Programmatic and Surgeon Specialization Improves Mortality in Isolated Coronary Bypass Grafting

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Background. **Throughout surgery, specialization in a procedure has been shown to improve outcomes. Currently, there is no evidence for or against subspecialization in coronary surgery. Tasked with the goal of improving outcomes after isolated coronary artery bypass grafting (CABG), our institution sought to determine whether the development of a subspecialized coronary surgery program would improve morbidity and mortality.**

Methods. **All isolated CABG operations at a single institution were retrospectively examined in two distinct periods, 2002 to 2013 and 2013 to 2016, before and after the implementation of a subspecialized coronary surgery program. Improved policies included leadership and subspecialization of a program director, standardization of surgical technique and postoperative care, and monthly multidisciplinary quality review. Outcomes were collected and compared.**

Results. **Between 2002 and 2013, 3,256 CABG operations were done by 16 surgeons, the most frequent surgeon doing 33%. Between 2013 and 2016, 1,283 operations were done by 10 surgeons, 70% by the coronary program director. CABGs done in the specialized era had shorter bypass and clamps times and increased use of bilateral internal mammary arteries. Blood transfusion and complication rates, including permanent stroke and prolonged ventilation, were significantly decreased after implementation of the coronary program. Likewise, overall operative mortality (2.67% vs 1.48%, $p = 0.02$) was significantly reduced.**

Conclusions. **Subspecialization in CABG and dedicated coronary surgery programs may lead to faster operations, increased use of bilateral internal mammary arteries, fewer complications, and improved survival after isolated CABG.**

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Subspecialization in academic surgery is increasing common. Studies suggest increased hospital and surgeon volume throughout surgery may lead to improved surgical outcomes [1]. The degree of specialization has been shown to reduce operative mortality in a variety of procedures [2]. The relative contribution of hospital volume, surgeon volume, or degree of specialization on operative mortality after isolated CABG is unclear in the current literature [3–5].

As the most common cardiac operation performed [5], coronary artery bypass grafting (CABG) has not seen the degree of specialization seen in mitral valve, aortic, or congenital cardiac surgery. Studies suggest hospital [6] and surgeon volume [3] may both increase the repair rate and operative survival in mitral valve surgery. Higher-volume cardiac surgery centers have been shown to have improved outcomes after repair of acute aortic dissections [7]. However, results for or against subspecialization in CABG are equivocal [4, 8–11].

The topic of surgical subspecialization coincides with a new era of increased public reporting of surgical outcomes. The outcomes after elective isolated CABG carry an increasing expectation of an operative mortality of less than 1% [12]. In 2013, The University of Maryland Medical Center instituted a programmatic and surgeon subspecialization in coronary bypass surgery with the goal of improving outcomes after isolated CABG. This report presents the retrospectively reviewed outcomes of isolated CABG operations in a single institution before and after the implementation of subspecialization in coronary surgery.

Patients and Methods

Patient Data Set

The Society of Thoracic Surgeons (STS) cardiac surgery database entries for all patients undergoing isolated

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Abbreviations and Acronyms

CABG	= coronary artery bypass grafting
CPB	= cardiopulmonary bypass
IMA	= internal mammary artery
IABP	= intraaortic balloon pump
NYHA	= New York Heart Association Functional Classification for heart failure
O/E	= observed-to-expected
PA	= physician assistant
PROM	= Predicted Risk of Mortality
RBC	= red blood cell
STS	= The Society of Thoracic Surgeons

CABG at a single institution between 2002 and 2016 were used for this study. All techniques for CABG were included. Reoperative and initial CABG, all degrees of cardiac function, and elective, urgent, and emergent/salvage cases were included. The STS Predicted Risk of Mortality (PROM) was used to ascertain operative risk for each patient. Approval for this study was waived by the Institutional Review Board.

