, preoperative chest radiation was one of the most significant factors associated with increased mortality (odds ratio = 2.98, $p<0.01$). Patients who underwent preoperative radiation were more likely to have a lower (8.9% with BMI < 30 kg/m^2 vs. 7.1% with BMI ≥ 30 kg/m^2, $p<0.0001$). Thus by including radiation in our analyses we adjusted for a large source of increased mortality for patients with lower BMI's.

Our study has several limitations to consider. There was a significant amount of missing data for numerous variables, which required multiple imputation. Imputing large amounts of missing data could potentially decrease the “interpretability” of our results. However, when we analyzed only complete data, the results were unchanged (data not shown). There is also a substantial lack of diversity within this population, with 87% of patients being white and only 8% black. Increased research and data collection within underrepresented minority populations are needed. A major strength of the study is the national, multi-institutional nature of the STS database, which enhances the generalizability of our findings. Also, since the data in the STS GTSD are collected prospectively, our analyses are not biased by knowledge of the outcome.

We have demonstrated that obesity increases OR times for patients undergoing lobectomy for primary lung cancer. If the prevalence of obesity continues to rise, a greater number of patients undergoing lobectomies for lung cancer will likely be obese. Thus, we have identified a significant source of increased healthcare costs that must be considered on both a hospital and a national health policy level.

Abbreviations and Acronyms

BMI	Body Mass Index
STS	Society of Thoracic Surgeons
GTSD	General Thoracic Surgery Database
OR	Operating room
LOS	Length of stay
FEV_1	Forced expiratory volume in one second
s.d	Standard deviation
CI	Confidence interval

References

1. Mokdad AH, Bowman BA, Ford ES, et al. The continuing epidemics of obesity and diabetes in the United States. JAMA. 2001; 286:1195–1200. [PubMed: 11559264]
2. Sturm R. Increases in morbid obesity in the USA: 2000–2005. Public Health. 2007; 121:492–496. [PubMed: 17399752]
3. Mokdad AH, Ford ES, Bowman BA, et al. Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. JAMA. 2003; 289:76–79. [PubMed: 12503980]
4. Ogden, CL.; Carroll, MD. NHANES: Prevalence of Overweight, Obesity, and Extreme Obesity Among Adults: United States, Trends 1960–1962 Through 2007–2008. Jun. 2010 p. 1-6.
5. Kim S, Boye KS. Obesity and incremental hospital charges among patients with and without diabetes in the United States. Value Health. 2009; 12:723–729. [PubMed: 19508656]
6. Finkelstein EA, Trogdon JG, Cohen JW, Dietz W. Annual medical spending attributable to obesity: payer-and service-specific estimates. Health Aff (Millwood). 2009; 28:w822–831. [PubMed: 19635784]
7. Andreyeva T, Sturm R, Ringel JS. Moderate and severe obesity have large differences in health care costs. Obes Res. 2004; 12:1936–1943. [PubMed: 15687394]
8. Finkelstein EA, Fiebelkorn IC, Wang G. State-level estimates of annual medical expenditures attributable to obesity. Obes Res. 2004; 12:18–24. [PubMed: 14742838]
9. Quesenberry CP Jr, Caan B, Jacobson A. Obesity, health services use, and health care costs among members of a health maintenance organization. Arch Intern Med. 1998; 158:466–472. [PubMed: 9508224]

