Impact of Trainee Involvement on Video-Assisted Thoracoscopic Lobectomy for Cancer

Ethan S. Rosenfeld, MD, Michael A. Napolitano, MD, Andrew D. Sparks, MS, Gregor Werba, MD, Jared L. Antevil, MD, and Gregory D. Trachiotis, MD

Division of Cardiothoracic Surgery and Heart Center, Washington, DC Veterans Affairs Medical Center, Washington, DC; and Department of Surgery, George Washington University, Washington, DC

Background. **Previous literature in other surgical disciplines regarding the impact of resident and fellow involvement on operative time and outcomes has yielded mixed results. The impact of trainee involvement on minimally invasive thoracic surgery is unknown. This study compared risk-adjusted differences in operative time and outcomes of video-assisted thoracoscopic lobectomy for cancer between cases performed with and without residents and fellows involved.**

Methods. **All patients undergoing elective video-assisted thoracoscopic lobectomy for cancer between 2008 and 2018 were identified in the Veterans Affairs Surgical Quality Improvement Program database. Patients were stratified into 2 cohorts: cases with residents and fellows involved, and cases performed only by attending surgeons. Primary outcomes included operative time, postoperative hospital length of stay, and composite 30-day morbidity and mortality. Secondary outcomes included factors associated with high and low trainee operative autonomy.**

Results. **A total of 3678 patients met study inclusion criteria. In all, 1780 cases were performed with residents and fellows involved (median postgraduate year, 5; interquartile range, 4-7). Multivariate analysis showed that operative time was significantly shorter in resident- and fellow-involved cases compared with attending-only cases (mean [SD], 3.6 [1.4] versus 3.8 [1.6] hours; $P < .001$). There were no significant differences in composite 30-day morbidity and mortality (16.0% versus 17.1%; adjusted odds ratio = 0.93; 95% confidence interval, 0.77-1.11; $P = .40$) or length of stay. Substratification of trainees by postgraduate year resulted in similar findings. Cases performed in July through October and those in the Northeastern United States were associated with low autonomy.**

Conclusions. **Current training paradigms in thoracic surgery are safe, and the involvement of motivated and skilled trainees with appropriate supervision may benefit operative duration.**

(Ann Thorac Surg 2021;112:1855-61)

Surgical residency training is predicated on graduated trainee responsibility and autonomy, both in and out of the operating room, with the acquisition of skills and demonstration of advancing clinical aptitude. Although training is an essential process, there is always concern about potential risks presented to patients during the maturation of surgeons toward independent practice. Whereas most surgical patients are supportive of resident education, there are those with apprehensions. Up to one-third of patients are unwilling to have trainees participate in their operations.[1] When provided the specific level of resident engagement in their surgery, many patients' willingness to allow participation substantially decreases, particularly when told the resident will have a more extensive role.[2]

Several studies in varied surgical disciplines have examined the effects of resident participation on operative conduct and outcomes, yielding mixed results. Existing literature has shown either equivalent[3-8] or worsened[9-11] morbidity with resident participation. Longer operative time with trainee involvement, a presumed by-product of intraoperative teaching and novice inefficiency, has been demonstrated in most studies,[3,5,6,8-10] although this finding is not unanimous.[4,12] The association likely varies by procedure and surgical discipline given the different skills required and variation in training paradigms.

To date, there is a paucity of literature examining the impact of trainee involvement specifically in thoracic surgery. Lobectomy for lung cancer is the most common

Accepted for publication Dec 2, 2020.

Address correspondence to Dr Trachiotis, Division of Cardiothoracic Surgery and Heart Center, Washington, DC Veterans Affairs Medical Center, 50 Irving St NW, Ste 2A-163, Washington, DC 20422; email: gregory.trachiotis@va.gov.

The Supplemental Tables can be viewed in the online version of this article [10.1016/j.athoracsur.2020.12.005] on http://www.annalsthoracicsurgery.org.

0003-4975/$36.00
https://doi.org/10.1016/j.athoracsur.2020.12.005

major procedure reported in The Society for Thoracic Surgeons General Thoracic Surgery Database, and accordingly represents a fundamental competency for thoracic surgery trainees.[13] Video-assisted thoracoscopic surgery (VATS) has become the recommended lobectomy approach for early-stage non-small cell lung cancer.[14] This technique requires advanced visuospatial anatomic understanding and a complex minimally invasive skill set.[15] Higher-complexity procedures such as lung cancer resection have stronger associations between operator experience and outcomes,[16,17] which presents a challenge for residency programs seeking to meet today's quality benchmarks while providing trainees the graduated autonomy to become competent thoracic surgeons of tomorrow.

