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The effect of trainee involvement on perioperative outcomes of abdominal aortic aneurysm repair

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Objective: **Although the effect of trainee involvement has been evaluated across different specialties, their effects on perioperative outcomes after abdominal aortic aneurysm (AAA) repair have not been examined. Our goal was to examine the association between resident and fellow intraoperative participation with perioperative outcomes of endovascular AAA repair (EVAR), open infrarenal AAA repair (OIAR), and open juxtarenal AAA repair (OJAR).**

Methods: **The American College of Surgeons National Surgical Quality Improvement Program data set (2005-2012) was queried to identify all patients who underwent EVAR, OIAR, or OJAR. Multivariate analysis was performed to assess the association of trainee involvement with perioperative morbidity and mortality.**

Results: **We identified 16,977 patients: 12,003 with EVAR, 3655 with OIAR, and 1319 with OJAR. Propensity matching and multivariate analyses revealed that there was no significant difference in perioperative death, cardiac arrest/myocardial infarction, pulmonary, renal, venous thromboembolic, or wound complications, or return to the operating room. However, trainee involvement in AAA repair led to a significant increase in operative time for EVAR (163 ± 77 vs 140 ± 67 minutes; *P* < .001), OIAR (217 ± 91 vs 185 ± 76 minutes; *P* < .001), and OJAR (267 ± 115 vs 214 ± 106 minutes; *P* < .001) and an extended length of stay for EVAR (3.1 ± 5.3 vs 2.8 ± 4.5 days; *P* < .001) and OIAR (10.6 ± 11.8 vs 9.1 ± 8.9 days; *P* < .001).**

Conclusions: **Trainee participation in aneurysm repair was not associated with major adverse perioperative outcomes. However, it was associated with an increased operative time and length of stay and therefore may lead to increased resource utilization and cost. (J Vasc Surg 2016;63:16-22.)**

Each year in the United States, ~22,200 residents and fellows undergo training in different surgical specialties.[1] These trainees participate in many of the 51 million procedures performed annually.[2] With the advent of the 80-hour work week, trainees are now spending significantly less time in the operating room and relying more on other methods, such as surgical simulators, to increase surgical profficiency.[3,4]

Increased emphasis on patient outcome tracking and quality improvement has led to scrutiny of the effect of surgical trainee participation on patient outcomes.[5] This question has been studied across a number surgical subspecialties, including general surgery, trauma surgery, surgical oncology, orthopedic surgery, and colorectal surgery.[5-15] These results vary about the effect of trainees on patient outcomes, with some showing no difference while others showing worse outcomes.[5-15]

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Vascular surgery is a rapidly changing field with new training paradigms, and with the growth of endovascular surgery, there is less exposure to open surgical cases, particularly open abdominal cases.[16,17] The effects of resident presence on outcomes from various operations have been studied, with varying results.[18-20] However, the effect of trainee presence on abdominal aortic aneurysm (AAA) repair has not been analyzed.

There are ~45,000 AAA repairs annually.[21] AAA repair can be performed by endovascular (EVAR) or open repair, as determined by patient anatomy, comorbidities, and surgeon preference. Each method requires a unique skill set to be able to perform these procedures effectively and safely. Our goal was to analyze the effect of trainee involvement on perioperative outcomes after different methods of AAA repair and, as such, evaluated EVAR, open infrarenal aneurysm repair (OIAR), and open juxtarenal aneurysm repair (OJAR). We analyzed the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) for this analysis because it is able to identify the level of trainee involvement, procedural details, and perioperative outcomes.

METHODS

The Boston University Medical Center Institutional Review Board reviewed the experimental protocol of this study. The protocol was approved and received an exemption, with patient consent waived.

NSQIP data set analysis. Patients undergoing EVAR, OIAR, and OJAR were identified in the 2005 to

Table I. Characteristics and outcomes of patients undergoing endovascular aneurysm repair (EVAR)

