

Association Between Operative Autonomy of Surgical Residents and Patient Outcomes

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IMPORTANCE Resident operative autonomy has been steadily decreasing. Whether this reduction in autonomy has been associated with changes in patient outcomes is unclear.

OBJECTIVE To assess whether surgical procedures performed by residents without an attending surgeon scrubbed are associated with differences in patient outcomes compared with procedures performed by attending surgeons alone or by residents with the assistance of attending surgeons.

DESIGN, SETTING, AND PARTICIPANTS This retrospective propensity score–matched cohort study analyzed 30-day outcomes among patients who received operations at US Veterans Affairs (VA) medical centers and were recorded within the VA Surgical Quality Improvement Program (VASQIP) database from July 1, 2004, to September 30, 2019. Among 1 797 056 operations recorded in the VASQIP during that period, 1 319 020 were eligible for inclusion. Operations performed by a surgical resident without an attending surgeon scrubbed (resident primary) were propensity score matched on a 1:1 ratio (based on year of procedure and patient age, race, sex, American Society of Anesthesiologists physical status classification, functional status, emergency status, inpatient status, presence of multiple comorbidities, and *Current Procedural Terminology* code) to operations performed by an attending surgeon only (surgeon primary) and operations performed by a resident with assistance from an attending surgeon (resident plus surgeon).

EXPOSURES Level of resident involvement.

MAIN OUTCOMES AND MEASURES Thirty-day adjusted all-cause mortality.

RESULTS Among 1 319 020 surgical procedures included, 138 750 were performed by residents only, 308 724 were performed by surgeons only, and 871 546 were performed by residents and surgeons. For the 1 319 020 total cases, patients' mean (SD) age was 61.6 (12.9) years; 1 223 051 patients (92.7%) were male; and 212 315 (16.1%) were Black or African American, 63 817 (4.9%) were Hispanic, 830 704 (63.0%) were White, and 212 814 (16.1%) were of other or unknown race and ethnicity. Propensity score matching produced 101 130 pairs of resident-primary and surgeon-primary procedures and 137 749 pairs of resident-primary and resident plus surgeon procedures. Patient all-cause mortality and morbidity were no different among those who received surgeon-primary procedures (mortality: odds ratio [OR], 1.03 [95% CI, 0.95-1.12]; morbidity: OR, 1.01 [95% CI, 0.97-1.05]) vs resident plus surgeon procedures (mortality: OR, 1.03 [95% CI, 0.97-1.11]; all-cause morbidity: OR, 0.97 [95% CI, 0.95-1.00]). Resident-primary procedures had longer operative times than surgeon-primary procedures (median, 80 minutes [IQR, 50-123 minutes] vs 70 minutes [IQR, 41-114 minutes], respectively; $P < .001$) but shorter operative times than resident plus surgeon procedures (median, 71 minutes [IQR, 43-113 minutes] vs 73 minutes [IQR, 45-115 minutes]; $P < .001$). Hospital length of stay was unchanged among resident-primary vs surgeon-primary procedures (median, 4 days [IQR, 2-10 days] vs 4 days [IQR, 2-9 days]; $P = .08$) and statistically significantly shorter than resident plus surgeon procedures (median, 4 days [IQR, 1-9 days] vs 4 days [IQR, 2-10 days]; $P < .001$).

CONCLUSIONS AND RELEVANCE In this cohort study, surgical procedures performed by residents alone were not associated with any changes in all-cause mortality or composite morbidity compared with those performed by attending surgeons alone or by residents with the assistance of attending surgeons. Given these findings and the importance of operative autonomy to prepare surgical residents for independent practice, efforts to increase autonomy are both safe and needed.

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A decrease in the incremental independence of surgical residents has occurred throughout all levels of training. This reduction is not solely associated with duty hours; a study within the US Veterans Affairs (VA) system found that the number of surgical procedures performed by residents without the attending surgeon present in the operating room decreased from 8.7% in 1998 to 2.7% in 2004.¹ The decrease in resident autonomy is instead suspected to be associated with a combination of work hour restrictions, a decreased level of confidence in residents' skills, and an increased focus on patient safety.² These factors have translated into more than 80% of graduating residents pursuing fellowships and a reduction in graduating surgeons' confidence in their ability to operate independently.³

Research on the consequences of fewer residents autonomously performing surgical procedures is limited. A comparison of surgical procedures performed by residents alone (in which attending surgeons were not present in the operating room but immediately available to provide assistance) with all other surgical procedures revealed no difference in mortality rate and lower odds of morbidity.¹ Analyses of cardiac or breast surgical procedures that compared procedures performed by attending surgeons alone with those performed by residents alone found longer operative times for residents but no substantial changes in patient outcomes.⁴⁻⁶ Other studies comparing resident involvement with no resident involvement in procedures reported increased complication rates⁷⁻⁹; however, these studies did not examine resident involvement on a granular level.