To understand the impact of resident and fellow involvement on thoracic surgery cases in the contemporary training landscape, this study compared 30-day morbidity and mortality outcomes, operative time, and postoperative hospital length of stay for patients undergoing VATS lobectomy for lung cancer with and without trainee participation. A secondary aim was to identify factors associated with high and low operative autonomy for trainees in these cases.

Patients and Methods

Data Source

This retrospective cohort study was performed using prospectively collected data in the Veterans Affairs Surgical Quality Improvement Program (VASQIP) database.[18] Originating in 1991, VASQIP is a national initiative requiring mandatory participation from all Veterans Affairs (VA) hospitals.[19,20] Predefined demographic, preoperative clinical and laboratory, and operative variables, as well as 30-day morbidity and mortality are prospectively collected by trained clinical abstractors from systematic sampling of eligible surgical cases.[19,20] Data are audited for validation with external studies corroborating high reliability.[19,21] The Washington, DC VA Medical Center Institutional Review Board approved this study, and the need for informed consent was waived because data did not contain identifiable protected health information and the analysis was retrospective.

Study Population

All veterans aged 18 years and greater who were undergoing VATS lobectomy between 2008 and 2018 were identified using Current Procedural Terminology code 32663 (Thoracoscopy, surgical; with lobectomy [single lobe]). Patients with primary International Classification of Diseases codes specifying malignancy as the diagnostic indication for surgery were included (Supplemental Table 1). Video-assisted thoracoscopic surgery lobectomy for other indications, robotic cases (identified by Current Procedural Terminology modifier S2900), sleeve lobectomy, bilobectomy, completion pneumonectomy, and lobectomy combined with other major concurrent procedures were excluded from analysis. For patients with more than 1 procedure within a 30-day period, only the first case was included (Figure 1). Veterans Affairs Surgical Quality Improvement Program records the postgraduate year (PGY) of any resident or fellow participating in an operation (reported as levels 1-10), or if an attending surgeon performed a case without trainees (reported as level 0). Based on this variable, the cohort was split into 2 groups for analysis: cases with residents and fellows (trainees) involved, and cases performed only by attending surgeons.

Variables

Table 1 lists preoperative demographic and clinical variables, hospital region, and operative year. Estimated glomerular filtration rate (eGFR) was calculated using the Chronic Kidney Disease Epidemiology Collaboration equation.[22] Hypoalbuminemia was defined as a preoperative serum albumin level less than 3.5 g/dL. Anemia was defined as hematocrit less than 41% in males and less than 36% in females. The hospital region was categorized according to the US Census Bureau designation.[23]

Primary outcomes included operative time, length of stay, and 30-day composite morbidity and mortality. Operative time was defined as time from the first incision to the application of all surgical dressings. Length of stay was calculated in days from the end time of surgery to the time of hospital discharge. Secondary outcomes included prolonged operative time and length of stay (defined as greater than 75th percentile for each), 30-day mortality, reoperation, perioperative bleeding requiring more than 3 units packed red blood cell transfusion, and the following organ system–specific composite complications: major adverse cardiovascular and cerebrovascular events (stroke, myocardial infarction, and/or cardiac arrest), pulmonary (pneumonia, prolonged ventilator support $>$48 hours, and/or unplanned reintubation), renal (progressive renal insufficiency and/or acute renal failure requiring new dialysis), thromboembolic (deep venous thrombosis or pulmonary embolism), infectious (sepsis, urinary tract infection, or *Clostridium difficile* infection), and wound-related (dehiscence or superficial, deep, or organ-space surgical site infections). Progressive renal insufficiency is defined in VASQIP as increased serum creatinine concentration 2 mg/dL or greater relative to the preoperative value, without needing dialysis. For subanalysis by training level, we categorized trainees into 3 groups: junior-level residents (PGY 1-3), senior-level residents (PGY 4-5), and fellow-level (PGY $\geq$6).

For cases involving residents and fellows, the level of operative autonomy was assessed using a variable describing the highest level of supervision provided by the attending surgeon. Low-autonomy cases were those reported as "Attending doing the operation." High-autonomy cases were those reported as "Attending in operating room assisting the resident," "Attending in operating room, not scrubbed," or "Attending in operating room suite, immediately available." The entry "Attending in operating room, scrubbed" was considered neutral.

