Declining Operative Experience in Pulmonary Resection for Cancer Among Trainees at Veterans Affairs Hospitals: A Concerning Trend in Thoracic Surgical Education

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BACKGROUND: There is substantial heterogeneity in thoracic surgery exposure among surgical trainees. This study analyzed national trends and outcomes of trainee involvement in surgery for early-stage lung cancer at Veterans Affairs (VA) hospitals, a major clinical training site.

STUDY DESIGN: We conducted a retrospective cohort study of patients undergoing surgery for stage I non-small cell lung cancer at VA hospitals between October 1, 2006, and December 31, 2020. We compared outcomes of patients who had their operations performed by attending surgeons and those who had operations with a resident or fellow involved. Cochran-Armitage tests were used to analyze temporal trends in intraoperative trainee involvement. Multivariable regression models were used to evaluate the association between trainee involvement and surgical outcomes.

RESULTS: In total, 10,175 Veterans were included in the analysis. Trainees participated in 4,887 operations (48.0%; median PGY level 5, interquartile range 4 to 6). The percentage of operations with trainees involved decreased from 63.1% in late 2006 to 44.2% in 2013 and to 29.2% in 2020 ($p < 0.001$). In multivariable analyses, operation duration ($p = 0.133$), major postoperative complications ($p = 0.222$), prolonged hospitalization ($p = 0.989$), 30-day readmission ($p = 0.704$), 90-day mortality ($p = 0.813$), and overall survival ($p = 0.337$) were similar between patients with attending-performed and trainee-involved operations. In subgroup analyses by surgical approach, similar findings were observed, except trainee involvement was associated with longer operation duration by 19.5 minutes (95% CI 9.7 to 29.3, $p < 0.001$) in operations performed via thoracotomy ($n = 5,464$; 53.9%).

CONCLUSIONS: Despite not being associated with increased patient morbidity or mortality, trainee involvement in surgery for early-stage lung cancer at VA hospitals has significantly decreased during the past decade. VA teaching hospitals may offer a suitable learning environment for surgical training programs interested in increasing trainee exposure to core thoracic procedures. (J Am Coll Surg 2025;241:1038–1049. © 2025 by the American College of Surgeons. Published by Wolters Kluwer Health, Inc. All rights reserved.)

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Abbreviations and Acronyms

CT	=	cardiothoracic
GS	=	general surgery
NSCLC	=	non-small cell lung cancer
OS	=	overall survival
VA	=	Veterans Affairs
VASQIP	=	Veterans Affairs Surgical Quality Improvement Program
VATS	=	video-assisted thoracic surgery

Lung cancer is a leading cause of cancer-related morbidity and mortality in the US.[1] The percentage of patients with lung cancer diagnosed with stage I, resectable non-small cell lung cancer (NSCLC) has increased substantially after the implementation of national screening guidelines in 2013.[2-4] Consequently, oncologic pulmonary resection remains the most frequently performed major operation by thoracic surgeons, making it a critical component of the training curriculum for surgical residents and fellows specializing in cardiothoracic (CT) surgery.[5] Adequate training in lung cancer resection is particularly important given the projected national shortage of CT surgeons, which threatens to strain the surgical workforce and may result in fewer patients undergoing surgery for stage I NSCLC.[6-12] Ensuring that surgical trainees receive sufficient hands-on experience performing pulmonary resections under the supervision of experienced faculty is essential to addressing this workforce shortage while maintaining high standards of patient care and surgical education.

During the past 2 decades, CT surgical education has evolved significantly due to advancements in minimally invasive surgical techniques and the development of integrated training programs.[7,13-15] However, substantial variation exists in the curricula of general surgery (GS) and CT training programs, leading to differences in training experiences and the self-reported comfort levels of graduating residents and fellows in performing core general thoracic procedures, such as lung cancer resection.[16-22] A recent national survey of fourth- and fifth-year GS residents, 64% of whom trained at institutions with a CT training program, revealed that the majority of trainees lacked comfort performing an open or video-assisted thoracic surgery (VATS) lobectomy.[19] Similarly, Boffa and colleagues[23] found that only 58% of CT fellowship graduates from 2006 to 2008 felt comfortable performing a VATS lobectomy. These findings raise concern and highlight the need to evaluate recent national trends in trainee participation in core thoracic procedures, such as lung cancer resection, to identify educational gaps in contemporary surgical training programs.

As major clinical training sites across the US, Veterans Affairs (VA) hospitals play a vital role in surgical education while also providing comprehensive care to nearly 8,000 Veterans diagnosed with lung cancer annually.[24-26] The VA Healthcare System operates the largest education and training platform for medical professionals in the nation,

Institute or Veterans Health Administration. Dr Tohmasi takes full responsibility for the integrity of this research and its results.

IRB and Informed Consent Statement: Protocol approved by the St Louis Veterans Health Administration's Research and Development Committee (No. 1214632, issued on August 2, 2019) and IRB. The requirement for signed informed consent was waived, given the de-identified nature of this retrospective analysis.