We hypothesized that surgical procedures performed autonomously by residents without an attending surgeon scrubbed would be safe with regard to patient outcomes. The VA Surgical Quality Improvement Program (VASQIP) database offers a distinct opportunity to assess this issue because all surgical procedures in the database are coded for the levels of attending surgeon and resident involvement; these levels include (1) the attending surgeon performed the procedure (surgeon primary), (2) the attending surgeon was scrubbed but the resident performed the major portions of the procedure (resident plus surgeon), and (3) the attending surgeon was not scrubbed while the resident performed the procedure (resident-primary). Using these designations, we examined whether operations performed by residents without an attending surgeon scrubbed were associated with differences in patient outcomes compared with those performed by attending surgeons or by residents and attending surgeons together. Comparing resident-primary with surgeon-primary cases allowed us to assess whether patient safety differed when residents independently performed surgical procedures, and comparing resident-primary vs resident plus surgeon cases allowed us to analyze the consequences of direct vs indirect supervision of residents.

Methods

Study Design

This retrospective cohort study prospectively collected data from the VASQIP database. These data were securely stored on the VA Informatics and Computing Infrastructure. This study

Key Points

Question Is surgical resident operative autonomy associated with worse patient outcomes?

Findings In this cohort study of 1 319 O2O surgical procedures recorded in the Veterans Affairs Surgical Quality Improvement Program database, those performed by residents alone were not associated with differences in all-cause mortality or morbidity compared with those performed by attending surgeons alone or by attending surgeons and residents together.

Meaning This study found that appropriately selected surgical procedures were safely performed by residents alone and may be further encouraged.

was approved by the institutional review boards of VA New Jersey and VA Informatics and Computing Infrastructure with a waiver of informed consent for the use of deidentified data. The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline for cohort studies¹⁰ (eTable 1 in the Supplement).

Setting and Data Collection

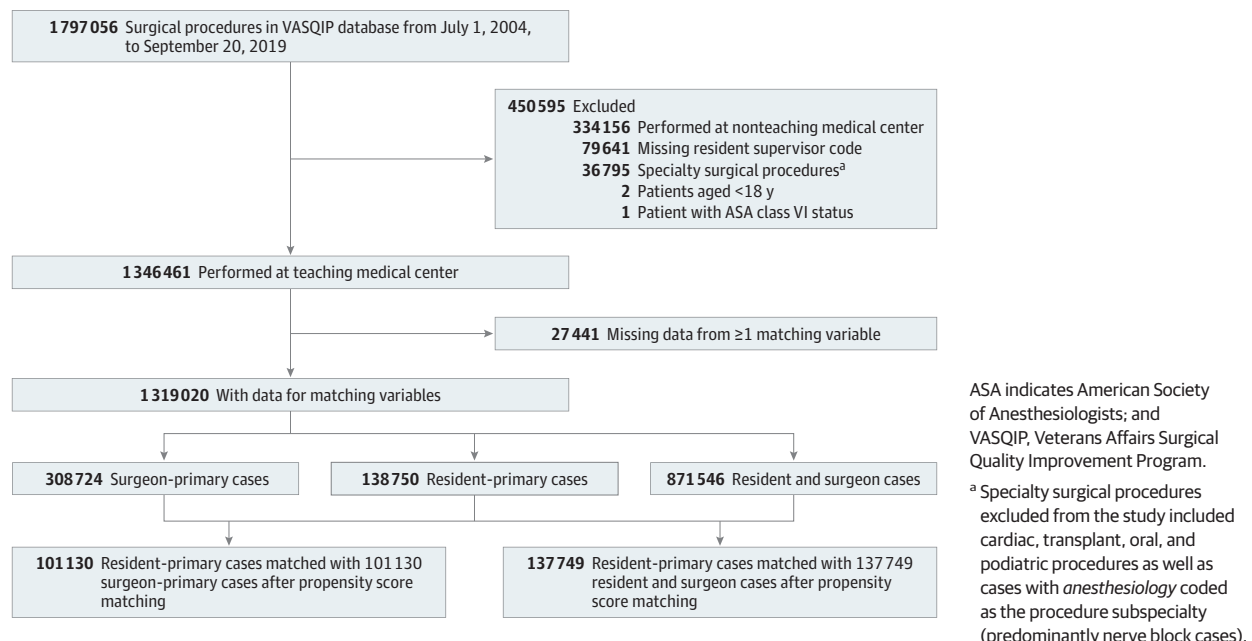
The VA comprises 1233 health care facilities, including 170 medical centers and 1063 outpatient sites providing care to more than 9 million enrolled veterans. A sampling of surgical procedures performed at all centers is recorded and entered in the VASQIP database by specifically trained clinical nurse data extractors. Variable definitions and criteria are publicly available.¹¹ This study used data for surgical procedures performed between July 1, 2004, and September 30, 2019.

Population

Surgical procedures performed by residents alone were defined as those with supervision codes for either *attending in the OR, not scrubbed* or *attending in the OR suite, immediately available* (ie, resident-primary procedures). These 2 supervision levels were combined because they captured the supervision level of interest and because the number of cases in which the attending surgeon was in the operating room suite and immediately available to assist with the procedure was small (<1% of all cases). Surgical procedures were excluded if they were performed at medical centers without residencies approved by the Accreditation Council for Graduate Medical Education for the specialty of the procedure performed, if they did not have a level of resident supervision recorded, or if they were performed among patients younger than 18 years or patients with American Society of Anesthesiologists (ASA) physical status classification VI (indicating the patient was declared brain dead). We also excluded cardiac, transplant, oral, and podiatric procedures as well as cases with *anesthesiology* coded as the procedure subspecialty (which were predominantly nerve block cases).