NIH-PA Author Manuscript

NIH-PA Author Manuscript

10. Must A, Spadano J, Coakley EH, et al. The disease burden associated with overweight and obesity. JAMA : the journal of the American Medical Association. 1999; 282:1523–1529. [PubMed: 10546691]
11. Allison DB, Fontaine KR, Manson JE, Stevens J, VanItallie TB. Annual deaths attributable to obesity in the United States. JAMA : the journal of the American Medical Association. 1999; 282:1530–1538. [PubMed: 10546692]
12. Foley K, Lee RB. Surgical complications of obese patients with endometrial carcinoma. Gynecol Oncol. 1990; 39:171–174. [PubMed: 2227591]
13. Jiganti JJ, Goldstein WM, Williams CS. A comparison of the perioperative morbidity in total joint arthroplasty in the obese and nonobese patient. Clin Orthop Relat Res. 1993:175–179. [PubMed: 8472410]
14. Vinton AL, Traverso LW, Jolly PC. Wound complications after modified radical mastectomy compared with tylectomy with axillary lymph node dissection. Am J Surg. 1991; 161:584–588. [PubMed: 2031542]
15. Thomas EJ, Goldman L, Mangione CM, et al. Body mass index as a correlate of postoperative complications and resource utilization. Am J Med. 1997; 102:277–283. [PubMed: 9217597]
16. Klasen J, Junger A, Hartmann B, et al. Increased body mass index and peri-operative risk in patients undergoing non-cardiac surgery. Obesity surgery. 2004; 14:275–281. [PubMed: 15027438]
17. Dindo D, Muller MK, Weber M, Clavien PA. Obesity in general elective surgery. Lancet. 2003; 361:2032–2035. [PubMed: 12814714]
18. Lee CT, Dunn RL, Chen BT, et al. Impact of body mass index on radical cystectomy. J Urol. 2004; 172:1281–1285. [PubMed: 15371824]
19. Mullen JT, Moorman DW, Davenport DL. The obesity paradox: body mass index and outcomes in patients undergoing nonbariatric general surgery. Ann Surg. 2009; 250:166–172. [PubMed: 19561456]
20. Kozower BD, Sheng S, O'Brien SM, et al. STS database risk models: predictors of mortality and major morbidity for lung cancer resection. Ann Thorac Surg. 2010; 90:875–881. discussion 881–873. [PubMed: 20732512]
21. Gedaly R, McHugh PP, Johnston TD, et al. Obesity, diabetes, and smoking are important determinants of resource utilization in liver resection: a multicenter analysis of 1029 patients. Ann Surg. 2009; 249:414–419. [PubMed: 19247028]
22. Gupta PK, Turaga KK, Miller WJ, Loggie BW, Foster JM. Determinants of outcomes in pancreatic surgery and use of hospital resources. Journal of surgical oncology. 2011; 104:634–640. [PubMed: 21520092]
23. Gupta PK, Miller WJ, Sainath J, Forse RA. Determinants of resource utilization and outcomes in laparoscopic Roux-en-Y gastric bypass: a multicenter analysis of 14,251 patients. Surg Endosc. 2011; 25:2613–2625. [PubMed: 21487887]
24. Hawn MT, Bian J, Leeth RR, et al. Impact of obesity on resource utilization for general surgical procedures. Ann Surg. 2005; 241:821–826. discussion 826–828. [PubMed: 15849518]
25. Park JW, Lim SW, Choi HS, et al. The impact of obesity on outcomes of laparoscopic surgery for colorectal cancer in Asians. Surg Endosc. 2010; 24:1679–1685. [PubMed: 20039065]
26. The Society of Thoracic Surgeons National Database. [Accessed August 2011] http://www.sts.org/national-database
27. Welke KF, Ferguson TB Jr, Coombs LP, et al. Validity of the Society of Thoracic Surgeons National Adult Cardiac Surgery Database. Ann Thorac Surg. 2004; 77:1137–1139. [PubMed: 15063217]
28. STS General Thoracic Surgery Database Data Collection Forms. In
29. National Institute of Health. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: The evidence report. 1998.
30. Greenland S, Pearl J, Robins JM. Causal diagrams for epidemiologic research. Epidemiology. 1999; 10:37–48. [PubMed: 9888278]
31. Oken MM, Creech RH, Tormey DC, et al. Toxicity and response criteria of the Eastern Cooperative Oncology Group. Am J Clin Oncol. 1982; 5:649–655. [PubMed: 7165009]

32. van Buuren, S.; Groothuis Oudshoorn, K. Draft. MICE: Multivariate Imputation by Chained Equations in R.
33. Shippert RD. A Study of Time-Dependent Operating Room Fees and How to Save $100 000 by using Time-Saving Products. The American Journal of Cosmetic Surgery. 2005:25–34.
34. Smith PW, Wang H, Gazoni LM, et al. Obesity does not increase complications after anatomic resection for non-small cell lung cancer. Ann Thorac Surg. 2007; 84:1098–1105. discussion 1105–1096. [PubMed: 17888954]

