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Observations on Surgeons' Case Selection, Morbidity, and Mortality Following Board Certification

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Abstract

Objective—The purpose of this study is to determine if patient selection varies based on years of surgical practice.

Summary Background Data—The impact of hospital and surgeon volume as a marker of experience has demonstrated an inverse association with surgical outcomes. However, temporal measures of experience often demonstrate no effect. Additionally, a self-reporting survey demonstrated decreasing case complexity over time, suggesting that changes in patient selection may account for some of these observed discrepancies.

Methods—General surgery cases at a single tertiary care center reported to the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) over a 10-year period were identified. Additionally general surgery cases from the ACS NSQIP 2008 PUF data were used to create risk models for any complications, 30-day mortality or a composite complication or mortality outcome. These models then estimated risk for our local data. Years of experience after American Board of Surgery (ABS) certification were calculated for each surgeon for each case. Multivariate linear regression, controlling for surgeon clustering, was used to determine the association between years of surgical experience and preoperative risk of complications and mortality.

Results—18,688 cases were identified from our institution. Surgeons selected patients of increasing operative risk until 15 years of practice before selecting lower risk patients throughout the rest of their career. After adjusting for risk, no association was observed between years from board certification and mortality. However, there was a trend toward decreasing complication rates with increasing experience.

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Conclusions—Surgical experience significantly impacts patient selection. Surgeons with over 25 years of experience had lower complication rates. Experience had no impact on mortality.

Introduction

Numerous recent studies evaluated surrogates of surgical experience and patient outcomes. The most common of these markers, surgical volume, demonstrated an inverse association with morbidity and mortality.¹⁻⁵ Logically, one would expect the cumulative effects of any surgeon's career operative volume would significantly improve outcomes over time. In contrast, studies with a more expansive view of experience found surgeon age or years of experience demonstrate mixed results in terms of patient outcomes.⁶⁻⁹

Does increasing age (or rather simply the passage of time) significantly affect surgical ability? Over time physicians in general are less likely to prescribe appropriate medications or participate in new treatment strategies.⁷ Failure rates for the American Board of Surgery (ABS) Maintenance of Certification exams increase with age.^{10, 11} However, studies of age-related cognitive decline found mixed results and some suggest that self-perceptions may outweigh any measureable differences in psychomotor function and cognitive ability.¹²⁻¹⁴

One of the most interesting findings of the Cognitive Changes and Retirement among Senior Surgeons Study (CCRASS) was a clear trend toward decreasing self-reported case complexity over time.¹⁵ Could changes in patient selection account for the apparent discrepancy between short-term and long-term surrogates of surgical experience? The purpose of this study was to determine if patient selection varies with experience. We hypothesized that with increasing years in surgical practice, surgeons operate on lower risk patients.

Methods

The University of Virginia Institutional Review Board for Health Sciences Research (IRB-HSR) approved this study.

We queried the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database for all general surgery cases occurring between January 1, 2003 and December 31, 2012 at our institution. The date of ABS board certification, along with the operative date, was used to calculate the number of years since board certification for the primary surgeon for each case.¹⁶ Each surgeon was assigned a random number for the rest of the analysis. Cases were grouped according to years since board certification from 0-30 years, in 5-year increments. Cases of uncertified surgeons (as is the case for some of our new faculty) were excluded (n = 1,754). Forty-two cases performed by a single surgeon with greater than 30 years of board-certified experience were also excluded, as this did not constitute a statistically valid group. Our outcomes included the presence of any complication, as defined by the ACS NSQIP Surgical Risk Calculator, 30-day mortality, and a composite outcome representing the presence of any complication or mortality¹⁷

To measure pre-operative patient risk, we took a two-step approach. First, we used the national ACS NSQIP Participant Use Files (PUF) from the year 2008 as our training set to

develop the risk prediction model. This year represents a mid-point of our test set and was chosen purposely to mitigate any potential bias caused by advances in surgical techniques over the study period. As with the test set, we only included general surgery patients and excluded patients with American Society of Anesthesiology (ASA) class 5, as these cases were not present in our test set.

Multivariable logistic regression was used to construct risk prediction models for any complication, 30-day mortality, and combined complication or mortality. We used the same variables described for the universal ACS NSQIP Surgical Risk Calculator with two modifications.¹⁷ First, because the recording of functional status changed during the study period, this variable was dichotomized to represent either independent or non-independent functional status. Second, since we did not have the Current Procedural Terminology (CPT)-specific linear risk models used in the Risk Calculator, relative value units served as surrogates for case complexity.