Among 1 797 056 surgical procedures recorded in the VASQIP between 2004 and 2019, 1 319 O2O were eligible for inclusion. Resident-primary cases were propensity score matched on a 1:1 ratio (based on year of procedure, age, race, sex, ASA physical status classification, functional status, emergency

Figure. Flow Diagram



status, inpatient status, presence of multiple comorbidities, and *Current Procedural Terminology* code) to surgeon-primary procedures (coded as *attending doing the operation*) and resident plus surgeon procedures (coded as *attending in the OR, scrubbed, but the resident performs major portions of the procedure*).

Outcomes

The primary outcome was 30-day all-cause mortality. Secondary outcomes included the composite complication rate of all VASQIP-collected complications, individual complication rates, returns to the operating room within 30 days of the procedure (including all operations, planned or unplanned), hospital lengths of stay, and operative times. Baseline characteristics, including patient demographic data, medical comorbidities, ASA physical status classification, and functional status, were collected and compared. Because only a small proportion of patients had ASA class V status (indicating the patient was moribund and not expected to survive without the operation), they were combined into 1 group with those who had class IV status (indicating the patient had severe systemic disease that was a constant threat to life).

Statistical Analysis

All statistical analyses were performed using SAS software, version 9.4 (SAS Institute Inc), for Windows (Microsoft, Inc). Propensity score matching was conducted using the PSMATCH function with a greedy matching algorithm, a caliper of 0.2, and an exact match to the principal *Common Procedural Terminology* code (variables and definitions available in the eMethods in the Supplement). Because of the small number of missing variables, records with missing values were excluded from the models. The propensity score was created based on the likelihood of a resident-primary supervision level.

Categorical variables were compared using Cochran-Mantel-Haenszel χ^2 tests and reported as counts with percentages or odds ratios (ORs) with 95% CIs. Continuous variables were compared using paired *t* tests or signed rank tests as appropriate and reported as means with SDs or medians with IQRs. Odds ratios used the surgeon-primary group as the comparator, with an OR less than 1 favoring the resident-primary group, and an OR greater than 1 favoring the surgeon-primary or resident plus surgeon groups. The significance threshold was 2-sided $P < .05$.

With regard to postoperative complications, *Clostridium difficile* colitis had been recorded in the database only since 2008. Some complications (eg, mechanical ventilation and multiple specific urinary tract infections) that were captured in the composite complication category beginning in 2015 were not reported individually because they overlapped with other complication markers (eg, reintubation and urinary tract infection).

Results

Among 1 319 020 surgical procedures eligible for inclusion, 138 750 were resident-primary cases, 308 724 were surgeon-primary cases, and 871 546 were resident plus surgeon cases. Propensity score matching resulted in 101 130 pairs of surgeon-primary and resident-primary cases (72.9% of resident-primary cases) and 137 749 pairs of resident plus surgeon and resident-primary cases (99.3% of resident-primary cases) (Figure). The standardized mean difference of the logit propensity score for matches was 0.070 for resident-primary to surgeon-primary cases (93.9% reduction) and 0.004 for resident-primary to resident plus surgeon cases (99.7% reduction). All continuous and binary factors had a standardized

mean difference of less than 0.200 (eTable 2 in the [Supplement](#)). The most common procedures included transurethral removal or biopsy of tumors or prostate; open inguinal and umbilical hernias; laparoscopic cholecystectomy and appendectomy; knee, hip, and shoulder arthroscopy or arthroplasty; and amputations (eTable 3 in the [Supplement](#)).

For the 1319 020 total cases, patients' mean (SD) age was 61.6 (12.9) years; 1 223 051 patients (92.7%) were male and 95 969 (7.3%) were female; and 212 315 (16.1%) were Black or African American, 63 817 (4.9%) were Hispanic, 830 704 (63.0%) were White, and 212 814 (16.1%) were of other race and ethnicity (including American Indian or Alaska Native, Asian, and unknown) ([Table 1](#)). Although many statistically significant variables remained after matching, most absolute differences were small. In the comparison of surgeon-primary vs resident-primary cases, there were 2995 fewer Black or African American patients (15 873 individuals [15.7%] vs 18 868 individuals [18.7%]; $P < .001$). This significant difference in Black or African American patients was not present in the comparison of resident plus surgeon vs resident-primary cases (23 443 individuals [17.0%] vs 23 832 individuals [17.3%]; $P = .16$). The surgeon-primary group compared with the resident-primary group also had a higher proportion of patients with congestive heart failure (4549 individuals [4.5%] vs 3432 individuals [3.4%], respectively; $P < .001$), ASA class IV or V (9414 individuals [9.3%] vs 9019 individuals [8.9%]; $P < .001$), and inpatient status at the time of the procedure (42 118 individuals [41.6%] vs 40 785 individuals [40.3%]; $P < .001$) but a lower proportion of emergency procedures (5874 individuals [5.8%] vs 6112 individuals [6.0%]; $P = .03$). None of these differences were observed in the resident plus surgeon group compared with the resident-primary group.