Characteristic[a]	*Overall (N = 12,003)*	*No trainee (n = 5576)*	*Trainee (n = 6427)*	P *value*
Age, years	73.6 ± 8.5	73.6 ± 8.5	73.5 ± 8.6	.717
Male	9846 (82)	4596 (82.4)	5250 (81.7)	.294
Caucasian	11,000 (91.6)	5164 (92.6)	5836 (90.8)	<.001
BMI, kg/m^2	28.1 ± 5.8	28 ± 5.6	28.2 ± 6	.253
Independent	11,437 (95.3)	5351 (96)	6086 (94.7)	.005
Partially dependent	440 (3.7)	176 (3.2)	264 (4.1)	
Totally dependent	126 (1)	49 (0.9)	77 (1.2)	
Emergency	743 (6.2)	267 (4.8)	476 (7.4)	<.001
Diabetes	1858 (15.5)	873 (15.7)	985 (15.3)	.618
Dyspnea	2820 (23.5)	1339 (24)	1481 (23)	.211
COPD	2345 (19.5)	1109 (19.9)	1236 (19.2)	.365
CHF	175 (1.5)	70 (1.3)	105 (1.6)	.085
MI	144 (1.2)	54 (1)	90 (1.4)	.030
Previous PCI	2517 (21)	1223 (21.9)	1294 (20.1)	.016
Previous cardiac surgery	2833 (23.6)	1323 (23.7)	1510 (23.5)	.765
PVD	696 (5.8)	380 (6.8)	316 (4.9)	<.001
Renal failure	55 (0.5)	18 (0.3)	37 (0.6)	.041
Dialysis	145 (1.2)	51 (0.9)	94 (1.5)	.006
History of TIA	808 (6.7)	380 (6.8)	428 (6.7)	.735
CVA with deficit	554 (4.6)	258 (4.6)	296 (4.6)	.956
Steroid use	509 (4.2)	218 (3.9)	291 (4.5)	.094
Bleeding disorder	1386 (11.5)	641 (11.5)	745 (11.6)	.870
Unmatched outcomes				
Death	265 (2.2)	125 (2.2)	140 (2.2)	.813
MI/cardiac arrest	176 (1.5)	71 (1.3)	105 (1.6)	.101
Pulmonary complications	461 (3.8)	196 (3.5)	265 (4.1)	.084
Renal failure	210 (1.7)	93 (1.7)	117 (1.8)	.525
Wound complications	300 (2.5)	139 (2.5)	161 (2.5)	.966
Bleeding complications	650 (5.4)	272 (4.9)	378 (5.9)	.015
Total operation time, min	152.1 ± 73.5	139.9 ± 66.3	162.8 ± 77.7	<.001
Postoperative LOS, days	3 ± 5.2	2.8 ± 4.5	3.3 ± 5.7	<.001
DVT/PE	93 (0.8)	45 (0.8)	48 (0.7)	.708
Return to operating room	606 (5)	260 (4.7)	346 (5.4)	.072

BMI, Body mass index; *CHF,* congestive heart failure; *COPD,* chronic obstructive pulmonary disease; *CVA,* cerebrovascular accident; *DVT,* deep vein thrombosis; *LOS,* length of stay; *MI,* myocardial infarction; *PE,* pulmonary embolism; *PCI,* percutaneous coronary intervention; *PVD,* peripheral vascular disease; *TIA,* transient ischemic attack.

[a]Continuous data are presented as mean ± standard deviation and categoric data as number (%).

2012 ACS-NSQIP data sets. The ACS-NSQIP maintains a prospective, multicenter database containing preoperative risk factors, demographics, procedural details, and 30-day and in-hospital outcomes. Details pertaining to the data gathering, sampling, and structure of the participant use files have been previously described.[22-24] The ACS-NSQIP collects perioperative data, including patient demographics, comorbidities, length of stay (LOS), operative details, perioperative complications, and mortality for specified surgical procedure.

Infrarenal AAA repairs were identified by Current Procedural Terminology (American Medical Association, Chicago, Ill) codes—EVAR: 34800, 34802, 34803, 34804; OIAR: 35081, 35082; and OJAR: 35091, 35092. Demographic variables examined included age, gender, race, and body mass index. Functional status (independent, partially dependent, totally dependent), assessing the patient's ability to perform activities of daily living before the operation, was recorded. Medical conditions included diabetes mellitus, chronic obstructive pulmonary disease, dyspnea, congestive heart failure, prior myocardial infarction (MI), prior percutaneous coronary intervention (PCI), prior cardiac surgery, angina, peripheral vascular disease (PVD), end-stage renal disease (ESRD), hemodialysis dependence, transient ischemic attacks, prior stroke, steroid use, and bleeding disorders. Specific details of the aortic aneurysm, aside from visceral involvement, are not variables in ACS-NSQIP. Outcomes evaluated included death, cardiac, pulmonary, renal, and wound complications, postoperative blood transfusions, venous thromboembolism (VTE), return to operating room, operative time, surgeon specialty, and postoperative LOS.

Resident participation in the operation and postgraduate year (PGY) was recorded. Operative cases with involvement of a ≥PGY 4 trainee or no trainee were recorded. This allowed for capture of senior residents and fellows and not junior residents, who would have likely not had a significant role in the case. Two variables in the database allow for this analysis—one for the highest PGY level resident in the room and another text variable describing whether there was a resident participating in the case of it was an attending only.