All variables were included *a priori* to create non-parsimonious regression models. It is worth re-emphasizing that all variables included in these models represent either preoperative data or data inherent in the operation performed. We used c-statistic, Hosmer-Lemeshow test, and Brier score to test calibration and discrimination of our prediction models. Brier score is a measure of both discrimination and calibration, with predictive ability increasing as values approach zero.¹⁷

As the second step, after the risk prediction models were developed with the training set, these models were then applied to our test set to compute a preoperative risk score for each outcome for each patient with the score ranging between 0 and 1.

We used linear regression to estimate the relationship between surgeon experience (indexed by years since board certification) and our preoperative risk estimates. Random-intercept modeling was used to control for clustering within surgeons and was estimated using generalized estimating equations. Because our dependent variables (risk scores) are proportions and not normally distributed, they were transformed to logit scale before they were used in the regression analysis. The predicted risk estimates for each practice group (and 99% confidence interval) were calculated. Less than 5 years of practice since board certification served as the referent group.

We conducted a supplementary analysis to examine whether surgeon experience had a significant effect on patient outcomes. For this purpose, the risk prediction models developed in the training set were applied to our test set with the number of years since board certification added to these models. We used random-intercept logistic regression models to control for clustering within surgeons.

Standard univariate statistics including Kruskal-Wallis and Chi-square were used to compare groups. ACS NSQIP abstracted surgical volume was also recorded. However, ACS NSQIP varies widely in accurately representing surgical volume depending upon the surgeon's practice pattern. For this reason, volume was not included in the multivariate analyses.

For the purposes of this analysis, statistical significance was set at p-values < 0.01 . All statistical analysis was conducted using SAS software, version 9.3 (SAS Institute, Cary, NC).

Results

We identified 196,650 cases in our PUF training set and 18,688 cases in our local test set that met our inclusion criteria. A comparison of both data sets is included in Supplemental Table A. Due to the large sample size, significant differences were observed for almost all variables, but the average absolute difference between groups was only 2.1% (median 1.6%).

Our training set models for any complication, 30-day mortality, or composite outcome had c-statistics of 0.84, 0.94, and 0.87 respectively suggesting good discrimination. However, the Hosmer-Lemeshow test for all models was statistically significant at p-values < 0.0001 . The Brier scores for our complication, mortality, and composite models were 0.027, 0.011, and 0.032 respectively. The scores for our complication and mortality models are similar to and in fact slightly lower than those reported by Bilimoria's study. There was no direct comparison for the composite model but the score is within the range of those previously reported.¹⁷

All cases in our test set were performed by 35 individual surgeons. The number of cases performed by surgeons in each group increased in the first 10 years before leveling off between 11 and 25 years since certification. Surgeons practicing between 26-30 years performed the lowest total number of cases. The practice profile of the surgeons in each experience group is listed in Table 1. The number of practicing surgeons decreased as years of experience increased. Minimally invasive / bariatric surgeons had the largest number of practicing surgeons ($n = 9$) while only one hepatobiliary surgeon practiced during the study period. By volume, 28.5% of the total cases were performed by minimally invasive / bariatric surgeons, followed by colorectal surgeons at 23.9%. Critical care and trauma surgeons performed the lowest number of cases (2.3% and 3.7% respectively). On a per-surgeon basis, the median number of cases abstracted by ACS NSQIP over the entire study period was 191 (IQR: 27.8 – 436.3). Surgeons in the 6-10 year practice group had the lowest median number of cases; those in the 21-25 year group had the highest. However, the 21-25 year group included only 4 practicing general surgeons, compared to 20 in the 5 year group. There was considerable heterogeneity in terms of pre-operative comorbidities across all surgeon experience groups (Table 2). Notably, the proportion of emergent cases decreased steadily as years of surgical experience increased.

Observed rates of any complication, 30-day mortality, and the composite outcome are listed in Table 3. Overall, unadjusted complication and mortality rates throughout the first 30 years of practice seemed to decline with a slight peak at 11-15 years of practice.

Figure 1 shows the relationship between surgeon experience and preoperative patient risk computed using our risk prediction models. Preoperative predicted odds ratios with 99% confidence intervals are listed. P-values for each experience group are listed at the chart

below each graph. The group with 5 years of surgical experience served as the *a priori* reference point with these p-values listed in row 'a'. However, all of our models demonstrated a peak in preoperative predicted risk at 11-15 years of experience, and so the models were also run with this group as the reference and p-values listed in row 'b'. Additionally, given the decrease in emergent cases seen in Table 2, the models were also repeated with these cases excluded.

