The influence of surgical specialty training on the outcomes of elective abdominal aortic aneurysm surgery

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Objective: **The aim of this study was to determine the independent impact of surgeon speciality training (vascular, cardiac, or general surgery) on the 30-day risk-adjusted mortality rate after elective abdominal aortic aneurysm (AAA) surgery.**
Patients and Methods: **All patients undergoing elective AAA surgery in Ontario between April 1, 1992, and March 31, 1996, were included. A retrospective cohort study with linked administrative databases was undertaken.**
Results: **The average 30-day mortality rate was 4.1%. Of the 5878 cases studied, 4415 (75.1%) were performed by 63 vascular surgeons, 1193 (20.3%) by 53 general surgeons, and 270 (4.6%) by 14 cardiac surgeons. After the adjustment for potential confounding factors of annual surgeon AAA volume, type of hospital, and patient age, sex, Charlson comorbidity score, and transfer status, the odds of patients dying were 62% higher when the surgery was performed by a general surgeon than when it was performed by a vascular surgeon. Cardiac surgeons' patient outcomes were similar to those of vascular surgeons.**
Conclusions: **Patients who undergo elective AAA repair that is performed by vascular or cardiac surgeons have significantly lower mortality rates than patients who have their aneurysms repaired by general surgeons. These results provide evidence that surgical specialty training in vascular procedures leads to better patient outcomes. (J Vasc Surg 2001;33:447-52.)**

Abdominal aortic aneurysm (AAA) surgery is commonly performed electively to prevent the risk of death from rupture. A number of studies have elucidated patient characteristics that influence survival after AAA repair,[1-3] but relatively little research has been conducted regarding the surgeon characteristics that may influence outcomes after AAA surgery. AAA surgery is performed by both vascular and cardiac surgeons who have undergone additional training and have taken certifying examinations, as well as by general surgeons who have not received this additional formal surgical training. To address the issue of whether surgical speciality training influences outcomes, we conducted a population-based study of the 30-day risk-adjusted mortality rate for all patients who received elective AAA surgery in the province of Ontario, Canada, over a 4-year period. We studied whether having surgery by a vascular, cardiac, or general surgeon affected the patient's short-term survival.

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Competition of interest: nil.
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METHODS

Data sources. We linked together data from three administrative databases to create the AAA patient cohort for this study. First, we identified all patients receiving elective AAA surgery in Ontario between April 1, 1992, and March 31, 1996, using physician billing codes for AAA surgery (R802, R816, R817) taken from the Ontario Health Insurance Plan (OHIP) physician claims database. Patients were classified as having nonruptured or ruptured aneurysms on the basis of the presence or absence of supplemental billing code (E627). Patients with ruptured aneurysms were excluded from the study. We then linked these patients, using unique scrambled personal identifiers, to the Canadian Institute for Health Information (CIHI) hospital discharge administrative database. The CIHI database contains information on patient demographics, transfer status, comorbidities, and in-hospital mortality. A Charlson comorbidity score was calculated for each patient with the 15 secondary diagnosis fields in the CIHI database.[4] These secondary diagnosis fields represent comorbidities present at the time of hospital admission as reported by the attending surgeon. Finally, we

Table I. OHIP physician billing codes used to define index procedures for each specialty