Statistical methods. Proportions of means and standard deviations were calculated to describe the sample. The risk groups were compared on demographic

Table II. Characteristics and outcomes of patients undergoing open infrarenal aneurysm repair (OIAR)

Characteristic[a]	*Overall (N = 3655)*	*No trainee (n = 1374)*	*Trainee (n = 2281)*	P *value*
Age, year	71.6 ± 9	71.9 ± 9.2	71.4 ± 8.9	.182
Male	2624 (71.8)	1000 (72.8)	1624 (71.2)	.303
Caucasian	3320 (90.8)	1253 (91.2)	2067 (90.6)	.014
BMI, kg/m^2	27.5 ± 5.8	27.5 ± 5.9	27.5 ± 5.7	.803
Independent	3173 (86.8)	1229 (89.4)	1944 (85.2)	.001
Partially dependent	237 (6.5)	70 (5.1)	167 (7.3)	
Totally dependent	245 (6.7)	75 (5.5)	170 (7.5)	
Emergency	916 (25.1)	313 (22.8)	603 (26.4)	.014
Diabetes	456 (12.5)	175 (12.7)	281 (12.3)	.711
Dyspnea	865 (23.7)	363 (26.4)	502 (22)	.002
COPD	718 (19.6)	287 (20.9)	431 (18.9)	.142
CHF	40 (1.1)	13 (0.9)	27 (1.2)	.504
MI	44 (1.2)	15 (1.1)	29 (1.3)	.630
Previous PCI	611 (16.7)	244 (17.8)	367 (16.1)	.190
Previous cardiac surgery	720 (19.7)	270 (19.7)	450 (19.7)	.954
PVD	234 (6.4)	94 (6.8)	140 (6.1)	.400
Renal failure	36 (1)	16 (1.2)	20 (0.9)	.394
Dialysis	40 (1.1)	14 (1)	26 (1.1)	.734
History of TIA	229 (6.3)	83 (6)	146 (6.4)	.664
CVA with deficit	165 (4.5)	66 (4.8)	99 (4.3)	.513
Steroid use	122 (3.3)	48 (3.5)	74 (3.2)	.684
Bleeding disorder	328 (9)	119 (8.7)	209 (9.2)	.607
Unmatched outcomes				
Death	423 (11.6)	159 (11.6)	264 (11.6)	.999
MI/cardiac arrest	174 (4.8)	73 (5.3)	101 (4.4)	.224
Pulmonary complications	814 (22.3)	286 (20.8)	528 (23.1)	.101
Renal failure	311 (8.5)	125 (9.1)	186 (8.2)	.322
Wound complications	163 (4.5)	58 (4.2)	105 (4.6)	.588
Bleeding complications	765 (20.9)	259 (18.9)	506 (22.2)	.016
Total operation time, min	205.5 ± 88.2	184.7 ± 76	218.1 ± 92.6	<.001
Postoperative LOS, days	9.8 ± 10.4	9 ± 8.8	10.3 ± 11.2	<.001
DVT/PE	93 (2.5)	34 (2.5)	59 (2.6)	.835
Return to operating room	408 (11.2)	142 (10.3)	266 (11.7)	.217

BMI, Body mass index; *CHF,* congestive heart failure; *COPD,* chronic obstructive pulmonary disease; *CVA,* cerebrovascular accident; *DVT,* deep vein thrombosis; *LOS,* length of stay; *MI,* myocardial infarction; *PE,* pulmonary embolism; *PCI,* percutaneous coronary intervention; *PVD,* peripheral vascular disease; *TIA,* transient ischemic attack.

[a]Continuous data are presented as mean ± standard deviation and categoric data as number (%).

characteristics and medical history using the *t*-test for continuous variables and the χ^2 test for categoric variables. For each procedure type, outcomes of cases with and without trainee involvement were compared using gamma regression for LOS and logistic regression for morbidity and mortality. The effect was expressed with the odds ratio (OR) and corresponding 95% confidence interval (CI). Multivariable gamma regression was used to compare the groups on total operation time and LOS by the means ratio (MR). We conducted multivariable analyses on nonmatched groups to compare the outcome in cases with and without resident involvement while adjusting for confounders. Potential confounders were examined with the use of univariate regression; factors with a *P* value of <.20 in the univariate analysis were included in the multivariable analyses.

We then propensity matched 1:1 AAA patients with and without trainee involvement within each of the three procedures. The characteristics used for propensity matching were surgeon specialty, emergency repair, patient age, gender, race, functional status, diabetes, dyspnea, history of chronic obstructive pulmonary disease, congestive heart failure, MI, PVD, transient ischemic attack, bleeding disorder, PCI, renal failure or dialysis, and steroid use. Caliper was set at 0.25 standard deviations of the propensity score. Morbidity, mortality, total operation time, and LOS were compared between the risk groups in the matched samples after adjusting for the propensity score and other covariates. Analysis was performed using SAS 9.3 software (SAS Institute Inc, Cary, NC). $P < .05$ was defined as statistically significant.