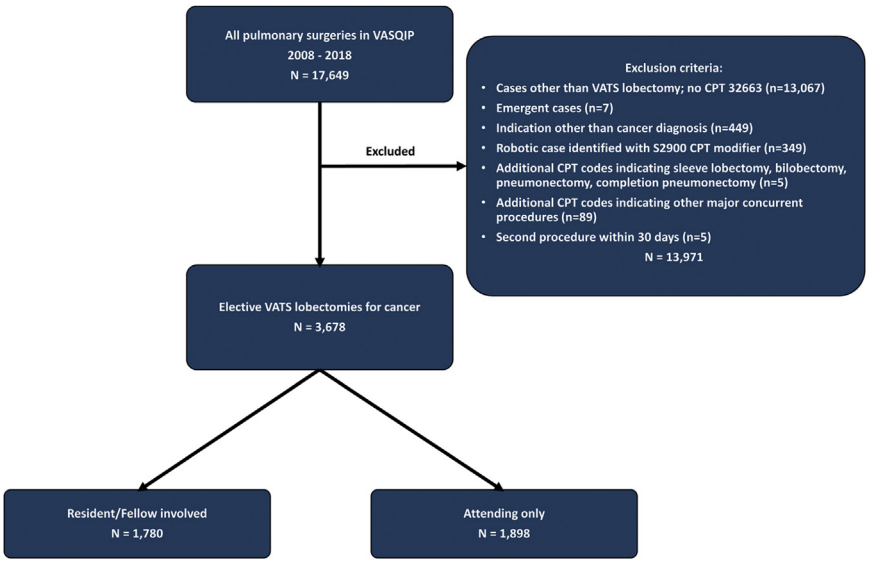

Figure 1. Flow diagram depicting selection method of patient cohort in this study. (CPT, Current Procedural Terminology code; VASQIP, Veterans Affairs Surgical Quality Improvement Program; VATS, video-assisted thoracoscopic surgery.)

Statistical Analysis

Descriptive statistics compared demographics, preoperative clinical characteristics, and hospital characteristics of patients in resident and fellow and attending-only cohorts. Chi-square and Fisher exact test were used for adequate and small expected cell count ($\geq$25% of cell counts $\leq$5) categorical variables, respectively. Independent-samples *t* test and Mann-Whitney U test were employed for normally distributed and nonparametric continuous variables, respectively. We assessed normality using the Kolmogorov-Smirnov test.

Univariable comparisons with *P* less than .2 were considered potential confounding covariates and entered into multivariable models after a backward stepwise selection procedure with stay criteria $\alpha = 0.1$. Covariates for adjustment included race, albumin, dependent functional status, American Society of Anesthesiologists (ASA) classification, prior myocardial infarction within 6 months of surgery, hypertension requiring medication, history of chronic obstructive pulmonary disease, dyspnea, disseminated cancer, receipt of preoperative radiation, and operative year. Multicollinearity of covariates was assessed by way of variance inflation factor analysis in conjunction with the condition index. A variance inflation factor less than 2 was considered acceptable and multicollinearity of covariates was not detected.

Multivariable logistic regression models were used to analyze categorical outcomes. Corresponding adjusted odds ratios (aORs), 95% confidence intervals (CIs), and *P* values are reported. Generalized linear regression models were used to analyze continuous outcomes. Corresponding parameter estimates (β), SEs, and *P* values are reported. Positive skew of the nonparametric continuous outcome for length of stay was addressed by way of natural logarithm (ln) transformation to meet assumptions of normally distributed residuals and homoscedasticity among variance of error terms within multivariable linear regression. Resulting transformed parameter estimates and SEs were reverse-transformed for interpretation.

The algorithm of statistical methodology mentioned earlier was reiterated in post hoc testing to compare junior-level residents (PGY 1-3), senior-level residents (PGY 4-5), and fellow-level (PGY $\geq$6) separately with the attending-only cohort.

Within the resident and fellow cohort, significant independent associates and predictors of high autonomy and low autonomy were identified. Demographic, preoperative clinical characteristics and hospital characteristics were compared between cohorts defined as having high autonomy versus not having high autonomy, as well as having low autonomy versus not having low autonomy. Multinomial categorical variables such as hospital region and academic quarter were individually binned to analyze independent associations better. Univariable comparisons with resulting *P* value less than .2 between autonomy cohorts were entered into respective multivariate models to identify significant independent factors associated with high autonomy and low autonomy.