Our model for any complication demonstrated a statistically significant increase in the pre-operative risk profile of patients selected for surgery peaking at 11-15 years of experience followed by a statistically significant decrease in preoperative risk at higher experience levels. When emergent cases were excluded, there was a significant increase in pre-operative risk, which plateaued after 11-15 years of experience. Overall, a similar pattern was seen for the composite outcome although the decrease in risk after 11-15 years of experience was more significant. When all cases were considered, preoperative risk of mortality demonstrated a clear decrease as experience increases. However, with emergent cases excluded, there was a small but significant increase in preoperative mortality risk at years 11-15, which again had a small but significant decrease by years 21-25 which then plateaued.

Our supplemental analysis shown in Figure 2 suggests that for both any complication and our combined outcome, increasing years of experience have an increasingly protective effect, which only becomes statistically significant at 26-30 years of practice. However, increasing years of experience do not have a significant effect on mortality.

Discussion

Our data suggests that as years of surgical practice increase, the risk-profile of patients selected for surgery changed. We believe that these observations reflect changes in surgical practice and patient selection with the passage of time. These findings reflect those of the CCRASS Self Reporting Survey, which demonstrated the proportion of surgeons who chose to perform less complex cases increased with age.¹⁵ Another study demonstrated that the scope of indications for shoulder arthroplasty narrowed over time.¹⁸ While not evaluating operative indications, our study demonstrated comparable time-sensitive changes in patient selection.

Experience may not guarantee performance. A study by Duclos et al., evaluated the role of surgical experience on outcomes from thyroid surgery accounting for clustering within surgeons. Their study demonstrated that for thyroid surgery, patient-specific factors had the greatest influence on surgical outcomes. Patients of surgeons with the most experience were at increased risk for laryngeal nerve palsy and hypothyroidism.⁸ Similarly, Neumayer et al. found that the risk of recurrence after laparoscopic inguinal herniorrhaphy increased significantly for patients with surgeons older than 45 years of age.^{6, 19} Lapar et al., found that for off-pump coronary artery bypass grafts, patient risk factors were more important than surgeon volume in determining outcomes.⁵ One may expect that surgeons in practice longer, or those who have greater experience, should operate on higher risk patients. Our data demonstrated that added years of experience may have a positive effect on patient

complication rates. However, this effect was only statistically significant for the most experienced surgeons. This experience group also had the lowest number of practicing surgeons. Our data did not demonstrate an association between experience and mortality. These observations suggest that for the majority of surgeons, experience level is likely not as important as patient risk factors. In other words, for most surgeons, “the die is cast” once the decision to operate is made, highlighting the importance of patient selection when evaluating outcomes.

What then drives differences in patient outcomes? Experience may not be as important as skill. Scardino’s group demonstrated that significant outcome variability might exist even among “high volume” surgeons.^{20, 21} Their studies suggest that differences in operative skill may account for variations in morbidity even among highly experienced surgeons. However, surgical skill is not a static quality and is not easily measured. The learning curves observed when learning a new procedure serve as well-described examples of volume influencing surgical skill.^{22, 23} For example, in spinal surgery, the accuracy with which free-hand vertebral pedicle screws are placed based on postoperative imaging improves over a relatively small number of cases.^{24, 25} However, among experienced surgeons, further increases in case volume may not result in further improvement in outcomes.⁶ While volume plays an important role in influencing surgical ability, the underlying psychomotor skills required to perform these tasks may continue to undergo predictable age-related decay.¹²

Is the real benefit of experience seen in the preoperative setting? One may expect that increasing experience should improve ability to discern which patients would benefit from surgery, or those in whom the risks start to outweigh the benefits. We do not have data on the outcomes of those patients evaluated but ultimately not considered appropriate for surgery. Such a comparison would be interesting, and assist in determining if changes in patient selection were appropriate. Irrespective of appropriateness, our data demonstrate time-dependent changes in patient selection. Surgeons with more experience also performed fewer emergent operations, which appears to explain a large degree of the observed variability.

We would caution against interpreting our data as a true measure of surgical experience, since “experience” was not directly measured in our study. Experience is an abstract concept that cannot be directly measured. The experience of any given surgeon is a complex amalgam of age, prior and ongoing case volume, and complexity, previous patient selection, and anecdotal experience with prior morbidity and mortality. The interactions between these elements are subtle and feedback on each other over time. Markers of experience are generally reported in the literature in one of three ways: Age, number of procedures performed over a given period of time, or years of practice. All of these measures are imperfect. For our purposes, NSQIP provides excellent data on comorbid conditions, pre-defined outcomes, and has known predictive capability but is limited by an inherent selection bias. It varies widely in its ability to capture the scope of practice of an individual surgeon, making it difficult to use as a marker of case volume. Surgeon age provides a continuous surrogate for experience but surgeons differ in their actual experiences at a given age, based on when they pursued surgery as a career, their length of training, and their scope of practice. These differences are likely more pronounced at younger ages. Years since

board certification provides similar information as age (the two are co-linear), with the benefit of being standardized to common starting point (completion of surgical training and board passage).