Table 1

Clinical and Demographic Characteristics of Study Population

Variable	All Patients	BMI < 30 kg/m^2	BMI ≥ 30 kg/m^2	P value
Total	19337	13222 (73)[a]	4898 (27) [a]	--
BMI (kg/m^2), mean (s.d.)	27.3 (6.1)	--	--	
BMI (kg/m^2), N (%)				
< 25	6830 (37.7)	--	--	
25 – 29.9	6392 (35.3)	--	--	
30 – 39.9	4273 (23.6)	--	--	
≥ 40	625 (3.4)	--	--	
Missing	1217	--	--	
Age (years), mean (s.d.)	66.7 (10.7)	67.2 (10.7)	65.5 (10.3)	<0.001
Gender, N (%)				
Male	9120 (47.2)	6182 (46.8)	2356 (48.1)	0.244
Female	10217 (52.8)	7040 (53.2)	2542 (51.9)	
Race, N (%)				
Caucasian	16852 (87.5)	11528 (87.6)	4293 (88)	<0.001
Black	1577 (8.2)	1032 (7.8)	449 (9.2)	
Other	825 (4.3)	610 (4.6)	139 (2.8)	
Missing	83	52	17	
Zubrod Score, N (%)				
0	8266 (43.4)	5797 (44.5)	2000 (41.5)	0.030
1	9639 (50.7)	6467 (49.6)	2522 (52.4)	
2	902 (4.7)	619 (4.7)	239 (5)	
3	191 (1)	136 (1)	43 (0.9)	
4	38 (0.2)	18 (0.2)	12 (0.2)	
Missing	301	185	82	
Smoking Status, N (%)				
Never	2716 (14)	1785 (13.5)	738 (15.1)	<0.001
Former	11507 (59.5)	7669 (58)	3137 (64.1)	
Current	5106 (26.5)	3762 (28.5)	1021 (20.8)	
Missing	8	6	2	
Preoperative Chemotherapy, N (%)				
No	16656 (88.7)	11454 (88.2)	4334 (90.2)	<0.001
Yes	2115 (11.3)	1526 (11.8)	472 (9.8)	
Missing	566	242	92	
Preoperative Radiation, N (%)				
No	17196 (91.5)	11828 (90.9)	4465 (92.8)	<0.001
Yes	1610 (8.5)	1180 (9.1)	349 (7.2)	

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Variable	All Patients	BMI < 30 kg/m^2	BMI ≥ 30 kg/m^2	P value
Missing	531	214	84	
Steroid Use, N (%)				
No	18082 (96.5)	12504 (96.5)	4620 (96.3)	0.622
Yes	654 (3.5)	456 (3.5)	176 (3.7)	
Missing	601	262	102	
FEV_1 % Predicted, mean (s.d.)	80.4 (22.3)	80.4 (22.7)	79.8 (21.5)	0.030
Missing	2575	1735	641	
Surgical Approach, N (%)				
Thoracotomy	12703 (65.9)	8514 (64.5)	3311 (67.8)	<0.001
Thoracoscopy	6587 (34.1)	4679 (35.5)	1575 (32.2)	
Missing	47	29	12	
Mediastinoscopy, N (%)				
No	16852 (87.2)	11443 (86.6)	4304 (87.9)	0.007
Yes	2485 (12.8)	1779 (13.4)	594 (12.1)	
Wedge Resection, N (%)				
No	15818 (81.8)	10733 (81.2)	4022 (82.1)	0.429
Yes	3519 (18.2)	2489 (18.8)	876 (17.9)	
Total Number of Comorbidities, mean (s.d.)	1.08 (1.0)	1.01 (0.9)	1.33 (1.0)	<0.001

[a]The combined total for these two comparison groups is 18,120. This represents the total study population (19,337) minus those with no BMI data (1,217).