Vascular surgery	
R802	Abdominal aorta–aneurysm
R816	Abdominal aorta–aneurysm, plus unilateral common femoral repair
R817	Abdominal aorta–aneurysm, plus bilateral common femoral repair
R780	Femoro-ant/post tibial/peroneal bypass graft (with or without endarterectomy) with prosthetic graft
R783	Aortoiliac repair, including common iliac repair (unilateral or bilateral)
R784	Aortoiliac repair, plus unilateral common femoral repair
R785	Aortoiliac repair, plus bilateral common femoral repair
R787	Femoro-ant/post tibial/peroneal bypass graft (with or without endarterectomy) with saphenous vein
R791	Femoropopliteal (with or without endarterectomy) with saphenous vein
R792	Carotid endarterectomy
R794	Femoropopliteal (with or without endarterectomy) with prosthetic graft
R797	In situ saphenous vein arterial bypass–popliteal
R804	In situ saphenous vein arterial bypass–popliteal tibial
R933	Axillofemoral, femorofemoral or axillo-axillary graft
General surgery	
S165	Operations on the digestive system, intestines (except rectum), excision–small intestine, other
S166	Small and large intestine terminal ileum, cecum, and ascending colon (right hemicolectomy)
S167	Large intestine, any portion
S171	Left hemicolectomy with anterior resection or proctosigmoidectomy (anastomosis below peritoneal reflection and mobilization of splenic flexure)
S287	Operations of the digestive system, biliary tract, excision–cholecystectomy
S323	Operations of the digestive system, abdomen, peritoneum and omentum, repair, herniotomy (adolescents and adults)
R107	Operations of the breast, excision, tumor or tissue for diagnostic biopsy and/or treatment (eg, carcinoma, fibroadenoma, fibrocystic disease)
R111	Operations of the breast, excision, partial mastectomy or wedge resection for treatment of breast disease with or without biopsy (eg, carcinoma, extensive fibrocystic disease)
Cardiac surgery	
R742	Coronary artery repair–one
R743	Coronary artery repair–two

Table II. Characteristics of patients undergoing elective AAA surgery categorized by type of surgeon in Ontario, 1992-1996

Characteristics	*Vascular surgeon*	*General surgeon*	*Cardiac surgeon*	*Total*
No. of surgeons (%)	63 (48.5)	53 (40.8)	14 (10.8)	130 (100)
No. of cases (%)	4415 (75.1)	1193 (20.3)	270 (4.6)	5878 (100)
Median patient age (IQR)	70 (65-75)	71 (66-76)	69 (65-74)	70 (65-75)
Female (%)	17.8	18.9	18.1	18.1
Charlson comorbidity index				
= 1, %	27.9	27.8	15.2*	27.3
= 2, %	9.4	10.4	7.0	9.5
≥ 3, %	3.8	3.6	1.5	3.6

P < .01 for comparison with vascular surgeons.
IQR, Interquartile range.

obtained information on out-of-hospital mortality from the Ontario Registered Persons Database, which contains the vital status of all Ontario residents. This allowed us to determine the 30-day mortality status of all patients receiving surgery in the study.

Surgeon speciality. The speciality of all surgeons in the study was determined as follows. First, one of the authors (KWJ) contacted the Royal College of Surgeons of Canada, who provided us with a list of the names of all surgeons in Ontario who have received and passed their fellowship examinations in vascular surgery or cardiovascular surgery. Next, each unique OHIP physician billing number was obtained. The surgeon's billing numbers were scrambled to protect surgeon confidentiality and then linked to the AAA patient cohort. The number of coronary artery bypass grafting (CABG) procedure billing codes (R742, R743) during the period of the study was used to define a surgeon with cardiovascular training as a cardiac or vascular surgeon. Residents trained in cardiovascular surgery in Canada have specific learning objectives for vascular surgery and obtain their clinical experience during a vascular surgery rotation or, in some cases, during their cardiovascular training on a service that has a high volume of vascular cases. A "cardiac surgeon" was defined as a surgeon with fellowship training in cardiovascular surgery that performed more than five CABG procedures per year during the time of the study. Virtually all cardiac surgeons in Ontario are high-volume surgeons,

Table III. Characteristics of surgeons performing elective AAA surgery in Ontario, 1992-1996

	Vascular surgeon	*General surgeon*	*Cardiac surgeon*
No. of surgeons	63	53	14
Median annual volume of index procedures (IQR)			
Elective AAA	15 (9-24)	5* (3-7)	4* (1-6)
Other vascular†	36 (21-63)	9* (4-18)	3* (2-10)
General surgery†	4 (1-87)	103* (34-184)	0* (0-0)
CABG	0 (0-0)	0 (0-0)	136* (97-150)
Type of hospital‡ no. (%)			
Small	4 (6.4%)	13 (24.5%)	0 (0%)
Medium	9 (14.3%)	23 (43.4%)	0 (0%)
Large	23 (36.5%)	11 (20.8%)	4 (28.6%)
Teaching	27 (42.9%)	6 (11.3%)	10 (71.4%)

*$P < .01$ for comparison with vascular surgeons.
†A list of index procedures for these surgical specialties are shown in Table I.
‡$P < .001$ for comparison across surgical specialties.
IQR, Interquartile range.