Our study has several important limitations. These data reflect practice patterns at a single tertiary-care institution over a 10-year period. Therefore our results may not be broadly generalizable. We chose to analyze outcomes that are not procedure-specific. Therefore, important procedure-specific changes in outcomes (recurrent laryngeal nerve injury for example) will be missed by our study. As a retrospective analysis, our results are additionally subject to the standard observation bias inherent in this type of study.

Conclusion

Our data showed that surgeons with more experience select cases with lower complexity after 15 years of practice but that the quality of care does not necessarily deteriorate with passage of time. Further work is needed to confirm these findings using multicenter data.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Mini-Abstract

Retrospective analysis of 18,688 cases performed at a single institution. Changes in the pre-operative risk profiles of patients selected for surgery were evaluated based upon years of surgical experience. Additionally, the associations between morbidity, mortality, and years of surgical experience were evaluated.

Figure 1. Pre-Operative Risk Profiles of Patients Selected for Surgery by Years of Experience
OR = Odds ratio

Values represent estimated pre-operative patient odds ratios with 99% confidence interval.

a = p-values using 5 years of experience as *a priori* reference.

b = p-values using 11-15 years of experience as post hoc reference.

Figure 2. Adjusted Odds Ratios for Outcomes Based on Years of Experience

OR = Odds ratio

Values represent odds ratios listed with 99% confidence interval.

Table 1

Surgeon Profiles by Years of Surgical Experience

	Totals		Years of Board Certified Surgeon Experience					
	Surgeons	Cases	5	6 - 10	11 - 15	16 - 20	21 - 25	26 - 30
Practicing Surgeons*	35	18688	20	16	13	9	4	2
NSQIP-captured case volume by surgeon**			157.5 (36-324.5)	119 (17-439.3)	132 (39-237)	156 (55-235)	627 (37-1272)	581 (370-792)
Primary Specialty								
Breast	3	1725	27.7%	49.1%	23.2%	0.0%	0.0%	0.0%
Colorectal	3	4473	34.3%	43.9%	21.8%	0.0%	0.0%	0.0%
Critical Care / Acute Care	4	430	34.2%	19.3%	33.7%	12.8%	0.0%	0.0%
Endocrine	2	2597	6.9%	0.0%	0.0%	8.0%	46.5%	38.6%
Hepatobiliary	1	1475	0.0%	37.4%	45.6%	17.0%	0.0%	0.0%
Minimally Invasive / Bariatric	9	5144	16.2%	16.6%	1.6%	34.0%	28.5%	3.1%
Surgical Oncology	3	1292	39.3%	30.7%	11.8%	18.2%	0.0%	0.0%
Transplant	8	859	35.2%	10.1%	13.2%	35.0%	6.5%	0.0%
Trauma	2	693	52.7%	23.4%	20.9%	3.0%	0.0%	0.0%

* Experience groups are not mutually exclusive for the number of practicing surgeons. Surgeons were classified according to their experience at the time of each case so many surgeons are listed in multiple groups.

** Median (IQR) values calculated on a per-surgeon basis. Only surgeons practicing in a given experience group were used in the calculation. For example, the volume calculated 26-30 year practice group was based off of 2 surgeons, not 35.

Table 2**Patient Demographics and Comorbidities by Years of Surgical Experience**