Data Availability Statement: The data used in this study are maintained by the US Department of Veterans Affairs (VA). VA data are available to VA-affiliated researchers with VA-secured computing access after appropriate study protocol approval. For more information, visit https://www.virec.research.va.gov or contact the VA Information Resource Center at VIReC@va.gov. Additional inquiries can be directed to the corresponding author. Deidentified data from the VA population discussed in this article can be made available on request with appropriate IRB and VA approval as well as data use agreements. We may balance the potential benefits and risks of each request and then provide the data that can be shared.

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Supplemental digital content is available for this article.

with nearly 51,000 resident physicians rotating through VA hospitals during the 2022 to 2023 academic year.[27] Despite this, limited research has examined the relationship between trainee involvement and thoracic surgery outcomes within the VA Healthcare System.[28] Given the VA Healthcare System's dual mission of delivering high-quality patient care and training the next generation of physicians, investigating trends and outcomes associated with trainee involvement in major operations is both timely and important.[25,26,28-30] Specifically, exploring the impact of trainee participation in core thoracic surgery procedures at VA hospitals is crucial, as these findings could provide valuable insights to optimize surgical training and guide policies that balance the educational needs of trainees with the imperative of ensuring safe, high-quality patient care.

In this study, we analyzed national VA data to assess trends in trainee involvement in lung cancer resections during a 14-year span. Additionally, we compared risk-adjusted outcomes between oncologic pulmonary resections performed with and without resident or fellow participation. We hypothesized that trainee involvement in oncologic pulmonary resections has decreased over time, despite there being no clear association between trainee participation and adverse patient outcomes.

METHODS

Study design and population

This retrospective cohort study included patients with clinical stage I NSCLC who underwent pulmonary resection at VA hospitals between October 1, 2006, and December 31, 2020. The VA St Louis Health Care System Research and Development Committee (No. 1214632, approved on August 2, 2019) and IRB approved the study protocol, waiving the requirement for informed consent due to the retrospective and deidentified nature of the analysis. This study followed the Declaration of Helsinki and adhered to the Strengthening the Reporting of Observational Studies in Epidemiology guidelines.[31]

Patient data were extracted from the VA Informatics and Computing Infrastructure and Corporate Data Warehouse, which integrate multiple national clinical and administrative datasets, including the VA Surgical Quality Improvement Program (VASQIP) and Corporate Data Warehouse–Oncology Raw Domain.[32,33] NSCLC diagnoses were identified using ICD for Oncology, third edition, codes, whereas procedures were identified through relevant ICD-9, ICD-10, and CPT codes. Patients aged 18 years and older diagnosed with clinical stage I NSCLC (tumors 5 cm or smaller, no lymph node involvement) based on the seventh edition of the American Joint Committee on Cancer staging system and who underwent curative-intent lung resection (lobectomy, pneumonectomy, segmentectomy, or wedge resection) were included. Patients were excluded if they had unknown dates of diagnosis, received neoadjuvant therapy, had recurrent cancer, or had missing operative details about intraoperative trainee participation (n = 82; 0.8%).

Intraoperative trainee involvement

Using methodology previously described in the VA literature, patients were categorized into 2 groups: those who underwent an operation with a trainee (resident or fellow) involved and those operated on only by attending surgeons.[28-30] The VASQIP database records the PGY level of trainees involved in operations, ranging from PGY level 1 to 10, whereas operations performed by attending surgeons are recorded as PGY level 0. Based on this variable, the study cohort was categorized into 2 groups for analysis: cases with trainees involved (cases assigned a PGY of 1 to 10) and cases performed only by attending surgeons (cases assigned a PGY level of 0). Additionally, VASQIP documents the highest level of attending surgeon supervision, categorized as "attending performing the operation," "attending in the operating room, scrubbed," or "attending in the operating room, not scrubbed." Using these codes, all lung cancer resections in our cohort were classified as follows: (1) "attending-performed," when the attending surgeon performed the operation; (2) "attending-assisted," when a trainee was documented as present with the attending surgeon scrubbed and assisting; or (3) "trainee-performed," where the trainee served as the primary surgeon, with the attending surgeon either present in the operating room or immediately available within the hospital. Due to the low frequency of "trainee-performed" cases in our cohort (n = 136; 1.3%), these cases were combined with "attending-assisted" cases into 1 group (trainee-involved). Cases labeled as "attending-performed" (assigned a PGY level of 0) but assigned a supervision level of "attending in the operating room, not scrubbed" were excluded as the study team deemed this coding inconsistent and inaccurate (n = 204; 2.0%). A study CONSORT diagram is shown in **Supplemental Digital Content 1, Figure 1** https://links.lww.com/JACS/A506. As clinical training level is not captured in VASQIP, we categorized junior-level residents, senior-level residents, and fellows as trainees with recorded PGY levels of 1 to 3, 4 to 5, and 6 or more, respectively.