Table IV. Crude and risk-adjusted 30-day mortality rates after elective AAA surgery categorized by type of surgeon

Specialty	*No. of surgeons*	*Volume of cases*	*Crude 30-day mortality rate, %*	*Risk-adjusted 30-day mortality rate (95% CI), %**
Cardiac	14	270	3.3	4.0 (1.4, 6.6)
General	53	1193	6.5	6.2 (5.1, 7.3)†
Vascular	63	4415	3.6	3.5 (2.9, 4.1)

*Adjusted for age, sex, transfer status, and Charlson comorbidity score.
†Significantly higher ($P < .05$) than the provincial average mortality rate (4.1%).

and this low cutoff value clearly separated vascular surgeons from cardiac surgeons.[5] A "vascular surgeon" was defined as a surgeon with fellowship training in either vascular surgery or cardiovascular surgery who performed fewer than five CABGs per year during the time of the study. A "general surgeon" was defined as any of the remaining surgeons.

To further describe the nature of the practice for each group, we determined the frequency of a number of index speciality procedures each of them performed during the period of the study. These index procedures were chosen because they represent procedures that were highly specific to a given surgical specialty. A complete list of these procedures and their associated billing codes are shown in Table I. The procedures were CABG surgery (R742, R743) for cardiac surgery; peripheral arterial surgery (R780, R783-5, R787, R791, R794, R797, R804, R933) and carotid endarterectomy (R792) for vascular surgery; and breast biopsy (R107), mastectomy (R111), colon resection (S165-7, S171), cholecystectomy (S287), and hernia repairs (S323) for general surgery.

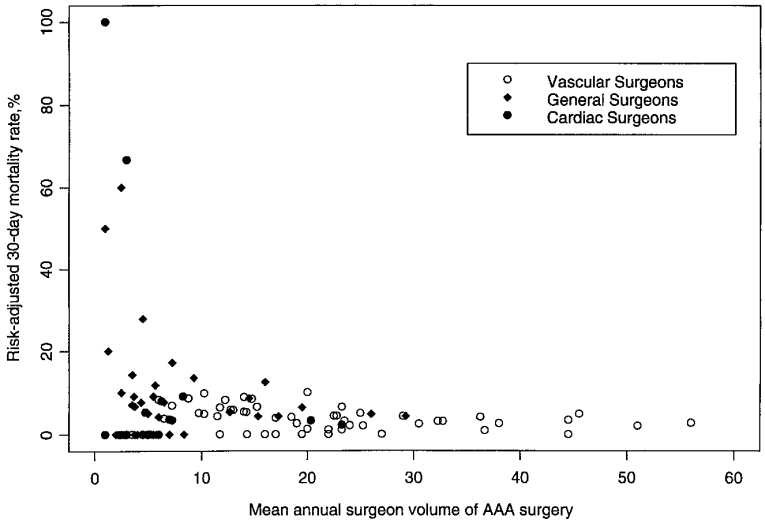
Type of hospital. The type of hospital where each operation was performed was classified into one of four groups: teaching, large, medium, and small. Large, medium, and small hospitals were defined on the basis of the average annual volume of elective AAA surgeries performed (large, > 15 cases per year; medium, 7-15 cases per year; small, 1-6 cases per year).

Statistical analyses. Univariate analyses of patient and surgeon characteristics were conducted initially. The annual surgeon volume of elective AAA surgery was divided into three terciles. A multivariate logistic regression model was then created to determine the independent impact of each of these factors on 30-day mortality rates after AAA surgery. The discriminatory power of this model was determined by calculating the area under the receiver operating characteristic curve.[6] Risk-adjusted 30-day mortality rates were determined with the use of logistic regression for each surgical speciality type. This can be interpreted as the mortality rate that would be expected if the patient case-mix for each surgeon specialty was similar to the provincial average.[5] The SAS statistical package (version 6.12) was used to conduct all of the analyses.