In a comparison of outcomes among patients in the surgeon-primary vs resident-primary groups, no difference was found between all-cause mortality (1214 patients [1.2%] vs 1250 patients [1.2%]; OR, 1.03 [95% CI, 0.95-1.12]; $P = .45$) and composite morbidity (6303 patients [6.2%] vs 6342 patients [6.3%]; OR, 1.01 [95% CI, 0.97-1.05]; $P = .71$) ([Table 2](#)). Patients in the resident-primary group vs the surgeon-primary group had higher odds of returning to the operating room (6028 individuals [6.0%] vs 5670 individuals [5.6%]; OR, 1.08 [95% CI, 1.04-1.13]; $P < .001$). No significant difference in complications was observed between the surgeon-primary and resident-primary groups, with the exception of myocardial infarction (214 patients [0.2%] vs 172 patients [0.2%], respectively; OR, 0.80 [95% CI, 0.66-0.98]; $P = .03$) and postoperative bleeding of more than 4 U (165 patients [0.2%] vs 98 patients [0.1%]; OR, 0.59 [95% CI, 0.46-0.76]; $P < .001$), which occurred more frequently in surgeon-primary cases, and postoperative urinary tract infection (1354 patients [1.3%] vs 1504 patients [1.5%]; OR, 1.12 [95% CI, 1.04-1.20]; $P = .005$) and superficial surgical site infection (1032 patients [1.0%] vs 1140 patients [1.1%]; OR, 1.11 [95% CI, 1.02-1.21]; $P = .02$), which occurred more frequently in resident-primary cases ([Table 3](#)). The total length of stay for patients admitted to the hospital was the same between the surgeon-primary group (median, 4 days [IQR, 2-9 days]) and the resident-primary group (median, 4 days [IQR, 2-10 days]; $P = .08$). Patients in the surgeon-primary group had

a total operative time that was 10 minutes shorter than in the resident-primary group (median, 70 minutes [IQR, 41-114 minutes] vs 80 minutes [IQR, 50-123 minutes], respectively; $P < .001$).

In a comparison of outcomes among patients in the resident plus surgeon vs resident-primary groups, no difference was found between all-cause mortality (1528 patients [1.1%] vs 1583 patients [1.1%]; OR, 1.03 [95% CI, 0.97-1.11]; $P = .32$) and composite morbidity (8510 patients [6.2%] vs 8297 patients [6.0%]; OR, 0.97 [95% CI, 0.94-1.00]; $P = .09$) ([Table 2](#)). In addition, no difference in the resident plus surgeon vs resident-primary groups was observed in the rate of return to the operating room (8453 patients [6.1%] vs 8278 patients [6.0%]; OR, 0.98 [95% CI, 0.95-1.01]; $P = .16$). Similar to the comparison between surgeon-primary vs resident-primary groups, no significant difference in complications was found between patients in the surgeon plus resident vs resident-primary groups, with the exception of postoperative bleeding of more than 4 U (200 patients [0.1%] vs 121 patients [0.1%]; OR, 0.60 [95% CI, 0.48-0.76]; $P < .001$) and inability to remove mechanical ventilation more than 48 hours after the operation (1071 patients [0.8%] vs 908 patients [0.7%]; OR, 0.85 [95% CI, 0.77-0.93]; $P < .001$), which was more frequent in resident plus surgeon cases ([Table 4](#)). No specific complication occurred more frequently in resident-primary cases. The total hospital length of stay was 4 days in each group but was slightly higher in the resident plus surgeon group vs the resident-primary group (median, 4 days [IQR, 2-10 days] vs 4 days [IQR, 1-9 days]; $P < .001$). Operative time was 2 minutes longer in the resident plus surgeon group (median, 73 minutes [IQR, 45-115 minutes]) vs the resident-primary group (71 minutes [IQR, 43-113 minutes]; $P < .001$).

Discussion

This cohort study was designed with the assumption that resident involvement in surgical procedures and graduated autonomy are important in surgical training. It is reasonable to expect that the first time a surgeon operates independently will occur during residency and not when the surgeon is already in practice. Although residents and attending physicians in the general surgery field both expect that the performance of laparoscopic cholecystectomy, appendectomy, open inguinal hernia, wide local excision of melanoma, and hemorrhoidectomy will be at the supervision-only level, residents in postgraduate year 5 did not meet this level for any case.¹² However, the present study, which assessed almost 140 000 procedures performed independently by residents over multiple surgical specialties, found no associated differences in patient all-cause mortality and morbidity rates among resident-primary cases, suggesting that residents had adequate operative skills when assigned to appropriately selected cases.

This study's findings are consistent with those of a previous study within the VA. Using the VASQIP database in the era before duty hours restrictions (1998-2004), Itani et al¹ found no change in mortality and a decrease in morbidity. One explanation suggested for these findings was that they represented