Covariates

Patient-, cancer-, and operation-related data were collected, including age, sex, race, distance lived from

treatment facility (calculated from the center of the patient's residential ZIP code to the treatment facility's address), comorbidities, tumor size, histology (adenocarcinoma, squamous cell carcinoma, other), annual hospital caseload (volume of lung cancers diagnosed in the year before surgery at a Veterans Health Administration facility), year of operation, surgical approach (thoracoscopic or thoracotomy), lung resection type (lobectomy, segmentectomy, wedge resection, or pneumonectomy), number of lymph nodes sampled, and surgical resection margins. Comorbidities were assessed using the Charlson-Deyo Comorbidity Index, derived from ICD-9 and ICD-10 codes documented within 5 years before and 1 month after surgery.[34,35] Timely surgery was defined as NSCLC resection within 12 weeks of radiographic diagnosis based on earlier research associating treatment delays beyond this timeframe with increased recurrence risk and worse survival.[36]

Outcomes

Our primary outcome was the change in trainee involvement in lung cancer resections over time, assessed by examining the annual proportion of trainee participation in operations across the entire cohort. We also assessed multiple secondary outcomes, including differences in prolonged hospitalization (defined as a hospital admission lasting 14 days or more), 30-day major complications, 30-day readmission, 90-day mortality, and overall survival (OS) between attending-performed and trainee-involved operations. Major complications were defined as occurrences of respiratory failure, empyema, pneumonia, stroke, MI, or renal failure within 30 days after surgery. Complications were identified through query of the VASQIP database as well as ICD-9 and ICD-10 diagnosis codes. OS was defined as the time from the date of surgery to all-cause mortality.

Statistical analysis

Cochran-Armitage tests were used to analyze temporal trends in intraoperative trainee involvement in lung cancer operations. Multivariable logistic regression models were generated to assess the association between intraoperative trainee involvement and postoperative outcomes. Multivariable linear regression was used to analyze continuous outcomes (ie operative duration). OS was analyzed using multivariable Cox proportional hazard modeling. The Veterans Health Administration Death Ascertainment File was used to identify the date of death, with OS data censored at the conclusion of the study's follow-up period (October 15, 2024). Statistical models adjusted for age, sex, race, presence of a trainee in the operation, PGY level of the trainee involved, American Society of Anesthesiologists physical status classification, comorbidities, smoking status, BMI, distance lived from treatment facility, annual hospital caseload, transferred hospitals (defined as surgery performed at a VA facility different from where the cancer diagnosis was made), tumor size, histology, year of surgery, timely surgery, surgical approach, lung resection type, number of lymph nodes sampled, and surgical resection margins. Model results are reported as adjusted odds ratios or hazard ratios with 95% CIs.

Summary statistics are presented as means with SDs or medians with interquartile ranges for continuous data and as frequencies with proportions for categorical data. Continuous variables were compared using Student's *t*-test (for normally distributed data) or the Mann-Whitney *U* test (for nonparametric data). Categorical variables were analyzed using Pearson's chi-square test. Missing data were minimal and categorized as unknown when appropriate. Statistical tests were 2-sided, with significance defined a priori as a p value of <0.05. Analyses were performed using SAS version 9.3 (SAS Institute Inc, Cary, NC).

RESULTS

In total, 10,175 patients with resected clinical stage I NSCLC met the inclusion criteria. The mean patient age was 68.0 (SD 7.6) years. Most patients were men (n = 9,767; 96.0%), of White race (n = 8,286; 81.4%), reported smoking at the time of surgery (n = 5,826; 57.3%), American Society of Anesthesiologists class 3 (n = 8,307; 81.7%), with adenocarcinoma (n = 5,593; 55.0%), underwent lobectomy (n = 7,220; 71.2%), and had a thoracotomy (n = 5,464; 53.9%). Of the 10,175 unique operations, residents and/or fellows participated in 4,887 cases (48.0%; median PGY level 5, interquartile range 4 to 6). Of these operations, 1,108 (10.9%) had a junior-level resident involved, 1,897 (18.6%) had a senior-level resident involved, and 1,882 (18.5%) had a fellow involved. As shown in Table 1, patients who underwent operations involving trainees had significantly higher rates of having fewer comorbidities (mean Charlson-Deyo Comorbidity Index score: 2.8 vs 3.0, $p < 0.001$), identifying as Black (18.1% vs 13.8%, $p < 0.001$), a history of tobacco use (97.3% vs 94.1%, $p < 0.001$), tumors greater than 20 mm (49.0% vs 47.1%, $p = 0.017$), squamous cell carcinoma or other histology (46.8% vs 43.4%, $p = 0.002$), delayed surgery (31.4% vs 28.3%, $p < 0.001$), lower annual hospital caseloads (mean: 97.9 vs 108.3, $p < 0.001$), surgery at their diagnosing facility (94.3% vs 88.7%, $p < 0.001$), procedures performed via thoracotomy (56.2% vs 51.7%, $p < 0.001$), lobectomy (73.0% vs 69.5%, $p = 0.001$), and 10 or more lymph nodes sampled (37.0% vs 33.9%, $p < 0.001$).