RESULTS

We identified 16,977 patients with AAA repair in the NSQIP database, of which 12,003, 3655, and 1319 underwent EVAR, OIAR, and OJAR, respectively. The average patient age within these cohorts was 72.0, 71.4, and 71.7 years, respectively. Trainees were involved 6427 of 12,003 (54%) EVARs, 2281 of 3655 (62%) OIARs, and 984 of 1319 (75%) OJARs.

EVARs with the participation of a trainee were more likely to be performed by vascular surgeons on patients

Table III. Characteristics and outcomes of patients undergoing open juxtarenal aneurysm repair (OJAR)

Characteristic[a]	*Overall (N = 1319)*	*No trainee (n = 335)*	*Trainee (n = 984)*	P *value*
Age, years	71.1 ± 9	71.5 ± 8.9	70.9 ± 9	.302
Male	949 (71.9)	221 (66)	728 (74)	.005
Caucasian	1223 (92.7)	305 (91)	918 (93.3)	<.001
BMI, kg/m^2	27.3 ± 5.3	26.9 ± 5	27.4 ± 5.4	.142
Independent	1221 (92.6)	310 (92.5)	911 (92.6)	.989
Partially dependent	60 (4.5)	15 (4.5)	45 (4.6)	
Totally dependent	38 (2.9)	10 (3)	28 (2.8)	
Emergency	186 (14.1)	63 (18.8)	123 (12.5)	.004
Diabetes	132 (10)	34 (10.1)	98 (10)	.920
Dyspnea	301 (22.8)	77 (23)	224 (22.8)	.934
COPD	274 (20.8)	69 (20.6)	205 (20.8)	.927
CHF	15 (1.1)	4 (1.2)	11 (1.1)	.910
MI	20 (1.5)	4 (1.2)	16 (1.6)	.576
Previous PCI	251 (19)	69 (20.6)	182 (18.5)	.397
Previous cardiac surgery	280 (21.2)	62 (18.5)	218 (22.2)	.159
PVD	86 (6.5)	22 (6.6)	64 (6.5)	.968
Renal failure	10 (0.8)	3 (0.9)	7 (0.7)	.737
Dialysis	19 (1.4)	11 (3.3)	8 (0.8)	.001
History of TIA	99 (7.5)	20 (6)	79 (8)	.217
CVA with deficit	56 (4.2)	18 (5.4)	38 (3.9)	.236
Steroid use	41 (3.1)	10 (3)	31 (3.2)	.880
Bleeding disorder	108 (8.2)	30 (9)	78 (7.9)	.553
Unmatched outcomes				
Death	124 (9.4)	37 (11)	87 (8.8)	.233
MI/cardiac arrest	66 (5)	18 (5.4)	48 (4.9)	.720
Pulmonary complications	304 (23)	77 (23)	227 (23.1)	.975
Renal failure	136 (10.3)	34 (10.1)	102 (10.4)	.910
Wound complications	59 (4.5)	12 (3.6)	47 (4.8)	.361
Bleeding complications	356 (27)	76 (22.7)	280 (28.5)	.040
Total operation time, min	259.6 ± 114.4	215.8 ± 105.9	274.5 ± 113.4	<.001
Postoperative LOS, days	10.3 ± 10.3	9.6 ± 9	10.5 ± 10.7	.092
DVT/PE	33 (2.5)	8 (2.4)	25 (2.5)	.877
Return to operating room	146 (11.1)	43 (12.8)	103 (10.5)	.233

BMI, Body mass index; *CHF,* congestive heart failure; *COPD,* chronic obstructive pulmonary disease; *CVA,* cerebrovascular accident; *DVT,* deep vein thrombosis; *LOS,* length of stay; *MI,* myocardial infarction; *PE,* pulmonary embolism; *PCI,* percutaneous coronary intervention; *PVD,* peripheral vascular disease; *TIA,* transient ischemic attack.
[a]Continuous data are presented as mean ± standard deviation and categoric data as number (%).

who were non-Caucasian, functionally dependent, with a history of a recent MI, renal insufficiency, ESRD, and needing emergency repair, and less likely to have had PVD or previous PCI (Table I). OIARs with a trainee were more likely performed by a vascular surgeon on patients with a dependent functional status and those requiring emergency repair and less likely on those with dyspnea (Table II). OJARs with a trainee were more often performed by vascular surgeons and were less likely to be emergency and to have fewer patients with ESRD on dialysis (Table III).