Table 1. Patient Baseline Characteristics

Characteristic	Surgeon-primary vs resident-primary cases			Surgeon plus resident vs resident-primary cases		
	Surgeon primary (n = 101 130)	Resident primary (n = 101 130)	P value	Surgeon plus resident (n = 137 749)	Resident primary (n = 137 749)	P value
Age, mean (SD), y	60.5 (13.6)	60.2 (13.6)	<.001	61.8 (13.7)	61.8 (13.7)	.23
Sex						
Female	6281 (6.2)	6111 (6.0)	.12	7054 (5.1)	7208 (5.2)	.19
Male	94 849 (93.8)	95 019 (94.0)		130 695 (94.9)	130 541 (94.8)	
Race and ethnicity						
Black or African American	15 873 (15.7)	18 868 (18.7)	<.001	23 443 (17.0)	23 832 (17.3)	.16
Hispanic	4568 (4.5)	3761 (3.7)		5476 (4.0)	5575 (4.0)	
White	65 583 (63.9)	62 655 (62.0)		87 656 (63.6)	87 264 (63.4)	
Other or unknown ^a	16 206 (16.0)	15 846 (15.7)		21 174 (15.4)	21 078 (15.3)	
ASA physical classification status ^b						
I	2759 (2.7)	2948 (2.9)	.001	3455 (2.5)	3421 (2.5)	.06
II	29 308 (29.0)	29 384 (29.1)		37 055 (26.9)	36 709 (26.6)	
III	59 658 (59.0)	59 779 (59.1)		85 083 (61.8)	85 085 (61.8)	
IV or V	9414 (9.3)	9019 (8.9)		12 156 (8.8)	12 534 (9.1)	
Type of surgical procedure						
Emergency	5874 (5.8)	6112 (6.0)	.03	7204 (5.2)	7244 (5.3)	.73
Inpatient	42 118 (41.6)	40 785 (40.3)	<.001	53 107 (38.6)	52 895 (38.4)	.41
Wound cleanliness						
Clean	64 780 (64.1)	64 507 (63.8)	.43	73 429 (53.3)	73 218 (53.2)	.60
Clean/contaminated	25 633 (25.3)	25 798 (25.5)		51 388 (37.3)	51 590 (37.5)	
Contaminated	4404 (4.4)	4594 (4.5)		5480 (4.0)	5398 (3.9)	
Infected or dirty	6313 (6.2)	6231 (6.2)		7452 (5.4)	7543 (5.5)	
Functional status						
Partially dependent	7331 (7.2)	7730 (7.6)	.004	10 260 (7.4)	10 519 (7.6)	.14
Fully dependent	2021 (2.0)	2096 (2.1)		2571 (1.9)	2667 (1.9)	
DNR ^c	1344 (1.3)	1158 (1.1)	<.001	1615 (1.2)	1737 (1.3)	.04
BMI, mean (SD)	29.1 (18.7)	29.0 (17.2)	.31	29.0 (16.2)	29.0 (17.6)	.44
Diabetes	22 572 (22.3)	23 135 (22.9)	.01	32 195 (23.4)	32 479 (23.6)	.19
Preoperative sepsis	2374 (2.3)	2415 (2.4)	.55	2963 (2.2)	2940 (2.1)	.76
Current smoking	32 402 (32.0)	33 984 (33.6)	<.001	44 853 (32.6)	45 124 (32.8)	.27
Angina <1 mo before procedure ^d	1043 (1.0)	1183 (1.2)	.003	1588 (1.2)	1755 (1.3)	.003
Hypertension	62 306 (61.6)	62 700 (62.0)	.07	87 170 (63.3)	87 357 (63.4)	.46
Congestive heart failure	4549 (4.5)	3432 (3.4)	<.001	5664 (4.1)	5533 (4.0)	.21
Previous PCI or PTCA	7036 (7.0)	7297 (7.2)	.02	10 578 (7.7)	10 703 (7.8)	.37
Previous stroke						
With permanent deficit	3118 (3.1)	3607 (3.6)	<.001	4689 (3.4)	4952 (3.6)	.006
Without deficit	2877 (2.8)	2935 (2.9)	.44	4122 (3.0)	4233 (3.1)	.22
History of transient ischemic attack	2472 (2.4)	2683 (2.7)	.003	3598 (2.6)	3949 (2.9)	<.001
Preoperative ascites	532 (0.5)	535 (0.5)	.93	627 (0.5)	654 (0.5)	.45
Esophageal varices ^e	251 (0.2)	267 (0.3)	.46	358 (0.3)	363 (0.3)	.85
Bleeding disorder	4904 (4.8)	4760 (4.7)	.13	6260 (4.5)	6475 (4.7)	.05
Preoperative bleeding >4 U	176 (0.2)	164 (0.2)	.51	178 (0.1)	203 (0.1)	.20
Metastatic cancer	1116 (1.1)	1160 (1.1)	.35	1782 (1.3)	1810 (1.3)	.64
Chronic steroid use	1890 (1.9)	1951 (1.9)	.32	2618 (1.9)	2961 (2.1)	.31
Preoperative open wound infection	8828 (8.7)	9013 (8.9)	.15	11 125 (8.1)	11 141 (8.1)	.91
>10% Weight loss in 6 mo before procedure	2357 (2.3)	2662 (2.6)	<.001	3349 (2.4)	3454 (2.5)	.20

(continued)

Table 1. Patient Baseline Characteristics (continued)

Characteristic	Surgeon-primary vs resident-primary cases			Surgeon plus resident vs resident-primary cases		
	Surgeon primary (n = 101 130)	Resident primary (n = 101 130)	P value	Surgeon plus resident (n = 137 749)	Resident primary (n = 137 749)	P value
History of COPD	12 668 (12.5)	12 683 (12.5)	.92	18 150 (13.2)	18 818 (13.7)	<.001
Preoperative dialysis	1701 (1.7)	1761 (1.7)	.30	2100 (1.5)	2128 (1.5)	.66
History of PVD ^f	5907 (5.8)	6475 (6.4)	<.001	7914 (5.7)	8136 (5.9)	.06
Pain when at rest	4363 (4.3)	4333 (4.3)	.74	5058 (3.7)	5096 (3.7)	.70

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); COPD, chronic obstructive pulmonary disease; DNR, do not resuscitate; PCI, percutaneous coronary intervention; PVD, peripheral vascular disease; PTCA, percutaneous transluminal coronary angioplasty.