Intervention

Beginning in 2013, motivated by suboptimal CABG outcomes, our institution initiated a specialized program in coronary artery bypass surgery. Practices were restructured and clarified in an attempt to streamline the surgical care for CABG patients (Fig 1). A senior surgeon specializing in coronary surgery was recruited, appointed as clinical director, and held accountable for clinical outcomes. The clinical director evaluated all CABG referrals. Cases were distributed to mentored junior surgeons when appropriate, with recommendations regarding the operative plan. Fitting with the institution's broader model of subspecialization, other cardiac surgeons specialized in noncoronary work. All surgeons performed emergent CABG operations while on-call. Elective or urgent cases were referred to the CABG service as scheduled cases. Surgeons not specializing in coronary surgery performed occasional but far fewer CABGs.

Specific coronary service nurse practitioners and trainees provided increased continuity of care. Clinical protocols for timing of medications, management of atrial fibrillation, drain and pacing wire removal, and discharge were simplified and standardized. The consolidated team recommitted to ensuring unstable myocardial infarction patients were temporized with percutaneous intervention or mechanical support when possible. Medical optimization of symptomatic heart failure was managed by the heart failure cardiology and coronary surgery services.

Surgical approach was standardized, with standard on-cardiopulmonary bypass (CPB), arrested-heart operations being the planned approach for multivessel bypass grafting. Robotic totally endoscopic CABG was abandoned, and robot use was reserved for only isolated left anterior descending artery harvest for single-vessel CABG. Off-CPB CABGs were reserved for single left anterior descending bypass or very rare occasions of porcelain aorta, hepatic dysfunction, severe blood cell dyscrasia, or other medical limitations preventing cardiac arrest.

Operative techniques for conduit harvest, target exposure, and distal and proximal anastomosis were standardized among the director, junior attending surgeons, and surgical trainees. Skeletonized bilateral mammary

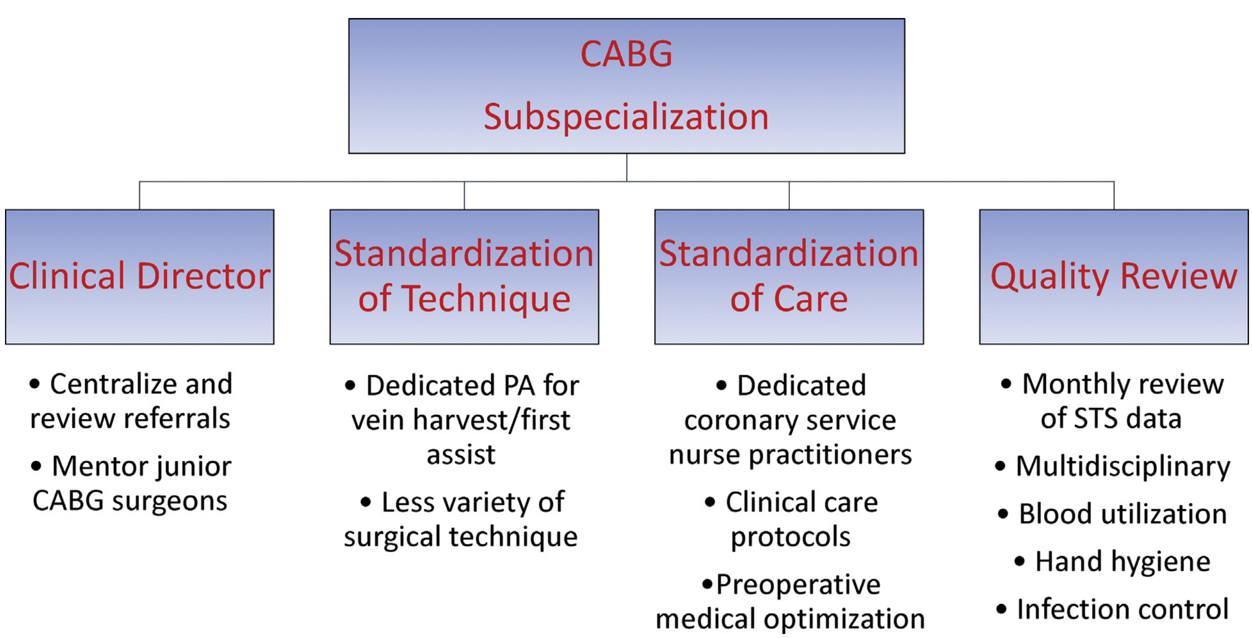

Fig 1. Coronary artery bypass grafting (CABG) subspecialization model. (PA = physician assistant; STS = The Society of Thoracic Surgeons.)