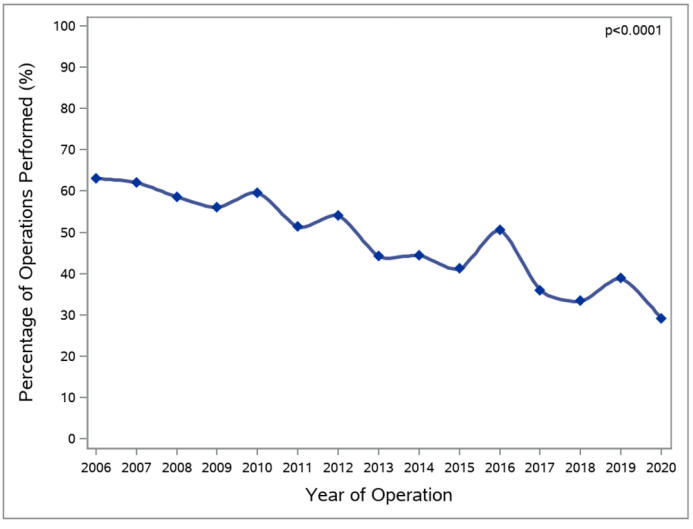
Table 1. Study Population Characteristics and Surgical Outcomes

Characteristic and outcome	Attending-performed (N = 5,288), n (%)	Trainee-involved, (N = 4,887), n (%)	p Value
Age, y, mean (SD)	68.08 (7.53)	67.88 (7.72)	0.1817
Sex, n (%)			0.5466
Male	5,070 (95.88)	4,697 (96.11)	
Female	218 (4.12)	190 (3.89)	
Race, n (%)			<0.0001
White	4,409 (83.38)	3,877 (79.33)	
Black	728 (13.77)	884 (18.09)	
Other	62 (1.17)	59 (1.21)	
Unknown	89 (1.68)	67 (1.37)	
Charlson-Deyo Comorbidity Index score, mean (SD)	3.04 (2.15)	2.76 (2.07)	<0.0001
Distance lived from treatment facility, miles (n = 544 missing), n (%)			0.7034
0–10	1,095 (22.44)	1,065 (22.41)	
11–50	2,015 (41.30)	1,999 (42.07)	
>50	1,769 (36.26)	1,688 (35.52)	
BMI, kg/m² (n = 9 missing), n (%)			0.3454
<18.5	148 (2.80)	148 (3.03)	
18.5–24.9	1,688 (31.94)	1,641 (33.62)	
25–29.9	1,936 (36.63)	1,721 (35.26)	
30–34.9	1,037 (19.62)	951 (19.48)	
≥35	476 (9.01)	420 (8.60)	
Smoking status at time of surgery (n = 185 missing), n (%)			<0.0001
Current	2,990 (58.06)	2,836 (58.60)	
Former	1,855 (36.02)	1,872 (38.68)	
Never	305 (5.92)	132 (2.73)	
American Society of Anesthesiologists class (n = 2 missing), n (%)			0.9071
2	166 (3.14)	159 (3.25)	
3	4,325 (81.80)	3,982 (81.50)	
4	796 (15.06)	745 (15.25)	
Tumor size, mm, n (%)			0.0170
≤10	548 (10.36)	461 (9.43)	
11–20	2,215 (41.89)	2,013 (41.19)	
21–30	1,401 (26.49)	1,352 (27.67)	
31–40	771 (14.58)	684 (14.00)	
41–50	318 (6.01)	357 (7.31)	
Unknown	35 (0.66)	20 (0.41)	
Histology (n = 2 missing), n (%)			0.0024
Adenocarcinoma	2,993 (56.62)	2,600 (53.20)	
Squamous cell carcinoma	1,660 (31.40)	1,646 (33.68)	
Other	633 (11.98)	641 (13.12)	
Timely surgery, n (%)			0.0006
Yes	3,793 (71.73)	3,353 (68.61)	
No	1,495 (28.27)	1,534 (31.39)	
Annual hospital caseload, mean (SD)	108.3 (51.11)	97.9 (40.78)	<0.0001
Emergent case, n (%)			0.9569
No	5,242 (99.13)	4,844 (99.12)	
Yes	46 (0.87)	43 (0.88)	

(Continued)