We performed multiple comparison adjustment using Bonferroni correction. A 2-sided *P* value less than .004 was considered statistically significant for primary and secondary outcome multivariable models, because 14 tests were used (.05 / 14 = .004). A 2-sided *P* value less than .05 was considered statistically significant for all post hoc analyses. All statistical analysis was performed using SAS software (version 9.4, SAS Institute Inc, Cary, NC).

Results

A total of 3678 cases met inclusion criteria for analysis, 1780 of which had resident and fellow involvement (48.4%). Mean age was 67.1 $\pm$ 7.4 years and the median (interquartile range) of PGY-level among resident and fellow

Table 1. Demographic, Preoperative Clinical, and Hospital Characteristics

Covariates	Resident/Fellow (n = 1780)	Attending Only (n = 1898)	P[c]
Age, y (mean [SD])	67.1 ± 7.5	67.1 ± 7.3	.99
Female	71 (4.0)	74 (3.9)	.89
White race	1240 (69.7)	1474 (77.7)	**<.001**[a]
Obesity (body mass index ≥30)	472 (26.5)	531 (28.0)	.32
Albumin <3.5 g/dL	157 (8.8)	194 (10.2)	.15[a]
Dependent functional status	40 (2.3)	26 (1.4)	**.045**[a]
American Society of Anesthesiologist score >3	202 (11.4)	274 (14.4)	**.005***
Recent (<6 mo) myocardial infarction	62 (3.5)	81 (4.3)	.22
Hypertension requiring medication	1341 (75.3)	1354 (71.3)	**.006**[a]
Congestive heart failure	133 (7.5)	162 (8.5)	.24
Prior stroke	178 (10.0)	198 (10.4)	.67
Chronic obstructive pulmonary disease	674 (37.9)	806 (42.5)	**.005**[a]
Dyspnea	410 (23.0)	503 (26.5)	**.015**[a]
Smoker	956 (53.7)	985 (51.9)	.27
Estimated glomerular filtration rate <60 mL/min	304 (17.1)	351 (18.5)	.26
Dialysis	7 (0.4)	5 (0.3)	.49
Diabetes	377 (21.2)	398 (21.0)	.88
Anemia[b]	753 (42.3)	772 (40.7)	.32
Disseminated cancer	57 (3.2)	42 (2.2)	.06[a]
Radiation therapy (within 30 d)	10 (0.6)	19 (1.0)	.13[a]
Chemotherapy (within 30 d)	8 (0.5)	12 (0.6)	.45
Hospital region			.27
Northeast	218 (12.3)	244 (12.9)	
Midwest	445 (25.0)	499 (26.3)	
South	761 (42.8)	822 (43.3)	
West	356 (20.0)	333 (17.5)	
Operative year			**<.001**[a]
2008	118 (65.6)	62 (34.4)	
2009	125 (51.4)	118 (48.6)	
2010	144 (60.5)	94 (39.5)	
2011	155 (51.2)	148 (48.8)	
2012	189 (56.3)	147 (43.7)	
2013	159 (50.5)	156 (49.5)	
2014	166 (42.2)	227 (57.8)	
2015	186 (44.6)	231 (55.4)	
2016	199 (39.3)	308 (60.7)	
2017	196 (48.6)	207 (51.4)	
2018	143 (41.7)	200 (58.3)	

[a]Entry into multivariable models before following backward stepwise selection procedure; [b]Anemia indicates a hematocrit value less than 41% (males) or less than 36% (females); [c]Bolded entries indicate univariate statistical significance ($P < .05$). Data are shown as n (%) except where otherwise indicated.

cases was 5 (4-7). Resident and fellow cases were associated with significantly higher proportions of black race, hypertension, and dependent functional status; lower proportions of American Society of Anesthesiologists classification greater than 3, chronic obstructive pulmonary disease, and dyspnea; and varied differences in operative year distribution (all $P < .05$) (Table 1).

After adjusting for confounding covariates in multivariate analysis, no difference was detected between resident and fellow and attending-only cases for 30-day composite morbidity (aOR = 0.93; 95% CI, 0.77-1.11; $P = .40$). Numeric (continuous) length of stay was not significantly different between cohorts (reverse-transformed mean ± SE adjusted length of stay, 3% ± 2% longer for resident and fellow involved cases; $P = .13$). On average, resident and fellow involved cases had an adjusted mean operative time of 11.4 ± 3 minutes shorter than attending-only cases ($P < .001$) (Table 2). No differences between groups were seen in 30-day major adverse cardiovascular and cerebrovascular events (aOR = 1.06; 95% CI, 0.63-1.78; $P = .84$), pulmonary complications (aOR = 0.96; 95% CI, 0.76-1.22; $P = .75$), renal complications (aOR = 1.39; 95% CI, 0.67-2.88; $P = .38$), hemorrhage (aOR = 1.41; 95% CI, 0.38-5.29; $P = .61$), thromboembolic complications (aOR = 0.70; 95% CI, 0.38-1.31; $P = .26$), infectious complications (aOR = 1.12; 95% CI, 0.80-1.56;