Analysis of outcomes of AAA repair in the EVAR, OIAR, and OJAR samples with and without trainees after propensity matching revealed no difference in perioperative mortality or major complications (MI/cardiac arrest, pulmonary complications, renal failure, wound complications, VTE events, postoperative blood transfusions, or return to the operating room). Total operation time was higher with trainee participation in the EVAR (163 ± 77 vs 140 ± 67 minutes; $P < .001$), OIAR (217 ± 91 vs 185 ± 76 minutes; $P < .001$), and OJAR (267 ± 115 vs 214 ± 106 minutes; $P < .001$) samples (Tables III-VI). Likewise, LOS was longer in the EVAR (3.1 ± 5.3 vs 2.8 ± 4.5 days), OIAR (10.6 ± 11.8 vs 9.1 ± 8.9 days; $P < .001$), and OJAR (11.0 ± 11.4 vs 9.6 ± 9.1 days; $P = .033$) samples (Tables IV-VI).

With regard to EVAR, multivariate analysis revealed no significant effect of intraoperative trainee participation on 30-day mortality (OR, 0.8; 95% CI, 0.6-1.0; $P = .065$), cardiac arrest/MI (OR, 1.2; 95% CI, 0.8-1.6; $P = .360$), pulmonary (OR, 0.9; 95% CI, 0.8-1.2; $P = .957$), renal (OR, 0.9; 95% CI, 0.7-1.3; $P = .946$), or wound complications (OR, 1.0; 95% CI, 0.8-1.3; $P = .991$), postoperative blood transfusions (OR, 1.1; 95% CI, 0.9-1.3; $P = .322$), VTE (OR, 0.8; 95% CI, 0.5-1.2; $P = .337$), and return to the operating room (OR, 1.1; 95% CI, 0.9-1.3; $P = .426$). Trainee participation was associated with increased total operation time (MR, 1.16; 95% CI, 1.15-1.18; $P < .001$) and LOS (MR, 1.10; 95% CI, 1.07-1.13; $P < .001$; Table VII).

For OIAR, participation of a trainee did not affect 30-day mortality (OR, 0.9; 95% CI, 0.7-1.1; $P = .244$), cardiac arrest/MI (OR, 0.8; 95% CI, 0.6-1.1; $P = .202$),

Table IV. Endovascular aneurysm repair (EVAR) matched outcomes

Characteristic[a]	*Overall (N = 10,676)*	*No trainee (n = 5338)*	*Trainee (n = 5338)*	P *value*
Death	214 (2)	119 (2.2)	95 (1.8)	.097
MI/cardiac arrest	148 (1.4)	70 (1.3)	78 (1.5)	.508
Pulmonary complications	386 (3.6)	191 (3.6)	195 (3.7)	.836
Renal failure	181 (1.7)	89 (1.7)	92 (1.7)	.822
Wound complications	266 (2.5)	129 (2.4)	137 (2.6)	.619
Postoperative blood transfusions	527 (4.9)	258 (4.8)	269 (5)	.623
Total operation time, min	151.4 ± 72.8	139.7 ± 66.6	163.1 ± 76.8	<.001
Postoperative LOS, days	3 ± 4.9	2.8 ± 4.5	3.1 ± 5.3	<.001

LOS, Length of stay; *MI,* myocardial infarction.
[a]Continuous data are presented as mean ± standard deviation and categoric data as number (%).

Table V. Open infrarenal aneurysm repair (OIAR) matched outcomes

Characteristic[a]	*Overall (N = 2624)*	*No trainee (n = 1312)*	*Trainee (n = 1312)*	P *value*
Death	283 (10.8)	154 (11.7)	129 (9.8)	.116
MI/cardiac arrest	118 (4.5)	68 (5.2)	50 (3.8)	.090
Pulmonary complications	576 (22)	275 (21)	301 (22.9)	.220
Renal failure	226 (8.6)	121 (9.2)	105 (8)	.266
Wound complications	114 (4.3)	56 (4.3)	58 (4.4)	.848
Postoperative blood transfusions	503 (19.2)	251 (19.1)	252 (19.2)	.960
Total operation time, min	200.9 ± 85.2	184.7 ± 76.2	217.2 ± 90.6	<.001
Postoperative LOS, days	9.9 ± 10.4	9.1 ± 8.9	10.6 ± 11.8	<.001

LOS, Length of stay; *MI,* myocardial infarction.
[a]Continuous data are presented as mean ± standard deviation and categoric data as number (%).