^a Includes American Indian or Alaska Native, Asian, and unknown.

^b Class I indicates normal health; class II, mild systemic disease; class III, severe

systemic disease; class IV, severe systemic disease that is a constant threat to life; and class V, moribund and not expected to survive without the operation.

^c Data missing for 321 patients.

^d Data missing for 994 patients.

^e Data missing for 1578 patients.

^f Data missing for 1001 patients.

Table 2. Patient Outcomes

Outcome	Surgeon-primary vs resident-primary cases			Surgeon plus resident vs resident-primary cases		
	Surgeon primary (n = 101 130)	Resident primary (n = 101 130)	P value	Surgeon plus resident (n = 137 749)	Resident primary (n = 137 749)	P value
All-cause mortality	1214 (1.2)	1250 (1.2)	.45	1528 (1.1)	1583 (1.1)	.32
Morbidity	6303 (6.2)	6342 (6.3)	.71	8510 (6.2)	8297 (6.0)	.09
Return to operating room	5670 (5.6)	6028 (6.0)	<.001	8453 (6.1)	8278 (6.0)	.16
Total hospital length of stay, median (IQR), d	4 (2-9)	4 (2-10)	.08	4 (2-10)	4 (1-9)	<.001
Operative time, median (IQR), min	70 (41-114)	80 (50-123)	<.001	73 (45-115)	71 (43-113)	<.001

appropriate selection of cases by attending physicians, who chose surgical procedures that residents would be best able to perform autonomously. This level of judgment cannot be captured in a database such as the VASQIP. Although some comparative procedures may not have been appropriate for residents to perform without the attending surgeon scrubbed, these findings suggest that residents could likely handle more cases independently.

These findings are not restricted to surgical procedures recorded in the VASQIP database. In a study of patients undergoing reduction mammoplasty in which the attending surgeon operated on the right breast and the resident operated on the left breast while the attending surgeon “held the retractors and observed and occasionally provided guidance during the operation”^{6(p451)} but “at no time was the attending surgeon ever the primary surgeon,”^{6(p451)} no difference in the occurrence of major complications between the 2 breasts was found. Cardiac procedures performed directly (ie, skin to skin) by residents compared with those performed entirely by attending surgeons had a mean operative time that was almost 2 hours longer overall, with twice the amount of time spent on cardiopulmonary bypass and aortic cross-clamping in procedures performed by residents alone.^{4,5} Despite these longer operative times, 30-day outcomes were no different,⁴ and, with a median follow-up of 28 months, no intermediate-term outcomes were different.⁵ The researchers noted the limitations of including only a single-surgeon experience and a select group of “high achieving residents.”^{4(pp2063-2064)} However, all of these findings were con-

sistent with our observation that, among resident-primary procedures, operative times were longer but were not associated with any detriment to patients, and our study was conducted on a substantially larger scale and included a more heterogeneous group of attending surgeons and residents.

However, studies of data from the National Surgical Quality Improvement Program^{9,13} have reported increased complication rates among patients who received operations from residents alone. One study⁹ including residents who participated in appendectomies found that patient complications increased and that a higher postgraduate year was associated with longer operative times and higher complication rates. The researchers surmised that residents in higher postgraduate years were more likely to have greater levels of operative autonomy, and this greater autonomy was associated with worse patient outcomes because of residents’ inexperience. Our data set included approximately 1600 laparoscopic appendectomies, and most of the cases had similar complexity. Another study¹³ conducted a similar analysis of data from the National Surgical Quality Improvement Program that included all procedures, reporting higher composite complication rates that were associated with superficial surgical site infections and a similar decrease in patient complications for operations performed by residents in lower postgraduate years. Neither of these studies^{9,13} captured residents’ autonomy levels, and their findings may instead be a measure of teaching hospitals compared with nonteaching hospitals, because the National Surgical Quality Improvement Program does not

Table 3. Postoperative Complications in Surgical Procedures Performed by Attending Surgeons Alone vs Residents Alone