Variable	Years of Board Certified Surgeon Experience						p-value
	<u>5</u>	<u>6 - 10</u>	<u>11 - 15</u>	<u>16 - 20</u>	<u>21 - 25</u>	<u>26 - 30</u>	
Patient Age Group	4348	4945	2683	2821	2729	1162	
64	73.0%	70.1%	68.4%	76.8%	79.0%	77.1%	<0.0001
65-74	15.9%	18.0%	18.1%	14.3%	13.4%	14.3%	<0.0001
75-84	8.2%	8.7%	10.6%	6.1%	5.5%	6.0%	<0.0001
85	2.8%	3.2%	2.9%	2.8%	22.0%	2.6%	0.19
Sex: Female	58.3%	60.2%	56.3%	60.6%	69.7%	76.8%	<0.0001
BMI Class							
Underweight (BMI: < 18.5)	7.9%	7.4%	7.5%	5.3%	3.1%	1.1%	<0.0001
Normal weight (BMI: 18.5-24.9)	28.3%	29.9%	31.5%	19.5%	19.7%	21.6%	<0.0001
Overweight (BMI: 25.0-29.9)	27.2%	28.5%	28.4%	21.2%	23.8%	28.2%	<0.0001
Obesity I (BMI: 30.0-34.9)	17.2%	16.3%	17.7%	12.8%	15.8%	22.7%	<0.0001
Obesity II (BMI: 35.0-39.9)	8.5%	8.2%	8.2%	8.9%	10.8%	12.1%	<0.0001
Obesity III (BMI: 40.0)	11.1%	9.7%	6.7%	32.3%	26.9%	14.3%	<0.0001
Hypertension	42.5%	44.4%	42.9%	49.3%	53.4%	49.2%	<0.0001
Cardiac Event	7.4%	7.3%	7.5%	7.0%	5.6%	3.8%	<0.0001
Congestive Heart Failure	0.7%	0.5%	0.4%	0.4%	0.3%	0.2%	0.07
Ventilator Dependent	1.5%	0.9%	1.7%	1.2%	0.5%	0.3%	<0.0001
Dyspnea	17.5%	17.4%	14.8%	31.1%	25.0%	18.3%	<0.0001
Smoke	25.8%	23.7%	22.5%	20.1%	19.2%	15.6%	<0.0001
COPD	3.7%	3.1%	3.2%	2.6%	2.4%	1.6%	
Diabetes							
IDDM	6.5%	5.5%	6.4%	0.1%	7.3%	5.9%	0.0003
NIDDM	8.7%	10.1%	8.1%	12.4%	12.3%	8.4%	<0.0001
Renal Insufficiency	0.3%	0.2%	0.3%	0.1%	0.0%	0.1%	0.27
Hemodialysis	1.8%	1.0%	1.8%	1.9%	1.0%	0.5%	<0.0001
Ascites	3.4%	1.9%	1.9%	2.1%	0.8%	0.5%	<0.0001
Corticosteroid	6.7%	6.1%	7.8%	6.3%	3.9%	2.3%	<0.0001
Functional Status: Independent	85.9%	88.8%	92.8%	81.8%	97.8%	98.8%	<0.0001
Disseminated Cancer	4.2%	5.3%	6.7%	3.3%	0.7%	0.3%	<0.0001
Emergent	19.0%	11.2%	13.2%	12.8%	8.4%	3.2%	<0.0001
Pre-Operative Infection							
SIRS	4.4%	2.2%	3.7%	2.5%	2.0%	0.5%	<0.0001
Sepsis	2.0%	1.3%	1.9%	1.5%	1.1%	0.5%	0.001
Septic Shock	1.4%	0.9%	1.3%	1.1%	0.6%	0.3%	0.0004
Wound Class							
Clean	31.7%	33.1%	29.6%	37.1%	60.5%	87.8%	<0.0001
Clean-Contaminated	48.0%	51.8%	52.3%	51.5%	31.7%	10.0%	<0.0001

	Years of Board Certified Surgeon Experience						p-value
	<u>5</u>	<u>6 - 10</u>	<u>11 - 15</u>	<u>16 - 20</u>	<u>21 - 25</u>	<u>26 - 30</u>	
Contaminated	9.0%	7.2%	8.7%	4.3%	3.2%	1.2%	<0.0001
Dirty	11.3%	7.9%	9.4%	7.2%	4.7%	1.0%	<0.0001
ASA Class							
ASA 1	7.0%	5.7%	6.1%	4.8%	7.2%	7.5%	0.0003
ASA 2	51.7%	53.9%	51.3%	45.2%	52.0%	61.0%	<0.0001
ASA 3	36.0%	36.7%	37.7%	45.2%	38.3%	29.4%	<0.0001
ASA 4	4.9%	3.5%	4.6%	4.6%	2.5%	2.0%	<0.0001
Surgeon Age at OR (Median/IQR)	39 (35-40)	43 (41-44)	47 (46-48)	51 (50-53)	57 (55-59)	63 (62-64)	<0.0001

Table 3

Outcomes by Years of Surgical Experience

	Years of Board Certified Surgeon Experience						p-value
	<u>5</u>	<u>6 - 10</u>	<u>11 - 15</u>	<u>16 - 20</u>	<u>21 - 25</u>	<u>26 - 30</u>	
Any Complication	15.80%	15.80%	17.00%	13.20%	6.90%	2.90%	<0.0001
30-Day Mortality	2.10%	1.50%	2.40%	1.80%	1.20%	0.30%	<0.0001
Combined Complication or Mortality	16.80%	16.30%	18.00%	13.90%	7.50%	3.00%	<0.0001