Table VI. Open juxtarenal aneurysm repair (OJAR) matched outcomes

Characteristic[a]	*Overall (N = 648)*	*No trainee (n = 324)*	*Trainee (n = 324)*	P *value*
Death	68 (10.5)	35 (10.8)	33 (10.2)	.798
MI/cardiac arrest	36 (5.6)	13 (4)	23 (7.1)	.086
Pulmonary complications	155 (23.9)	74 (22.8)	81 (25)	.519
Renal failure	75 (11.6)	33 (10.2)	42 (13)	.269
Wound complication	34 (5.2)	12 (3.7)	22 (6.8)	.078
Postoperative blood transfusions	153 (23.6)	74 (22.8)	79 (24.4)	.644
Total operation time, min	240.5 ± 113.3	214.3 ± 105.5	266.8 ± 114.8	<.001
Postoperative LOS, days	10.3 ± 10.3	9.6 ± 9.1	11 ± 11.4	.033

LOS, Length of stay; *MI,* myocardial infarction.
[a]Continuous data are presented as mean ± standard deviation and categoric data as number (%).

pulmonary complications (OR, 1.1; 95% CI, 0.9-1.4; $P = .157$), renal complications (OR, 0.9; 95% CI, 0.7-1.1; $P = .221$), wound complications (OR, 1.1; 95% CI, 0.8-1.5; $P = .664$), VTE (OR, 1.0; 95% CI, 0.7-1.6; $P = .851$), or return to the operating room (OR, 1.2; 95% CI, 0.9-1.4; $P = .217$). Trainee participation was associated with an increase in postoperative blood transfusion (OR, 1.2; 95% CI, 1.0-1.5; $P = .02$), total operation time (MR, 1.18; 95% CI, 1.15-1.22; $P < .001$), and LOS (MR, 1.15; 95% CI, 1.09-1.20; $P < .001$; Table VII).

Finally, for OJAR, trainee participation did not affect 30-day mortality (OR, 1.2; 95% CI, 0.7-1.8; $P = .524$), cardiac arrest/MI (OR, 1.4; 95% CI, 0.7-2.5; $P = .323$), pulmonary complications (OR, 1.2; 95% CI, 0.9-1.6; $P = .305$), renal complications (OR, 1.1; 95% CI, 0.7-1.7; $P = .632$), wound complications (OR, 1.5; 95% CI, 0.8-3.0; $P = .202$), VTE (OR, 1.2; 95% CI, 0.5-2.7; $P = .715$), or return to the operating room (OR, 1.0; 95% CI, 0.7-1.5; $P = .998$). Intraoperative presence of a trainee was associated with an increase in postoperative blood transfusion (OR, 1.4; 95% CI, 1.1-1.9; $P = .019$), total operation time (MR, 1.28; 95% CI, 1.22-1.35; $P < .001$), and LOS (MR, 1.11; 95% CI, 1.02-1.21; $P = .018$; Table VII).

When looking at operative time by experience of the trainee, an increase in operative time was higher for EVAR for PGY 3 and 4 compared with ≥PGY 5 (OR, 1.05; 95% CI, 1.03-1.07; $P < .001$) but was no higher for OIAR for PGY 3 and 4 compared with ≥PGY 5

Table VII. Multivariate analysis of nonmatched pairs (trainee vs no trainee)

Outcome	*OR*	*95% CI*	*P value*
EVAR			
Death	0.782	0.601-1.016	.065
MI/cardiac arrest	1.155	0.848-1.572	.360
Pulmonary complications	0.995	0.815-1.214	.957
Renal failure	0.990	0.744-1.318	.946
Wound complications	1.001	0.793-1.264	.991
Postoperative blood transfusions	1.087	0.921-1.283	.322
Total operation time	1.163	1.145-1.180	<.001
Days from operation to discharge	1.100	1.069-1.132	<.001
DVT/PE	0.816	0.538-1.237	.337
Return to operating room	1.071	0.905-1.267	.426
OIAR			
Death	0.862	0.671-1.107	.244
MI/cardiac arrest	0.809	0.584-1.120	.202
Pulmonary complications	1.136	0.952-1.354	.157
Renal failure	0.857	0.670-1.097	.221
Wound complication	1.077	0.771-1.504	.664
Postoperative blood transfusions	1.225	1.032-1.453	.020
Total operation time	1.184	1.152-1.217	<.001
Days from operation to discharge	1.147	1.093-1.204	<.001
DVT/PE	1.043	0.674-1.614	.851
Return to operating room	1.152	0.920-1.443	.217
OJAR			
Death	1.162	0.732-1.846	.524
MI/cardiac arrest	1.361	0.739-2.508	.323
Pulmonary complications	1.176	0.862-1.604	.305
Renal failure	1.109	0.726-1.694	.632
Wound complications	1.544	0.793-3.008	.201
Postoperative blood transfusions	1.432	1.062-1.930	.019
Total operation time	1.284	1.219-1.351	<.001
Days from operation to discharge	1.111	1.018-1.213	.018
DVT/PE	1.171	0.502-2.734	.715
Return to operating room	1.000	0.668-1.499	.998

CI, Confidence interval; *DVT,* deep vein thrombosis; *EVAR,* endovascular aneurysm repair; *MI,* myocardial infarction; *OIAR,* open infrarenal aneurysm repair; *OJAR,* open juxtarenal aneurysm repair; *OR,* odds ratio; *PE,* pulmonary embolism.