Table 2. Operative Time and Postoperative Outcomes

Outcomes	Resident/ Fellow (n = 1780)	Attending Only (n = 1898)	Univariable *P*	Resident/Fellow Versus Attending Only (Adjusted Odds Ratio [95% Confidence Interval])	Multivariable *P*
Composite morbidity, n (%)	285 (16.0)	325 (17.1)	.37	0.93 (0.77-1.11)	.40
Total postoperative hospital length of stay continuous, d (median [interquartile range]) days	6 (4-8)	6 (4-8)	.33	[ln (β (SE)] = 0.03 (0.02)	.13
Operative time, h (mean [SD])	3.6 ± 1.4	3.8 ± 1.6	<.001	β (SE) = –0.19 (0.05)	<.001[a]

[a]Statistically significant ($P < .0035$, from Bonferroni correction using 14 tests).
ln, natural logarithm transformed.

$P = .52$), wound complications (aOR = 1.01; 95% CI, 0.62-1.64; $P = .98$), reoperation (aOR = 1.27; 95% CI, 0.92-1.73; $P = .14$), or prolonged length of stay (aOR = 1.13; 95% CI, 0.96-1.33; $P = .13$). Thirty-day mortality was 2.3% in resident-involved cases versus 1.3% in attending-only cases, although this finding did not meet statistical significance (aOR = 1.66; 95% CI, 0.98-2.81; $P = .06$). Resident and fellow involvement was associated with significantly decreased adjusted odds of prolonged operative time relative to attending-only cases (aOR = 0.72; 95% CI, 0.62-0.83; $P < .001$) (Supplemental Table 2).

Comparing junior-level resident, senior-level resident, and fellow-level cases with attending-only cases, no cohort showed differences in adjusted odds of composite morbidity or length of stay (Supplemental Table 3). Junior-level resident involvement was associated with significantly decreased adjusted odds of prolonged (greater than 75th percentile) operative time relative to attending-only cases (aOR = 0.67; 95% CI, 0.51-0.89; $P = .005$). On average, junior-level resident cases had an adjusted mean operative time 14.4 ± 5.4 minutes shorter than attending-only cases ($P = .007$). Senior-level resident involvement was significantly associated with a decreased adjusted odds of prolonged operative time relative to attending-only cases (aOR = 0.64; 95% CI, 0.51-0.81; $P < .001$). On average, senior-level resident cases had an adjusted mean operative time 16.2 ± 4.2 minutes shorter than attending-only cases ($P < .001$). Fellow-level trainee involvement was associated with a significantly decreased adjusted odds of prolonged operative time relative to attending-only cases (aOR = 0.79; 95% CI, 0.65-0.95; $P = .01$). On average, fellow-level cases had an adjusted mean operative time 6.6 ± 3.6 minutes shorter than attending-only cases; however, this was not detected to be statistically significant ($P = .07$).

Figure 2A and 2B illustrates forest plots of corresponding reduced multivariable models predicting high and low operative autonomy, respectively. Cases with congestive heart failure patients (aOR = 1.89; 95% CI, 1.03-3.47; $P = .04$) and more recent operative years (aOR = 1.32; 95% CI, 1.19-1.46; $P < .001$) were independently associated with an increased odds of high operative autonomy. Cases occurring in the first half of the academic year were independently associated with a decreased odds of high operative autonomy (July through September, aOR = 0.17, 95% CI, 0.08-0.37; $P < .001$; October through December, aOR = 0.10, 95% CI, 0.03-0.31, $P < .001$) (Figure 2A). In addition, cases with congestive heart failure patients (aOR = 1.76; 95% CI, 1.05-2.96; $P = .03$), in Northeast region facilities (aOR = 1.81; 95% CI, 1.17-2.82; $P = .008$), occurring in the first quarter of the academic year (July through September, aOR = 1.50; 95% CI, 1.07-2.11; $P = .02$), and involving junior-level residents (aOR = 2.65; 95% CI, 1.77-3.98; $P < .001$) and senior-level residents (aOR = 1.83; 95% CI, 1.26-2.65; $P = .002$) compared with fellows were independently associated with an increased odds of low operative autonomy. Cases from facilities in the Midwest (aOR = 0.47; 95% CI, 0.30-0.74; $P = .001$) and South (aOR = 0.32; 95% CI, 0.21-0.50; $P < .001$) were independently associated with a decreased odds of low operative autonomy (Figure 2B).