Table 1. Continued

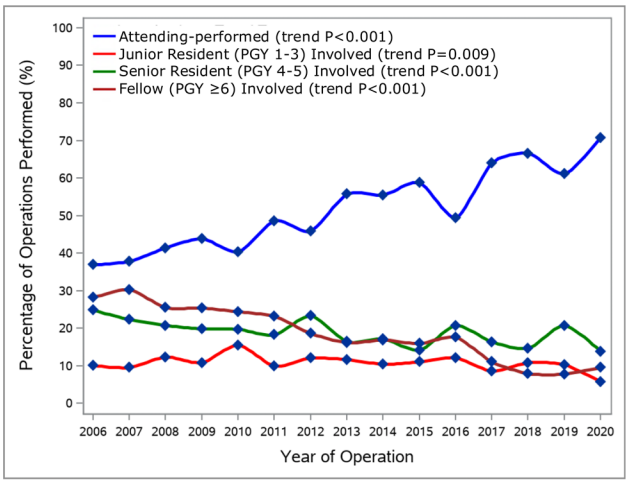
Characteristic and outcome	Attending-performed (N = 5,288), n (%)	Trainee-involved, (N = 4,887), n (%)	p Value
Transferred hospitals, n (%)	598 (11.31)	277 (5.67)	<0.0001
Trainee PGY level, median (interquartile range)	0	5 (4–6)	NA
Surgical approach (n = 34 missing), n (%)			<0.0001
Thoracoscopic	2,543 (48.26)	2,134 (43.80)	
Thoracotomy	2,726 (51.74)	2,738 (56.20)	
Lung resection type (n = 32 missing), n (%)			0.0012
Lobectomy	3,663 (69.51)	3,557 (72.99)	
Wedge resection	1,186 (22.50)	960 (19.70)	
Segmentectomy	342 (6.49)	297 (6.09)	
Pneumonectomy	79 (1.50)	59 (1.21)	
No. of lymph nodes sampled (n = 128 missing), n (%)			<0.0001
0	583 (11.20)	466 (9.62)	
1–4	1,339 (25.72)	1,100 (22.72)	
5–9	1,521 (29.22)	1,486 (30.70)	
≥10	1,763 (33.86)	1,789 (36.96)	
Positive resection margin (n = 110 missing), n (%)	154 (2.95)	153 (3.16)	0.5308
Operation duration, h, mean (SD), n (%)	3.11 (1.54)	3.25 (1.42)	<0.0001
Prolonged hospitalization (n = 183 missing), n (%)	645 (12.42)	706 (14.71)	0.0008
30-d major complications, n (%)	736 (13.92)	766 (15.67)	0.0126
30-d readmission (n = 55 missing), n (%)	294 (5.60)	380 (7.80)	<0.0001
90-d mortality, n (%)	175 (3.31)	209 (4.28)	0.0105



Year of Operation	Trainee-involved Operations, n=4,887 (%)	Attending-performed Operations, n=5,288 (%)
2006 (data from 10/1/2006-12/31/2006)	94 (63.1)	55 (36.9)
2007	468 (62.2)	285 (37.9)
2008	432 (58.6)	305 (41.4)
2009	455 (56.1)	356 (43.9)
2010	445 (59.7)	301 (40.4)
2011	408 (51.4)	386 (48.6)
2012	403 (54.1)	342 (45.9)
2013	315 (44.2)	397 (55.8)
2014	345 (44.5)	431 (55.5)
2015	305 (41.2)	435 (58.8)
2016	324 (50.6)	317 (49.5)
2017	290 (36.0)	516 (64.0)
2018	232 (33.4)	462 (66.6)
2019	234 (38.9)	368 (61.1)
2020	137 (29.2)	332 (70.8)

Figure 1. Proportion of operations performed for early-stage lung cancer with trainees involved at Veterans Affairs hospitals.

Overall, the proportion of operations with trainees involved significantly decreased from 63.1% (n = 94 of 149) in late 2006, to 44.2% (n = 315 of 712) in 2013, and ultimately to 29.2% (n = 137 of 469) in 2020 (trend p < 0.001; Fig. 1). The proportion of operations involving junior-level residents, senior-level residents, and fellows decreased from 10.1% (n = 15 of 149), 24.8% (n = 37 of 149), and 28.2% (n = 42 of 149) in late 2006 to 5.8% (n = 27 of 469), 13.9% (n = 65 of 469), and 9.6% (n = 45 of 469) in 2020, respectively (all trend p < 0.010; Fig. 2).



Year of Operation	Attending-performed, n=5,288 (%)	Junior resident involved, n=1,108 (%)	Senior resident involved, n=1,897 (%)	Fellow involved, n=1,882 (%)
2006 (data from 10/1/2006-12/31/2006)	55 (36.9)	15 (10.1)	37 (24.8)	42 (28.2)
2007	285 (37.9)	72 (9.6)	168 (22.3)	228 (30.3)
2008	305 (41.4)	91 (12.4)	153 (20.8)	188 (25.5)
2009	356 (43.9)	88 (10.9)	161 (19.9)	206 (25.4)
2010	301 (40.4)	116 (15.6)	147 (19.7)	182 (24.4)
2011	386 (48.6)	79 (10.0)	145 (18.3)	184 (23.2)
2012	342 (45.9)	90 (12.1)	174 (23.4)	139 (18.7)
2013	397 (55.8)	83 (11.7)	117 (16.4)	115 (16.2)
2014	431 (55.5)	81 (10.4)	133 (17.1)	131 (16.9)
2015	435 (58.8)	82 (11.1)	105 (14.2)	118 (16.0)
2016	317 (49.5)	78 (12.2)	133 (20.8)	113 (17.6)
2017	516 (64.0)	69 (8.6)	132 (16.4)	89 (11.0)
2018	462 (66.6)	75 (10.8)	102 (14.7)	55 (7.9)
2019	368 (61.1)	62 (10.3)	125 (20.8)	47 (7.8)
2020	332 (70.8)	27 (5.8)	65 (13.9)	45 (9.6)

Figure 2. Proportion of operations performed for early-stage lung cancer at Veterans Affairs hospitals, stratified by the PGY level of the trainees involved.