Complication	No. (%)		OR (95% CI)	P value
	Surgeon primary (n = 101 130) ^a	Resident primary (n = 101 130)		
Cardiac arrest	348 (0.3)	334 (0.3)	0.96 (0.82-1.12)	.59
Myocardial infarction	214 (0.2)	172 (0.2)	0.80 (0.66-0.98)	.03
Coma	42 (0.04)	49 (0.05)	0.90 (0.77-1.76)	.46
Cerebrovascular accident ^b	131 (0.1)	118 (0.1)	0.90 (0.70-1.16)	.41
<i>Clostridium difficile</i> infection ^c	258 (0.3)	260 (0.3)	1.11 (0.93-1.33)	.38
Bleeding >4 U	165 (0.2)	98 (0.1)	0.59 (0.46-0.76)	<.001
Deep vein thrombosis	380 (0.4)	375 (0.4)	0.99 (0.86-1.14)	.85
Graft loss	82 (0.1)	67 (0.1)	0.82 (0.59-1.13)	.21
Sepsis	923 (0.9)	956 (0.9)	1.04 (0.95-1.14)	.44
Inability to remove mechanical ventilation >48 h after procedure	812 (0.8)	786 (0.8)	0.97 (0.87-1.07)	.51
Pneumonia	876 (0.9)	793 (0.8)	0.90 (0.82-0.99)	.04
Pulmonary embolism	237 (0.2)	232 (0.2)	0.98 (0.82-1.17)	.82
Reintubation	742 (0.7)	772 (0.8)	1.04 (0.94-1.15)	.44
Urinary tract infection	1354 (1.3)	1504 (1.5)	1.12 (1.04-1.20)	.005
Dialysis	200 (0.2)	218 (0.2)	1.09 (0.90-1.32)	.38
Acute kidney failure	284 (0.3)	352 (0.3)	1.24 (1.06-1.45)	.007
Wound dehiscence	372 (0.4)	340 (0.3)	0.91 (0.79-1.06)	.23
Surgical site infection				
Organ space	286 (0.3)	273 (0.3)	0.91 (0.79-1.06)	.59
Superficial space	1032 (1.0)	1140 (1.1)	1.11 (1.02-1.21)	.02
Deep wound	444 (0.4)	481 (0.5)	1.08 (0.95-1.23)	.22

Abbreviation: OR, odds ratio.

^a Reference group (OR <1 favors resident-primary group, and OR >1 favors surgeon-primary group).^b With deficit, hemorrhagic vs ischemic unspecified.^c *Clostridium difficile* infections were recorded starting in 2008; therefore, 43 767 records were missing these data and excluded from the analysis.

possess the granularity of supervision data that the VASQIP database and single-center studies possess.

To our knowledge, this cohort study is the first to explicitly compare surgical procedures performed by residents alone with those performed by residents with assistance and guidance from attending surgeons. This comparison is important because it addresses the true decision point regarding whether a resident can safely perform the procedure without an attending surgeon scrubbed or whether there is evidence to mandate that an attending surgeon be scrubbed. We found that, among a similar group of patients with the same principal procedures, there were no associated differences in all-cause mortality or morbidity. This finding likely represents appropriate patient and case selection and does not necessarily suggest that residents perform better without constant supervision from an attending surgeon who is scrubbed (although performance anxiety may play a small role). It is also notable that not every operation performed by residents plus surgeons included the resident acting in the primary role. Nonetheless, the findings suggest that, among selected resident-primary procedures, worse outcomes did not occur, and consideration of increasing the level of operative autonomy among residents is warranted.

The American Board of Surgery has recognized the need to increase residents' autonomy and, in 2014, began mandating cases in which the chief resident would function as a teaching assistant.¹⁴ The intention behind this mandate, which specifies that a junior resident act as the primary surgeon and a

senior resident serve as the primary teaching assistant, is to require surgical training programs to develop graduated autonomy. After this mandate was implemented, the number of procedures performed by senior residents serving as teaching assistants increased from 24.4% (July 2001 to June 2014) to 40.3% (July 2014 to June 2018).¹⁵ Although this increase was important, it was not necessarily associated with an increase in procedures performed by residents alone.¹⁶ It would be preferable if the American Board of Surgery specifically stipulated that, for a surgical procedure to be considered a teaching assistant case, the attending surgeon would not be scrubbed for substantial portions of the procedure, if not the entire procedure.

The history of decreasing resident autonomy can be traced to several events. The death of Libby Zion and the subsequent Bell Commission Report, coupled with the 2003 duty hour restrictions instituted by the Accreditation Council for Graduate Medical Education, have resulted in less resident time in the hospital and operating room.¹⁷ The Omnibus Budget Reconciliation Act of 1989 and the focus on reimbursement for relative value units exerted pressure to expedite operative times and increase throughput.¹⁷ Furthermore, the 2002 mandate from the Centers for Medicare & Medicaid Services requiring an attending surgeon to be present during "critical portions"^{17(p1)} of the procedure, and VA mandates minimizing use of the code for *attending in the OR suite, immediately available*, have decreased the potential for intraoperative autonomy among residents.¹⁷

Table 4. Postoperative Complications in Surgical Procedures Performed by Surgeons Plus Residents vs Residents Alone