BMI – body mass index; FEV_1 – forced expiratory volume in one second; s.d. – standard deviation

Table 2

Multivariable Regression Results for Total OR Time

Variable	Total OR Time		
	Impact in Minutes	95 % CI	P value
BMI (10 unit increments)	+ 7.2 [a]	4.8 – 8.4	<0.001
Age (10 year increments)	− 2.4	−2.2 – −4.1	<0.001
Male Gender	+ 19.2	16.1 – 20.2	<0.001
Race			
White (reference)	0	--	--
African American	+ 7.2	3.6 – 10.8	0.001
Other	− 2.4	−7.4 – +2.2	0.285
Total Number of Comorbidities	+ 2.4	0.7 – 2.6	0.002
Zubrod Score			
0 (reference)	0	--	--
1	+ 4.8	1.9 – 6.2	<0.001
2	+ 4.8	1.0 – 7.9	0.014
>3	− 2.4	−12.2 – +7.2	0.587
Smoking Status			
Never (reference)	0	--	--
Former	+ 2.4	−0.7 – +5.0	0.154
Current	+ 4.8	0.2 – 7.0	0.036
Preoperative Chemotherapy	+ 12	5.8 – 16.3	<0.001
Preoperative Radiation Therapy	+ 16.8	10.1 – 23.5	<0.001
Steroid Use	− 2.4	−7.9 – +2.4	0.305
FEV_1 Predicted, %	− 2.4	−1.7 – −0.7	<0.001
Thoracotomy	− 4.8	−2.6 – −7.2	<0.001
Mediastinoscopy	+ 52.8	48 – 55.7	<0.001
Wedge Resection	+ 12	9.6 – 14.9	<0.001

[a]Every 10 unit increase in BMI was associated with a 7.2 minute average increase in total OR time; BMI – body mass index; CI – confidence interval; FEV_1 – forced expiratory volume in one second; OR – operating room

Table 3

Multivariable Regression Results on the Components of Operative Time

Variable	Impact in Minutes[a]		
	Pre-procedure	Procedure	Post-procedure
BMI (10 unit increments)	+ 2.4	+3.5	+ 0.5
Age (10 year Increments)	--	− 3.5	+ 0.3
Male Gender	− 1.0	+ 17.4	
Race			
White (reference)	0	0	0
African American	--	+ 5.2	+ 0.9
Other	--	--	--
Total Number of Comorbidities	+ 1.0	--	--
Zubrod Score			
0 (reference)	0	0	0
1	--	+ 3.5	--
2	--	+ 5.2	--
>3	--	--	--
Smoking Status			
Never (reference)	0	0	0
Former	--	--	--
Current	--	--	--
Preoperative Chemotherapy	+ 2.4	+ 8.7	--
Preoperative Radiation Therapy	--	+ 19.2	--
Steroid Use	--	--	--
FEV_1 Predicted, %	--	− 1.7	− 0.2
Thoracotomy	+ 2.9	− 8.7	--
Mediastinoscopy	− 7.3	+ 52.2	+ 1.4
Wedge Resection		+ 15.7	− 0.5

[a]Only significant (p<0.01) results shown; BMI – body mass index; FEV_1 – forced expiratory volume in one second

Table 4

Adjusted 30-day Mortality

Variable	Mortality		
	Odds Ratio	**95% CI**	**P value**
BMI (10 unit increments)	0.82	0.66 – 1.21	0.063
Age (10 year Increments)	2.0	1.74 – 2.30	<0.001
Male Gender	1.59	1.26 – 2.01	<0.001
Race			
White (reference)	0	--	--
African American	1.10	0.74 – 1.64	0.643
Other	1.14	0.65 – 1.99	0.658
Total Number of Comorbidities	1.24	1.12 – 1.38	<0.001
Zubrod Score			
0 (reference)	0	--	--
1	1.26	1.0 – 1.59	0.051
2	1.80	1.29 – 2.5	<0.001
>3	3.83	2.02 – 7.25	<0.001
Smoking Status			
Never (reference)	0	--	--
Former	1.05	0.7 – 1.57	0.812
Current	1.38	0.89 – 2.14	0.157
Preoperative Chemotherapy	0.55	0.27 – 1.1	0.091
Preoperative Radiation Therapy	2.98	1.46 – 6.1	0.003
Steroid Use	1.45	0.89 – 2.36	0.133
FEV_1 Predicted, %	0.88	0.83 – 0.92	<0.001
Thoracotomy	1.69	1.28 – 2.23	<0.001
Mediastinoscopy	1.00	0.71 – 1.41	0.986
Wedge Resection	0.89	0.66 – 1.21	0.462

BMI – body mass index; CI – confidence interval; FEV_1 – forced expiratory volume in one second