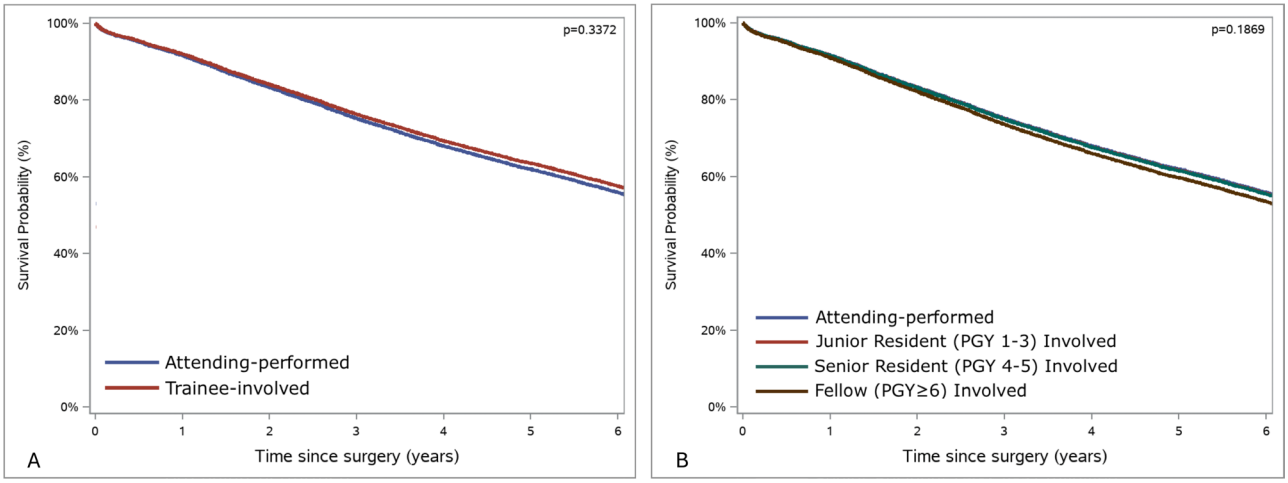


Figure 3. Adjusted survival analyses stratified by (A) trainee involvement during lung cancer resection (yes/no) and (B) the PGY level of the involved trainees.

In multivariable analyses, operation duration ($p = 0.133$), prolonged hospitalization ($p = 0.989$), 30-day major complications ($p = 0.222$), 30-day readmission ($p = 0.704$), 90-day mortality ($p = 0.813$), and OS ($p = 0.337$; Fig. 3A) were similar between patients with attending-performed and trainee-involved operations (Table 2). After risk-adjustment, OS was also similar between patients who had operations performed only by attending surgeons and patients with operations with junior-level residents, senior-level residents, or fellows involved ($p = 0.187$; Fig. 3B). In subgroup analyses by surgical approach, similar findings were observed, except trainee involvement was associated with longer operation duration by 19.5 minutes (95% CI 9.7 to 29.3, $p < 0.001$) in operations performed via thoracotomy (Table 3).

DISCUSSION

The VA Healthcare System has a rich tradition of surgical education, with more than half of US-trained surgeons receiving some portion of their clinical training at a VA hospital.[37,38] However, recent reports have raised concerns about decreasing resident operative autonomy across core GS operations (eg cholecystectomy, inguinal hernia repair) at the VA since the early 2000s.[29,39-41] To date, there is limited literature examining the impact of intraoperative trainee involvement on outcomes after thoracic surgery.[28,42] Using national data, this study

Table 2. Association Between Intraoperative Trainee Involvement and Surgical Outcomes*

Outcome	Point estimate (95% CI)	p Value
Operation duration		0.133
Attending-performed	Reference	
Trainee-involved	Adjusted difference: 5.64 (–1.74 to 13.02) min	
Prolonged hospitalization		0.989
Attending-performed	Reference	
Trainee-involved	aOR: 0.988 (0.765–1.302)	
30-d major complications		0.222
Attending-performed	Reference	
Trainee-involved	aOR: 1.174 (0.907–1.519)	
30-d readmission		0.704
Attending-performed	Reference	
Trainee-involved	aOR: 1.072 (0.750–1.531)	
90-d mortality		0.813
Attending-performed	Reference	
Trainee-involved	aOR: 1.059 (0.660–1.700)	
Overall survival		0.337
Attending-performed	Reference	
Trainee-involved	aHR for death: 0.949 (0.852–1.056)	

*Multivariable models adjusted for: age, sex, race, intraoperative trainee involvement, PGY level of trainee involved, American Society of Anesthesiologists class, comorbidities, smoking status, BMI, distance lived from treatment facility, annual hospital caseload, transferred facilities, tumor size, histology type, year of surgery, timely surgery, surgical approach, lung resection type, number of lymph nodes sampled, and surgical resection margins.
aHR, hazard ratio; aOR, odds ratio.