Complication	No. (%)		OR (95% CI)	P value
	Surgeon plus resident (n = 137 749) ^a	Resident primary (n = 137 749)		
Cardiac arrest	461 (0.3)	417 (0.3)	0.90 (0.79-1.03)	.14
Myocardial infarction	218 (0.2)	209 (0.2)	0.96 (0.79-1.16)	.66
Coma	59 (0.04)	57 (0.04)	0.97 (0.67-1.39)	.85
Cerebrovascular accident ^b	163 (0.1)	156 (0.1)	0.92 (0.64-1.32)	.69
<i>Clostridium difficile</i> infection ^c	329 (0.1)	325 (0.2)	0.99 (0.85-1.16)	.94
Bleeding >4 U	200 (0.1)	121 (0.1)	0.60 (0.48-0.76)	<.001
Deep vein thrombosis	449 (0.3)	448 (0.3)	1.00 (0.88-1.14)	.97
Graft loss	106 (0.1)	77 (0.1)	0.73 (0.54-0.97)	.03
Sepsis	1303 (0.9)	1200 (0.9)	0.92 (0.85-1.00)	.05
Inability to remove mechanical ventilation >48 h after procedure	1071 (0.8)	908 (0.7)	0.85 (0.77-0.93)	<.001
Pneumonia	1069 (0.8)	974 (0.7)	0.91 (0.83-0.99)	.03
Pulmonary embolism	288 (0.2)	299 (0.2)	1.04 (0.88-1.22)	.65
Reintubation	1029 (0.7)	960 (0.7)	0.93 (0.85-1.02)	.12
Urinary tract infection	2439 (1.8)	2498 (1.8)	1.02 (0.97-1.08)	.40
Dialysis	245 (0.2)	256 (0.2)	1.05 (0.88-1.25)	.63
Acute kidney failure	391 (0.3)	438 (0.3)	1.12 (0.98-1.28)	.10
Wound dehiscence	432 (0.3)	410 (0.3)	0.95 (0.83-1.08)	.45
Surgical site infection				
Organ space	322 (0.2)	292 (0.2)	0.91 (0.77-1.06)	.23
Superficial space	1302 (0.9)	1290 (0.9)	0.99 (0.92-1.07)	.81
Deep wound	543 (0.4)	547 (0.4)	1.01 (0.89-1.13)	.90

Abbreviation: OR, odds ratio.

^a Reference group (OR <1 favors resident-primary group, and OR >1 favors surgeon plus resident group).^c *Clostridium difficile* infections were recorded starting in 2008; therefore, 64 924 records were missing these data and excluded from the analysis.

Limitations

This study has several limitations. All databases are limited by the quality of the data reported; however, the VASQIP database has been found to be highly accurate.¹⁸ Thus, we are confident in the reported supervision levels and outcomes. The supervision levels in the VASQIP database are surgeon-reported; therefore, the designation of primary surgeon (ie, resident vs attending physician) may be subjective for cases in which both the resident and attending physician were scrubbed. In addition, the VASQIP database does not capture cases in which a resident-primary procedure had to be converted to a resident plus surgeon procedure because of technical difficulties or complications that occurred during the procedure. Therefore, it is important to not overemphasize any results that substantially favor resident-primary cases vs resident plus surgeon cases. Furthermore, although cases were exactly matched by *Current Procedural Terminology* code, this matching process does not ensure that the complexity of these cases could be matched. A cholecystectomy performed in a patient with gallstone pancreatitis and a history of multiple previous operations is a different case than a cholecystectomy performed in a patient aged 40 years with biliary colic and no surgical history; however, this type of information cannot be captured in a database.

Some residual confounding in measured and unmeasured comorbidities remained that could skew our results. Although the 15-year study period is an overall strength of our study and

provides robust data, it is also a limitation. We controlled for the year of the procedure during the matching process; however, that approach may not capture the fact that, as resident autonomy has decreased, the skill levels of the residents performing the operations might not be equivalent. One of the important next steps in this research will be to assess whether any change in outcomes occurs over time among patients who receive operations from residents alone. In addition, we have only short-term data regarding immediate complications, and important longer-term outcomes, such as hernia or cancer recurrence, would need further studies to examine these specific issues.

Conclusions

This cohort study found that surgical procedures performed by residents alone were not associated with changes in all-cause morbidity or mortality compared with those performed by attending surgeons alone or by residents with direct supervision from an attending surgeon who is scrubbed. These data can be used to potentially reverse the pattern of decreasing resident autonomy. Attending physicians need to assess the clinical skills of the resident involved in the case to ensure they have the competency to perform the surgical procedure independently. It is also important for attending physicians to assess the different aspects of cases to ensure they are appropriately selected for resident-primary assignment. Furthermore, attending physicians need to

be readily available to aid, supervise and, when necessary, intervene. However, the current status quo is not serving residents or current and future patients to the fullest extent. Efforts to increase

surgical resident autonomy are needed because, as this study's findings suggest, resident autonomy and good patient outcomes are not incompatible.

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Invited Commentary

Lack of Attending Surgeon Scrubbed and Resident Autonomy Are Not Equivalent

Jonah J. Stulberg, MD, PhD; Sasha D. Adams, MD; Lillian S. Kao, MD, MS

In their article, "Association Between Operative Autonomy of Surgical Residents and Patient Outcomes," Oliver and colleagues¹ analyzed records from the Veterans Affairs Surgical Quality Improvement Program database to assess the association between resident autonomy and surgical outcomes. The lack of an attending surgeon being scrubbed was used as a surrogate for resident autonomy. Using propensity score matching, the authors found no statistically significant differences in patient mor-

tality, all-cause morbidity, or length of stay between surgical procedures performed by residents alone vs those performed by attending surgeons alone or by residents and attending surgeons together.

The topic of resident autonomy has never been more important, particularly given the decrease in surgical procedures performed during training as a result of the COVID-19 pandemic.² Dating back to prepandemic times, studies found that residents often did not feel ready to practice independently after graduating from residency³ and that fel-



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