Comment

The VA Healthcare System has a rich history of resident education, in which more than half of all US-trained physicians receive part of their graduate medical education at VA medical centers.[24] Leveraging the meticulous record-keeping of the mandatory nationwide VASQIP program, with its unique inclusion of data documenting resident and fellow operative participation, this study found that VATS lobectomy for cancer performed with trainees involved was associated with similar morbidity and length of stay although shorter operative time compared with cases performed by attending surgeons alone. These same findings held true regardless of resident and fellow training level. This study also revealed important temporal and regional trends associated with the degree of trainee operative autonomy afforded, because cases early in the academic year (July through October) and those performed in the US Northeast were associated with low autonomy.

This study specifically describes the impact of trainee involvement in general thoracic surgery. Previous studies in other surgical disciplines associated trainee involvement with longer operative time. One study suggested that on average over the course of general surgery residency, a resident adds 11,184 lost minutes of operative time equivalent to $47,979 of excess operating room costs.[25] Our

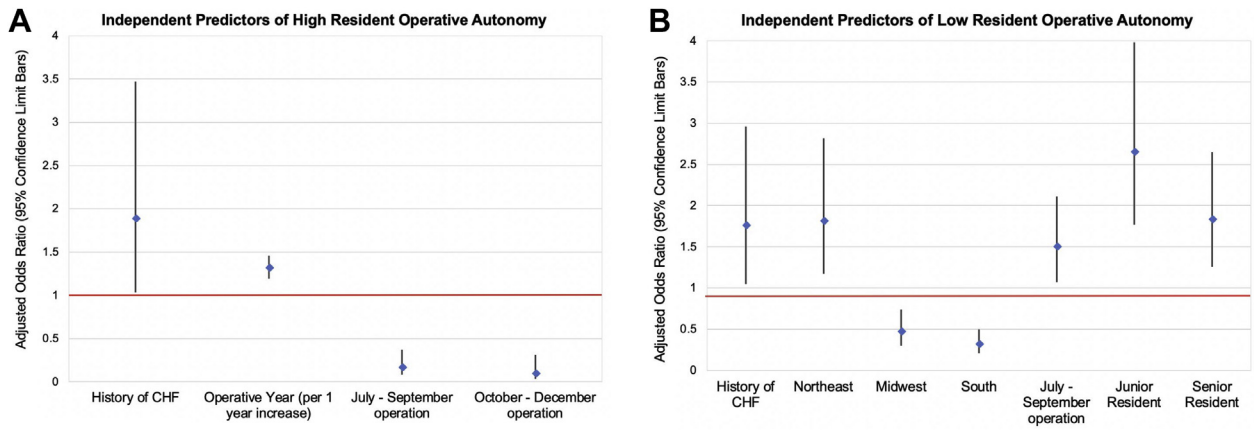

Figure 2. Forest plots showing adjusted odds ratios from reduced multivariable models of factors found to be independently associated with (A) high and (B) low trainee operative autonomy. (CHF, congestive heart failure.)

finding that on average, VATS lobectomies for cancer involving residents and fellows had 11 minutes shorter operative time than attending-only cases clearly runs counter to the previous literature and suggests that resident teaching does not necessarily increase operative inefficiency for this procedure. Decreased operative time also did not come at the expense of clinical outcomes, because we found no difference in postoperative morbidity or length of stay with resident and fellow versus attending-only cases. This mirrors the outcome profile shown in one study by Itani and colleagues[26] of high-autonomy resident cases. These findings imply that the impact of resident and fellow involvement on operative conduct is procedure-specific and cannot be broadly generalized. Perhaps given the complexity in both technical skills and visuospatial processing required for VATS, the addition of residents and fellows working in conjunction with teaching faculty enables greater efficiency than if faculty were to operate with less-trained surgical assistants. It is also probable that access to advanced VATS simulation technology, which is more likely to be available in academically affiliated centers, may be beneficial to residents and fellows as well as the large number of attending faculty who trained before the advent of these VATS techniques.[27]