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artery grafts were preferred in all nondiabetic patients aged younger than 70 years. Single mammary grafts were nonskeletonized. Proximal graft anastomoses were preferentially done with partial aortic occlusion.

Quality review was intensified in the remodeled coronary surgery program. The clinical program director, coronary service nurse practitioners, and third-party quality and safety review personnel met monthly to examine STS outcome data. Operations were delayed to give this meeting priority, and attendance was mandatory. Other disciplines included in this meeting were anesthesia, perfusion, nursing administration, critical care respiratory therapy, blood bank, and infectious disease. Meetings were less frequent in the specialized era but were more prioritized and productive. Specific quality-improvement task forces were initiated for prevention of sternal wound infection and blood conservation.

Outcomes

Outcomes were defined according to STS database definitions. Primary outcome was operative mortality (in-hospital and 30-day mortality). The annual observed-to-expected (O/E) mortality ratio was determined by dividing observed mortality by the mean STS PROM. Secondary outcomes included permanent stroke, reoperation, renal failure, deep sternal wound infection, transfusion, readmission, and length of stay. Operative variables examined included robot use, CPB use, CPB time, cross-clamp time, skin-to-skin time, and bilateral internal mammary artery use. Additional factors compared between the two groups were number of CABG surgeons and their degree of surgeon specialization in CABG. Specialization in CABG was determined as the percentage of isolated CABG operations done out of a surgeon's total case volume.

Statistical Analysis

Primary analysis compared outcomes among the two time periods: 2002 to 2013, before the CABG specialization program; and 2013 to 2016, after implementation of the CABG specialization program. Continuous variables are expressed as mean and SD and were compared using the Student *t* test. Categoric variables are expressed as a percentage and were analyzed with the χ^2 or Fisher exact test. A variable life-adjusted plot [13], also called a cumulative sum plot of risk adjusted mortality [14], was used to examine trends in operative mortality over time adjusted for expected risk. This scoring system accumulates point for survival and loses points for deaths with each sequential case, based on the STS PROM for each case. All analyses were computed using JMP software (SAS Institute, Inc, Cary, NC).

Results

Baseline Characteristics

Between 2002 and 2016, 4,539 patients underwent isolated CABG operations. The general era, 2002 to 2012, included 3,256 patients. The specialized era, 2013 to 2016, had 1,283 patients (Table 1). Patients were of similar age,

Table 1. Preoperative Demographics

Variable[a]	General Era 2002–2012 (n = 3,256)	Specialized Era 2013–2016 (n = 1,283)	*p* Value
Age, years	64 ± 11	64 ± 11	0.2
Male sex	2,307 (70)	948 (74)	0.04
White race	2,536 (78)	986 (77)	0.5
Family history of coronary disease	877 (27)	112 (10)	<0.0001
Diabetes	1,410 (43)	653 (51)	<0.0001
Renal failure/dialysis	144 (10)	46 (4)	<0.0001
Chronic lung disease	417 (13)	181 (15)	<0.0001
Peripheral vascular disease	509 (16)	159 (12)	0.006
Cerebrovascular disease	570 (17)	275 (21)	0.002
Ejection fraction	0.47 ± 0.14	0.51 ± 0.13	<0.0001
NYHA class III and IV	1,520 (70)	61 (34)	<0.0001
Previous cardiac intervention	935 (29)	395 (31)	0.008
Prior myocardial infarction	1,721 (53)	746 (58)	0.001
Prior cardiac operation	80 (3)	33 (3)	0.18
Intraaortic balloon pump	381 (12)	157 (12)	0.6
Shock	90 (3)	13 (1)	<0.0001
Inotropes	27 (1)	10 (1)	1
Nitrates	398 (12)	124 (10)	0.015
Emergent or salvage status	83 (3)	33 (3)	1
STS Predicted Risk of Mortality	1.6 ± 1	1.5 ± 1	0.06

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

NYHA = New York Heart Association Functional Classification for heart failure; STS = The Society of Thoracic Surgeons.