(OR, 1.01; 95% CI, 0.97-1.04; $P = .691$) or OJAR (OR, 0.97; 95% CI, 0.92-1.02; $P = .185$).

DISCUSSION

Our results demonstrate that the intraoperative presence of a trainee during all types of AAA repair was not associated with perioperative mortality, major morbidity, or return to the operating room. This was so despite an associated increase in operative time for all three repairs, an increase in LOS for EVAR and OIAR, and an increase in postoperative blood transfusions for open repair seen on the multivariate analysis. In our series, the differences in operative times were significant but were not very large and may not be clinically relevant. Similar observations were noted in other analyses of trainee intraoperative involvement.[25] Whether the increase in operative time was in a critical portion of the procedure or during exposure and closure is unclear.

Trainee involvement increased LOS, on average, by a fraction of a day. LOS can be used as a surrogate of resource utilization, which tends to be higher in academic centers where trainees are common.[26] Programs that do not have trainee involvement may have a more streamlined pathway for discharge. Postoperative blood transfusion was higher with trainee participation; however, the indication for the transfusion is unavailable, and these findings were not replicated in the matched analyses. Finally, despite the increased need for blood transfusion with trainee involvement, the rate of reoperation was not increased.

Other studies have looked at the effect of trainees on patient outcomes, with varying results. An analysis of emergency general surgery procedures showed higher perioperative morbidity with trainee involvement.[5] With regard to vascular procedures, an analysis of trainee participation in carotid endarterectomy noted that trainee participation was not associated with an increased risk of adverse perioperative events.[18] However, a study analyzing perioperative outcomes with resident involvement in lower extremity amputation noted that trainee involvement increased the odds of major morbidity, operative time, and the risk of intraoperative transfusions.[19] An analysis of lower extremity bypass showed resident involvement was an independent risk factor for graft failure.[20]

Limitations to this study are those inherent to any study using a large administrative database. It is possible that errors in coding misclassified the level of trainee. Also, whether two attending surgeons were involved in a case is unknown. Importantly, there is no easy way to accurately capture the anatomic variations in these patients aside from infrarenal and juxtarenal aneurysms. It could be argued that patients with more tortuous anatomy and occlusive disease are inherently at higher risk of complications, and this would be missed when matching the patients in the two groups. Each resident's role in the case is also variable, as is his or her individual attending oversight during the case. Also unclear is the effect of potentially a second attending surgeon.

CONCLUSIONS

No significant association was found between trainee involvement and mortality, cardiac arrest/MI, pulmonary, renal, or wound complications, or VTE, and return to the operating room with trainee involvement in EVAR, OIAR, and OJAR. However, trainee involvement may be associated with slightly higher resource utilization due to increased operative time, LOS, and postoperative blood transfusion.

AUTHOR CONTRIBUTIONS

Conception and design: JS
Analysis and interpretation: SD, AF, DR, JK, ME, CM, NS, JS
Data collection: Not applicable
Writing the article: SD, JS

Critical revision of the article: SD, AF, DR, JK, ME, CM, NS, JS
Final approval of the article: SD, AF, DR, JK, ME, CM, NS, JS
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REFERENCES