RESULTS

The characteristics of the patients, divided by type of surgeon, are shown in Table II. Seventy-five percent of the elective AAAs were performed by vascular surgeons, 20% by general surgeons, and 5% by cardiac surgeons. Patients operated on by cardiac surgeons had a lower prevalence of comorbidities ($P < .01$) when compared with those in the other two specialties.

The characteristics of the surgeons are shown in Table III. The 63 vascular surgeons had significantly higher median annual volumes of elective AAA surgery (15 cases per year) than the general surgeons (5 cases per year) or



Relationship between annual volume of elective AAA surgery performed and 30-day risk-adjusted mortality rates categorized by speciality of operating surgeon.

Table V. Multivariable regression model to identify predictors of 30-day mortality after elective AAA surgery

Characteristic	*Regression coefficient*	*Odds ratio*	*95% CIs*	P *value*
Surgeon specialty				
General	0.4838	1.62	(1.18-2.23)	.0030
Cardiac	–0.0731	0.93	(0.45-1.91)	.8423
Vascular		1.00		
Annual surgeon AAA volume				
< 5 cases/y	0.6064	1.83	(1.01-3.32)	.0452
5-13 cases/y	0.3333	1.40	(0.97-2.02)	.0755
> 13 cases/y		1.00		
Hospital				
Small, medium	–0.12	0.89	(0.56-1.41)	.6133
Large	–0.0182	0.98	(0.73-1.33)	.9055
Teaching		1.00		
Patient				
Age 65-74	0.4804	1.62	(1.05-2.49)	.0289
Age 75 and older	1.0870	2.97	(1.93-4.57)	< .0001
Male	–0.1123	0.89	(0.65-1.24)	.4968
Transferred status	0.9717	2.64	(1.42-4.90)	.0021
Charlson comorbidity score	0.3342	1.40	(1.27-1.54)	< .0001
Intercept	–4.1782	—	—	< .0001

Area under the receiver operating characteristic (ROC) curve, 0.70. Small and medium hospitals are those that had an average annual AAA volume of fewer than 16 cases per year.

cardiac surgeons (4 cases per year) ($P < .01$ for both comparisons). The overall median annual surgeon volume was seven AAA cases per year. Cardiac surgeons primarily performed CABG surgery, with a median annual volume of 136 cases per year, and performed none of the index procedures shown in Table I that are primarily associated with general surgery. Vascular surgeons were more likely to perform other types of index vascular procedures and performed only four of the index general surgery procedures per year on average. In contrast, general surgeons had a high frequency of performing the index general surgical procedures (median, 103 cases per year) when compared with surgeons in the other two specialities. Over 40% of the vascular and cardiac surgeons operated in teaching hospitals in comparison with only 11% of the general surgeons ($P < .001$). Surgeons who operated in more than one type of hospital were classified by the hospital where they did most of their operations.

The crude and risk-adjusted 30-day AAA mortality rates for the three surgeon specialities are shown in Table IV, and individual surgeon data are shown in the Figure. Overall, the risk-adjusted mortality rate was significantly higher for general surgeons at 6.2% (95% CI, 5.1%-7.3%) as compared with vascular surgeons at 3.5% (95% CI, 2.9%-

4.1%) and cardiac surgeons at 4.0% (95% CI, 1.4%-6.6%). An examination of individual surgeon level data showed that general surgeons were much more likely to have lower annual volumes of AAA surgery and higher risk-adjusted mortality rates than vascular surgeons (Figure).