sex, and race within the two groups. Patients in the general era had a higher history of renal failure, peripheral vascular disease, and coronary disease in their families. The patients in the specialized era group had significantly more diabetes, chronic lung disease, cerebrovascular disease, prior myocardial infarction, and prior cardiac intervention. The New York Heart Association Functional Classification for heart failure was higher (70% vs 30%) and the ejection fraction was lower (0.47 vs 0.51) in the generalized era patients ($p < 0.001$). Isolated CABGs done between 2002 and 2013 were more likely in patients in cardiogenic shock, 3% versus 1% ($p < 0.001$), and on nitrates for chest pain, 12% versus 10% ($p = 0.015$). Both groups had a similar incidence of redo sternotomy and preoperative intraaortic balloon pump use. Despite these differences, the STS PROM score was similar in both groups, at 1.6% in the generalized era and 1.5% in the specialized era ($p = 0.06$). The number of isolated CABG operations done per year varied throughout the time periods but remained between 250 and 350 (Fig 2A).

Surgeon and Operative Characteristics

Isolated CABG operations were done by 16 surgeons in the general era and 10 surgeons in the specialized era (Table 2). The highest-volume surgeon in the specialized era, the program director, did 70% of the isolated CABG operations, whereas the highest percentage done by 1 surgeon in the general era was only 33% ($p < 0.0001$). Three surgeons contributed to both time periods. In the specialized era, the program director did 2.0% (n = 18) of emergent or salvage cases, and the other 9 surgeons did 3.8% (n = 15; range was 0% to 28% individually). The degree of specialization (number of isolated CABGs/all cases) of the program director was 75%, and ranged widely among surgeons in the general era (6% to 87%).

Neither increasing case volume nor degree of specialization led to improved mortality in the general era. However, increased volume and specialization both led to improved mortality in the specialized era (Fig 3). This demonstrates the effects of programmatic and team specialization in coronary surgery, with standardization of technique and perioperative care as well as an intense quality review process likely accounting improved returns on surgeon's efforts.

Among operative characteristics (Table 2), fewer off-CPB CABG operations were done in the specialized era (10% vs 33%, $p < 0.0001$). The da Vinci robot (Intuitive, Sunnyvale, CA) was used in 13% of cases in the generalized era but was used more selectively, at 11%, in the specialized era ($p < 0.0001$). Operations