With health care systems facing increasing pressure to limit expenditures, graduate medical education is often seen as a target for cost-cutting rather than as a potential contributor to efficiency and value in patient care.[28] As it stands, current financial pressures negatively affect the progressive autonomy that is fundamental to surgical training, because one survey study showed that 70% of surgical teaching faculty strongly agreed that regulations regarding reimbursement were implicated in decreased resident operative autonomy.[29] Objective evidence regarding the contributions and outcomes of surgical trainee participation in operative care in specific disciplines, such as the results of this study with respect to VATS lobectomy for cancer, is necessary to show the value resident training can bring to health care systems and to guide support for graduate medical education funding.[28]

In addition to understanding the impact residents have on surgical outcomes, determining the factors that influence resident involvement in VATS lobectomies for cancer also has not been previously explored. Beyond financial pressures, numerous institutional, temporal, and patient factors contribute to the degree of operative autonomy afforded to trainees. Our review showed that low operative autonomy in VATS lobectomy cases was more frequent in the Northeast and less prevalent in the Midwest and South. Clearly, regional differences in culture and health care economics influence trends in trainee operative autonomy. More nuanced, prospectively collected data on surgical faculty attitudes and objective observation of trainee operative performance are needed to better substantiate the trends reported in this study. In addition to regional variations, we observed that less experienced residents and those participating in cases early in the academic year are likely appropriately given less autonomy because of their relative inexperience.

This study had limitations. First, it was a retrospective database review and therefore limited by the bias inherent in such design. In addition, VASQIP does not record tumor-specific data such as size, location, and stage, which may affect operative time and outcomes. Also, VASQIP does not provide information regarding trainees' specialties (general surgery or thoracic integrated). Furthermore, there is no way to distinguish between a senior resident and a fellow greater than PGY 5. Moreover, we did not have granular information detailing the exact steps and extent of operations performed by trainees to quantify the operative autonomy granted. Finally, VASQIP reports cases using systematic sampling; therefore, we could not ascertain the impact of hospital or surgeon volume on outcomes.

This study suggests that VATS lobectomy for cancer performed with trainees versus cases performed by attending surgeons alone is not associated with increased morbidity or length of stay, and that it may be associated with shorter operative time. These findings suggest that current training paradigms in minimally invasive thoracic surgery are safe and that the involvement of motivated

trainees with appropriate supervision may benefit operative conduct. This information can help inform patient and institutional perceptions of the role and contributions that residents and fellows make to health care delivery in general thoracic surgery.

The authors wish to acknowledge that this work would not have been possible without the collaboration and resources of VASQIP and the VA Informatics and Computing Infrastructure. This work was supported with resources and facilities at the Washington, DC VA medical center. Ethan S. Rosenfeld, Michael A. Napolitano, Jared L. Antevil, and Gregory D. Trachiotis receive a salary from the Department of Veterans Affairs. The views expressed in this report are those of the authors and do not necessarily represent the views of the Department of Veterans Affairs or the US Government.