The multivariate odds ratios for 30-day mortality after elective AAA surgery categorized by type of surgeon and other factors are shown in Table V. Having a general surgeon perform an operation was associated with an increased odds ratio of 1.62 (95% CI, 1.18-2.23; $P = .0030$) for mortality after the procedure, after adjusting for the other confounding factors shown. Cardiac surgeons had outcomes similar to vascular surgeons. A low annual surgeon AAA volume was also a significant independent predictor of 30-day mortality in univariate analyses (7.10% for < 5 cases per year vs 5.47% for 5-13 cases per year vs 3.55% for > 13 cases per year; $P < .001$) and in the multivariate analyses, as shown in Table V.

DISCUSSION

AAA surgery is performed by vascular, cardiac, and general surgeons and is associated with a significant short-term mortality rate. Because higher short-term mortality rates after the procedure reduce the long-term benefits from the procedure, any factor that significantly increases the risk of short-term mortality should be taken into account when clinicians and patients are making decisions regarding the performance of the procedure. In this study, we observed a 62% higher risk of 30-day mortality in patients who received elective AAA surgery by a general surgeon as compared with a vascular surgeon, after adjusting for possible confounding factors. Receiving AAA surgery performed by a vascular surgeon was associated with 2.7 fewer deaths per 100 surgical candidates.

The results of our study have important policy implications. Because surgery for nonruptured aneurysms is performed on an elective basis, physicians could choose to selectively refer their patients to only those surgeons with speciality training in vascular procedures. Hospitals could consider restricting operating room privileges for aneurysm surgery to vascular specialists. Our results suggest that the adoption of these types of policies would lead to a significant increase in the number of patients surviving the operation. However, the potential benefits from adopting these policies would need to be weighed against the potential inconvenience to some patients who may have to travel significant distances to receive their surgery from a vascular specialist. Furthermore, reducing the experience of general surgeons with elective AAA cases could potentially lead to worse outcomes when these same surgeons are confronted with emergent ruptured aneurysms.

In general, vascular surgeons who perform a large volume of vascular surgery might intuitively be expected to have better outcomes because they would have handled a significant number of additional operations during their fellowship training under the tutelage of experts in the field. In contrast, general surgeons have to develop expertise in many other types of operations and may have less time to gain expertise in vascular procedures. The results of our study are consistent with two previous population-based studies that have been recently published in the United States. *The Dartmouth Atlas of Vascular Health Care*[7] showed that, in elderly Americans receiving Medicare, having elective AAA surgery performed by a vascular surgeon was associated with a lower 30-day mortality rate (4.4%) as compared with having it performed by a cardiothoracic surgeon (5.4%) or a general surgeon (7.3%). Low surgeon volume was also an important predictor of mortality in that study. Pearce et al[8] have recently reported a 24% lower risk of adverse outcomes when surgery for nonruptured aneurysms was performed by surgeons with certification in vascular surgery in the state of Florida. Only 18% of the operations were performed by vascular specialists in that study.

Our study has certain limitations. First, because we used administrative data, we did not have complete information on the clinical characteristics of the patients undergoing surgery and it is possible, although unlikely, that the patients of general surgeons were much sicker than those of the vascular surgeons, in spite of our adjustments for several comorbid conditions with the Charlson comorbidity index. Second, we based our classification of surgeons primarily on their fellowship training. However, there are likely some older vascular surgeons who were misclassified as general surgeons because the speciality of vascular surgery was not recognized by the Royal College of Surgeons of Canada until 1981. At that time, surgeons in practice were invited to take their certifying examinations if their practice volume exceeded 40 major vascular procedures per year. This misclassification could only have served to diminish the effect observed.

In summary, we found that patients undergoing elective AAA surgery performed by vascular and cardiac surgeons in Ontario have significantly better outcomes than those operated on by general surgeons. These results have important implications for patients undergoing resection of their aneurysms and for surgical training programs because a lower short-term mortality rate is associated with greater long-term benefits from this prophylactic surgery. Although the data from this study should not be used to deny general surgeons with excellent surgical outcomes the opportunity to perform vascular surgery, the results do provide empirical evidence that surgical specialty training in vascular procedures leads to better patient outcomes.

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Please see related commentary by Dr Jack L. Cronenwett on pages 654-6.