1. American College of Surgeons Health Policy Institute. The surgical workforce in the United States: profile and recent trends. Available at: http://www.acshpri.org/documents/ACSHPRI_Surgical_Workforce_in_US_apr2010.pdf. Accessed September 12, 2014.
2. Centers for Disease Control and Prevention. Number of all-listed procedures for discharges from short-stay hospitals, by procedure category and age: United States, 2010. Available at: http://www.cdc.gov/nchs/data/nhds/4procedures/2010pr04_numberprocedureage.pdf. Accessed September 12, 2014.
3. Drake FT, Horvath KD, Goldin AB, Gow KW. The general surgery chief resident operative experience: 23 year of national ACGME case logs. JAMA Surg 2013;148:841-7.
4. Robinson WP, Baril DT, Taha O, Schanzer A, Larkin AC, Bismuth J, et al. Simulation-based training to teach open abdominal aortic aneurysm repair to surgical residents requires dedicated faculty instruction. J Vasc Surg 2013;58:247-53.
5. Kasotakis G, Lakha A, Sarkar B, Kunitake H, Kissane-Lee N, Dechert T, et al. Trainee participation is associated with adverse outcomes in emergency general surgery: an analysis of the National Surgical Quality Improvement Program database. Ann Surg 2014;260:483-90.
6. Kiran RP, Ahmed AU, Coffey JC, Vogel JD, Pokala N, Fazio VW. Impact of resident participation in surgical operations on postoperative outcomes: National Surgical Quality Improvement Program. Ann Surg 2012;256:469-75.
7. Uecker J, Luftman K, Ali S, Brown C. Comparable operative times with and without surgery resident participation. J Surg Educ 2013;70:696-9.
8. Davis SS, Husain FA, Lin E, Nandipati KC, Perez S, Sweeney JF. Resident participation in index laparoscopic general surgical cases: impact of the learning environment on surgical outcomes. J Am Coll Surg 2013;216:96-104.
9. Papandria D, Rhee D, Ortega G, Zhang Y, Gorgy A, Makary MA, et al. Assessing trainee impact on operative time for common general surgical procedure in ACS-NSQIP. J Surg Educ 2012;69:149-55.
10. Castleberry AW, Clary BM, Migaly J, Womi M, Gerranti JM, Pappas TN, et al. Resident education in the era of patient safety: a nationwide analysis of outcomes and complications in resident-assisted oncologic surgery. Ann Surg Oncol 2013;20:3715-24.
11. Pugely AJ, Gao Y, Martin CT, Callagh JJ, Weinstein SL, Marsh JL. The effect of resident participation on short-term outcomes after orthopaedic surgery. Clin Orthop Relat Res 2014;472:2290-300.
12. Scarborough JE, Bennett KM, Pappas TN. Defining the impact of resident participation on outcomes after appendectomy. Ann Surg 2012;255:577-82.
13. Iannuzzi JC, Rickles AS, Deeb AP, Sharma A, Fleming FJ, Monson JR. Outcomes associated with resident involvement in partial colectomy. Dis Colon Rectum 2013;56:212-8.
14. Seib CD, Geenblatt DY, Campbell MJ, Shen WT, Gosnell JE, Clark OH, et al. Adrenalectomy outcomes are superior with the participation of residents and fellows. J Am Coll Surg 2014;219:53-60.
15. Tseng WH, Jin L, Canter RJ, Martinez SR, Khatri VP, Gauvin J, et al. Surgical resident involvement is safe for common elective general surgery procedures. J Am Coll Surg 2011;213:19-26; discussion: 26-8.
16. Smith BK, Greenberg JA, Mitchell EL. The evolving integrated vascular surgery residency curriculum. Ann Vasc Surg 2014;28:1761-8.
17. Dua A, Upchurch GR Jr, Lee JT, Eidt J, Desai SS. Predicted shortfall in open aneurysm experience for vascular surgery trainees. J Vasc Surg 2014;60:945-9.
18. Reeves JG, Kasirajan K, Veeraswamy RK, Ricotta JJ, Salam AA, Dodson TF, et al. Characterization of resident surgeon participation during carotid endarterectomy and impact on perioperative outcomes. J Vasc Surg 2012;55:268-73.
19. Iannuzzi JC, Chandra A, Rickles AS, Kumar NG, Kelly KN, Gillespie DL, et al. Resident involvement is associated with worse outcomes after major lower extremity amputation. J Vasc Surg 2013;58:827-31.
20. Scarborough JE, Pappas TN, Cox MW, Bennett KM, Shortell CK. Surgical trainee participation during infrainguinal bypass grafting procedures is associated with increased early postoperative graft failure. J Vasc Surg 2012;55:715-20.
21. Dua A, Kuy S, Lee CJ, Upchurch GR Jr, Desai SS. Epidemiology of aortic aneurysm repair in the United States from 2000 to 2010. J Vasc Surg 2014;59:1512-7.
22. Giles KA, Schermerhorn ML, O'Malley AJ, Cotterill P, Jhaveri A, Pomposelli FB, et al. Risk prediction for perioperative mortality of endovascular vs open repair of abdominal aortic aneurysms using the Medicare population. J Vasc Surg 2009;50:256-62.
23. American College of Surgeons-National Surgery Quality Improvement Program. ACS- NSQIP participant use file user's guide. Available at: https://acsnsqip.org/puf/docs/ACS_NSQIP_Participant_User_Data_File_User_Guide.pdf. Accessed September 12, 2014.
24. Cohen ME, Bilimoria KY, Ko CY, Hall BL. Development of an American College of Surgeons National Surgery Quality Improvement Program: morbidity and mortality risk calculator for colorectal surgery. J Am Coll Surg 2009;208:1988-97.
25. Ruhotina N, Dagenais J, Gandaglia G, Sood A, Abdollah F, Chang SL, et al. The impact of resident involvement in minimally-invasive urologic oncology procedures. Can Urol Assoc J 2014;8:334-40.
26. Oswanski MF, Sharma OP, Raj SS. Comparative review of use of physician assistants in a level I trauma center. Am Surg 2004;70:272-9.

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