found a 53.7% decline in trainee participation in pulmonary resections for early-stage NSCLC within the VA Healthcare System during the past 14 years. Upon stratifying the cohort by PGY level, this trend persisted across all resident and fellow training levels. Notably, operative times and postoperative outcomes were similar between cases performed only by attending surgeons and those with surgical trainees participating. To rationalize the parity in outcomes between groups, one may conjecture that the procedures involving trainees were less complex. However, our data demonstrated that operations involving trainees were often associated with larger tumors, open procedures, lobectomies, and more extensive lymph node sampling. These results align with existing literature suggesting that, under proper supervision, trainee participation does not compromise patient safety in high-risk operations and may even enhance the quality of care provided to patients.[28,42-47] Our findings provide reassurance that the VA Healthcare System can successfully fulfill its dual mission of delivering high-quality patient care while also training the next generation of surgeons.

The decline in resident participation in oncologic pulmonary resections at VA teaching hospitals has significant implications for surgical education. Thoracic cases account for only 4% of the total procedures performed by graduating GS residents, most of which are completed at the junior resident level.[15,48] Although thoracic surgery experience is required for GS residency completion, the requirement is met through a self-reported minimum of 20 thoracic cases, which includes only 5 thoracotomies.[49] Furthermore, there is no mandate for supervision by an American Board of Thoracic Surgery–certified surgeon or competency assessments in fundamental thoracic surgical skills, such as VATS port placement or controlling intrathoracic bleeding.[21] Several GS residency programs have also reduced the number of rotations offered in CT surgery, allowing many trainees to meet the minimum case requirements without gaining significant exposure to the field.[17] Currently, about 70% of GS residents complete at least 1 CT surgery rotation, but 36% of these rotations only last 1 month or less.[17] This limited duration may not provide sufficient time for residents to develop skills, receive meaningful mentorship, or fully explore their potential interest in thoracic surgery. It is therefore plausible that the observed increase in CT fellowship applicants during recent years is driven by GS residents from programs with robust thoracic surgery exposure, while many others may not have had similar opportunities to consider the specialty.[6]

This study revealed that there is a substantial number of pulmonary resections performed only by attending

Table 3. Association Between Intraoperative Trainee Involvement and Outcomes Stratified by Surgical Approach*

	Thoracoscopic (N = 4,677)		Thoracotomy (N = 5,464)	
Outcome	**point estimate (95% CI)**	**p Value**	**Point estimate (CI)**	**p Value**
Operation duration		0.053		<0.001
Attending-performed	Reference		Reference	
Trainee-involved	Adjusted difference: –10.86 (–21.9 to 0.12) min		Adjusted difference: 19.50 (9.66–29.28) min	
Prolonged hospitalization		0.275		0.514
Attending-performed	Reference		Reference	
Trainee-involved	aOR: 1.304 (0.809–2.101)		aOR: 0.899 (0.653–1.237)	
30-d major complications		0.545		0.221
Attending-performed	Reference		Reference	
Trainee-involved	aOR: 1.147 (0.735–1.791)		aOR: 1.219 (0.888–1.674)	
30-d readmission		0.627		0.739
Attending-performed	Reference		Reference	
Trainee-involved	aOR: 1.169 (0.623–2.193)		aOR: 1.078 (0.693–1.676)	
90-d mortality		0.851		0.800
Attending-performed	Reference		Reference	
Trainee-involved	aOR: 1.085 (0.460–2.562)		aOR: 1.076 (0.610–1.898)	
Overall survival		0.318		0.755
Attending-performed	Reference		Reference	
Trainee-involved	aHR for death: 0.917 (0.774–1.087)		aHR for death: 0.978 (0.852–1.123)	

*Multivariable models adjusted for: age, sex, race, intraoperative trainee involvement, PGY level of trainee involved, American Society of Anesthesiologists class, comorbidities, smoking status, BMI, distance lived from treatment facility, annual hospital caseload, transferred facilities, tumor size, histology type, year of surgery, timely surgery, lung resection type, number of lymph nodes sampled, and surgical resection margins.
aHR, adjusted hazard ratio; aOR, adjusted odds ratio.

surgeons at VA teaching hospitals each year. Based on these findings, surgical training programs may consider establishing or expanding designated thoracic surgery rotations at affiliated VA hospitals to address program-specific gaps in CT surgical education. VA teaching hospitals serve as clinical training sites for approximately 95% of US medical schools and numerous surgical training programs.[25] In a national survey of 292 CT surgical trainees and faculty, 93% of respondents rated an affiliation with a VA hospital as beneficial, whereas 73% rated the quality of CT training at VA hospitals as good to excellent.[50] Additionally, the operating room environment at VA hospitals is at least as conducive to learning as that of affiliate teaching hospitals, with trainees benefiting from graduated autonomy.[50,51] As evidenced by this study and others performed by our group, VA hospitals have excellent outcomes after surgery for lung cancer and may offer a suitable learning environment for surgical training programs interested in providing residents with increased exposure to these core thoracic procedures.[52]