References

1. Cowles RA, Moyer CA, Sonnad SS, et al. Doctor-patient communication in surgery: attitudes and expectations of general surgery patients about the involvement and education of surgical residents. *J Am Coll Surg*. 2001;193:73-80.
2. Porta CR, Sebesta JA, Brown TA, Steele SR, Martin MJ. Training surgeons and the informed consent process: routine disclosure of trainee participation and its effect on patient willingness and consent rates. *Arch Surg*. 2012;147:57-62.
3. Whealon MD, Young MT, Phelan MJ, Nguyen NT. Effect of resident involvement on patient outcomes in complex laparoscopic gastrointestinal operations. *J Am Coll Surg*. 2016;223:186-192.
4. Cvetanovich GL, Schairer WW, Haughom BD, Nicholson GP, Romeo AA. Does resident involvement have an impact on postoperative complications after total shoulder arthroplasty? An analysis of 1382 cases. *J Shoulder Elbow Surg*. 2015;24:1567-1573.
5. Siam B, Al-Kurd A, Simanovsky N, et al. Comparison of appendectomy outcomes between senior general surgeons and general surgery residents. *JAMA Surg*. 2017;152:679-685.
6. Lim S, Parsa AT, Kim BD, Rosenow JM, Kim JYS. Impact of resident involvement in neurosurgery: an analysis of 8748 patients from the 2011 American College of Surgeons National Surgical Quality Improvement Program database. *J Neurosurg*. 2015;122:962-970.
7. Meyer CP, Hanske J, Friedlander DF, et al. The impact of resident involvement in male one-stage anterior urethroplasties. *Urology*. 2015;85:937-941.
8. Kiran RP, Ahmed Ali U, Coffey JC, et al. Impact of resident participation in surgical operations on postoperative outcomes: National Surgical Quality Improvement Program. *Ann Surg*. 2012;256:469-475.
9. Doyon L, Moreno-Koehler A, Ricciardi R, Nepomnayshy D. Resident participation in laparoscopic Roux-en-Y gastric bypass: a comparison of outcomes from the ACS-NSQIP database. *Surg Endosc*. 2016;30:3216-3224.
10. Ejaz A, Spolverato G, Kim Y, et al. The impact of resident involvement on surgical outcomes among patients undergoing hepatic and pancreatic resections. *Surgery*. 2015;158:323-330.
11. Jordan SW, Mioton LM, Smetona J, et al. Resident involvement and plastic surgery outcomes: an analysis of 10,356 patients from the american college of surgeons national surgical quality improvement program database. *Plast Reconstr Surg*. 2013;131:763-773.
12. Uecker J, Luftman K, Ali S, Brown C. Comparable operative times with and without surgery resident participation. *J Surg Educ*. 2013;70:696-699.
13. Kozower BD, O'Brien SM, Kosinski AS, et al. The Society of Thoracic Surgeons composite score for rating program performance for lobectomy for lung cancer. *Ann Thorac Surg*. 2016;101:1379-1387.
14. Howington JA, Blum MG, Chang AC, Balekian AA, Murthy SC. Treatment of stage I and II non-small cell lung cancer: diagnosis and management of lung cancer, 3rd ed: American College of Chest Physicians evidence-based clinical practice guidelines. *Chest*. 2013;143(5 suppl):e278S-e313S.
15. Zwischenberger BA, D'Amico TA, Tong BC. How I teach a thoracoscopic lobectomy. *Ann Thorac Surg*. 2016;101:846-849.
16. Harrison S, Sun T, Kamel MK, et al. Do individual surgeon volumes affect outcomes in thoracic surgery? *Eur J Cardiothorac Surg*. 2019;56:770-777.
17. Falcoz PE, Puyraveau M, Rivera C, et al. The impact of hospital and surgeon volume on the 30-day mortality of lung cancer surgery: a nation-based reappraisal. *J Thorac Cardiovasc Surg*. 2014;148:841-848.
18. VA Informatics and Computing Infrastructure. Available at: https://vaww.vinci.med.va.gov. Accessed November 7, 2019.
19. Khuri SF, Daley J, Henderson W, et al. The Department of Veterans Affairs' NSQIP: the first national, validated, outcome-based, risk-adjusted, and peer-controlled program for the measurement and enhancement of the quality of surgical care. *Ann Surg*. 1998;228:491-507.
20. Massarweh NN, Kaji AH, Itani KMF. Practical guide to surgical data sets: Veterans Affairs Surgical Quality Improvement Program (VASQIP). *JAMA Surg*. 2018;153:768-769.
21. Davis CL, Pierce JR, Henderson W, et al. Assessment of the reliability of data collected for the Department of Veterans Affairs National Surgical Quality Improvement Program. *J Am Coll Surg*. 2007;204:550-560.
22. Levey AS, Stevens LA, Schmid CH, et al. A new equation to estimate glomerular filtration rate. *Ann Intern Med*. 2009;150:604-612.
23. US Census Bureau, Geography Division. Census Regions and Divisions of the United States. Available at: https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf. Accessed March 26, 2020.
24. Longo WE, Cheadle W, Fink A, et al. The role of the Veterans Affairs Medical Centers in patient care, surgical education, research and faculty development. *Am J Surg*. 2005;190:662-675.
25. Bridges M, Diamond DL. The financial impact of teaching surgical residents in the operating room. *Am J Surg*. 1999;177:28-32.
26. Itani KMF, DePalma RG, Schifftner T, et al. Surgical resident supervision in the operating room and outcomes of care in Veterans Affairs hospitals. *Am J Surg*. 2005;190:725-731.
27. Tong BC, Gustafson MR, Balderson SS, D'Amico TA, Meyerson SL. Validation of a thoracoscopic lobectomy simulator. *Eur J Cardiothorac Surg*. 2012;42:364-369.
28. Fayanju OM, Aggarwal R, Baucom RB, Ferrone CR, Massaro D, Terhune KP. Surgical education and health care reform. *Ann Surg*. 2017;265:459-460.
29. Kempenich JW, Willis RE, Rakosi R, Wiersch J, Schenarts PJ. How do perceptions of autonomy differ in general surgery training between faculty, senior residents, hospital administrators, and the general public? A multi-institutional study. *J Surg Educ*. 2015;72:e193-e201.