With an aging population and increasing adoption of lung cancer screening in the US, the demand for a robust general thoracic surgery workforce remains critical, as the number of patients with resectable NSCLC continues to rise nationwide.[2,4] Using data from the US Area Health Resources File, Surveillance Epidemiology End Results database, and National Cancer Database, Potter and colleagues[6] found that from 2010 to 2018, the number of CT surgeons per 100,000 individuals declined by 12%, whereas stage I NSCLC diagnoses increased by 40%. During this period, the percentage of patients undergoing resection of stage I NSCLC decreased by nearly 10%. This trend is alarming given that the national caseload for CT surgeons is projected to increase by 61% by 2035, with a potential 121% increase in cases per surgeon.[8] Without a corresponding expansion of the thoracic surgery workforce, the growing number of patients requiring surgery for early-stage NSCLC could lead to delays in surgical care and non–guideline-concordant treatments, both of which are associated with higher risks of long-term mortality and cancer recurrence.[36,53] Consequently, CT surgical educators should prioritize strategies to promote the growth of the thoracic surgical workforce. One potential approach would be to increase the number of CT surgery training positions to align with the growing interest in the field. During the past decade, the number of CT surgery fellowship positions and the number of matched applicants has remained largely unchanged.[6] However, during this

time, the number of applicants to CT surgery fellowship programs has risen by approximately 50%.[6] As the demand for high-quality educational experiences in thoracic surgery increases, stronger collaboration between CT surgical training programs and VA teaching hospitals may ensure future trainees have clinical opportunities to gain broad thoracic surgery exposure and proficiency in managing lung cancer patients with high surgical risk. Veterans undergoing lung cancer resection tend to have more comorbidities and a higher prevalence of smoking than the general US population, making their care uniquely challenging and highly educational.[52] Many fellows have positive educational experiences rotating at VA hospitals and may, as a result, choose to pursue future career opportunities within the VA Healthcare System.[50]

A notable finding in this study was the annual decline in fellow participation in lung cancer resections at VA hospitals. This trend is likely driven, in part, by the rapid evolution of innovative surgical techniques in CT surgery during the past 2 decades, requiring trainees to master an increasing number of operations and surgical approaches.[54,55] A survey of recent US thoracic surgery training program graduates found that many respondents felt they needed additional training or lacked confidence in performing complex minimally invasive procedures, such as robotic-assisted pulmonary and esophageal resections.[13] Notably, robotic thoracic surgery programs have been successfully implemented at select VA hospitals, but nationwide adoption is ongoing.[56] A review of procedure log data by Mills and colleagues[57] found that between 2013 and 2021, robotic-assisted operations in the VA increased 16-fold nationally, compared with 7.5-fold in community centers and 6.7-fold in academic centers. Certainly, expanding robotic thoracic surgery programs at VA hospitals nationwide could further enhance training opportunities at these institutions.[56]

This study has several strengths. Most notably, it uses a uniquely compiled dataset that integrates clinical data from national VA repositories, providing a comprehensive list of covariates for risk-adjustment, including cancer-specific factors such as tumor size and histology, which are often missing from other studies.[28,42] Additionally, while most research on this topic focuses solely on short-term perioperative mortality, this study also evaluates long-term survival.

This study has limitations. First, VASQIP does not specify whether trainees are a part of GS or CT residency programs, limiting our ability to assess differences in participation based on residency type. Second, granular details on the extent of trainee involvement in operations were unavailable, preventing an assessment of operative autonomy. We acknowledge that the variables captured in VASQIP may not fully reflect the true nature of intraoperative trainee participation or the critical portions performed by either the attending or trainee. For example, cases coded as "attending performing the operation" could still involve resident assistance on less complex portions. Similarly, situations where the attending temporarily takes over or steps in for key portions are not discretely documented in VASQIP. Consequently, we intentionally refrained from drawing conclusions about operative autonomy and instead framed our findings around the presence or absence of a trainee in the operating room. Given the low number of "trainee-performed" cases, which might be considered higher-autonomy encounters, we are limited in our ability to assess how varying degrees of trainee participation may influence patient outcomes. Additionally, our analysis was limited by the lack of data on the number of thoracic surgeons employed at VA hospitals and the inability to capture patients who may have received nonsurgical treatment (eg stereotactic body radiotherapy) or had their surgery performed outside of the VA system. As such, while changes in treatment strategy may have contributed to the observed trends, this could not be directly evaluated within the scope of our dataset. Finally, the generalizability of these findings to other academic training environments may be limited, as the study only includes VA hospitals.

CONCLUSIONS

Trainee involvement in surgical resections for early-stage NSCLC has decreased by 53.7% within the VA Healthcare System during the past 14 years. However, short- and long-term patient outcomes remain comparable between operations performed by attending surgeons and those involving trainees. Enhancing CT surgical training opportunities at VA teaching hospitals may be a viable strategy to expand opportunities for surgical trainees to gain valuable experience in core thoracic procedures. Future research should focus on identifying factors driving the decline in trainee involvement in oncologic pulmonary resections within VA hospitals and assessing their long-term impact on both surgical education and workforce development.

Author Contributions

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