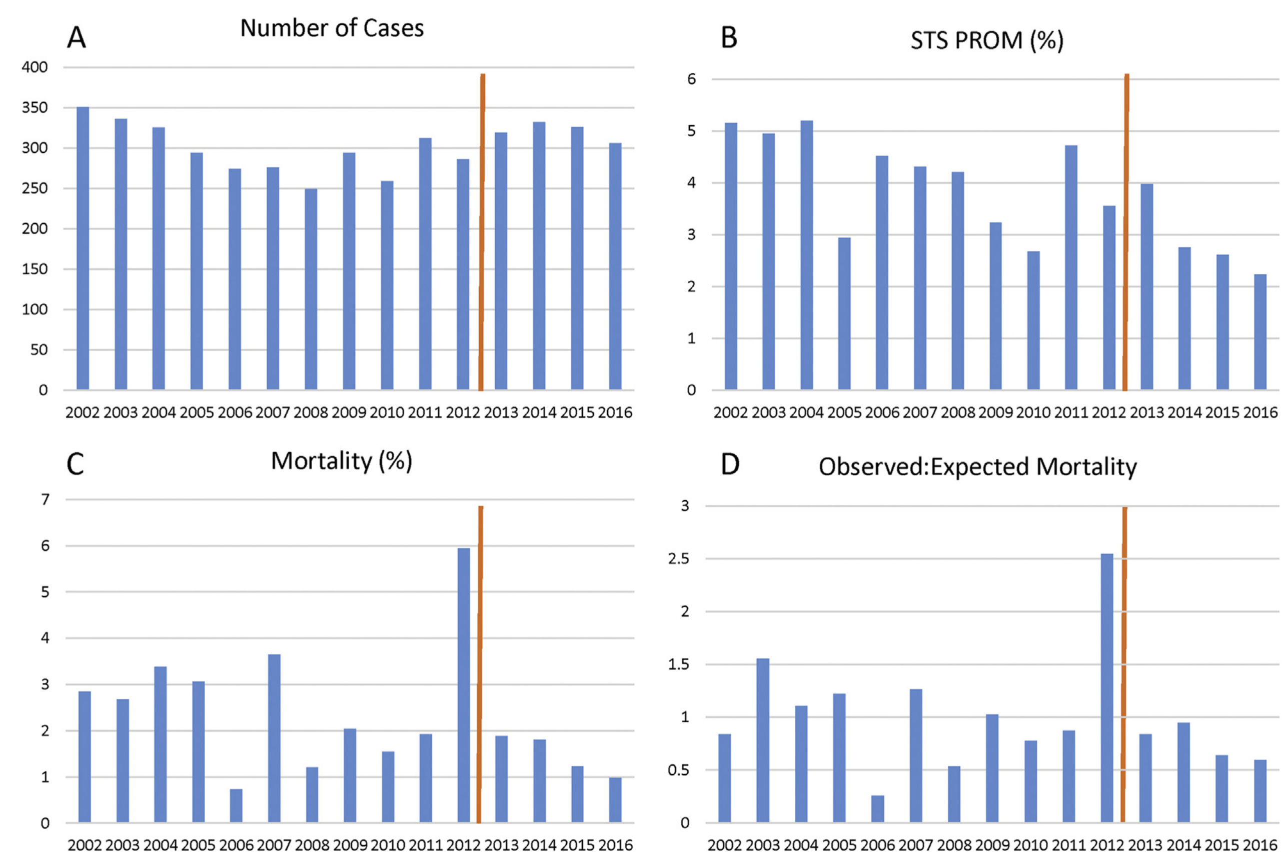

Fig 2. Trends in (A) volume, (B) risk, (C) mortality, and (D) observed-to-expected mortality ratios for isolated coronary artery bypass grafting operations. The red bar divides the general era and the era after implementation of the subspecialization program. (STS PROM = The Society of Thoracic Surgeons Predicted Risk of Mortality.)

Table 2. Intraoperative Characteristics

Variable[a]	General Era 2002–2012 (n = 3,256)	Specialized Era 2013–2016 (n = 1,283)	*p* Value
Surgeons, No.	16	10	…
Most CABGs done by 1 surgeon	1,062 (33)	891 (70)	<0.0001
Robot used	411 (13)	127 (11)	<0.0001
No CPB	1,089 (33)	137 (10)	<0.0001
CPB time, minutes	105 ± 39	89 ± 33	<0.0001
Cross-clamp time, minutes	70 ± 27	60 ± 24	<0.0001
Skin-to-skin time, minutes	270 ± 93	222 ± 64	<0.0001
Right or both IMAs used	335 (10)	183 (14)	0.0002
Intraoperative RBC transfusion, units	2.73 ± 2.34	2.1 ± 2.1	<0.0001

[a] Continuous data are presented as the mean ± SD and categoric data as number (%) or as indicated.

CABG = coronary artery bypass grafting; CPB = cardiopulmonary bypass; IMA = internal mammary artery; No. = number; RBC = red blood cell.

were less time consuming in the specialized era. Cross-clamp time decreased by an average of 10 minutes (mean, 70 vs 60 minutes, $p < 0.001$). Similarly, CPB time decreased by an average of 16 minutes (mean, 105 vs 89 minutes; $p < 0.001$) between the two eras. With the development of the specialized coronary program, overall operation time from incision to closure, “skin-to-skin time,” decreased by 48 minutes (mean, 270 vs 222 minutes; $p < 0.001$). In addition, in the specialized era, the use of the right internal mammary artery or both internal mammary artery grafts increased (11% vs 15%, $p < 0.002$), and the amount of intraoperative red blood cell transfusion required decreased (mean, 2.7 vs 2.1 units; $p < 0.001$). In the specialized era, a greater percentage of intraaortic balloon pump use was preoperative, 72% (381 of 529) versus 82% (157 of 191; $p < 0.005$), compared with intraoperative or postoperative, indicating a successful attempt to optimize more patients preoperatively.

Mortality

With a subspecialized coronary surgery program, the operative mortality rate for isolated CABG decreased from 2.67% to 1.48% ($p = 0.02$; Table 3). The specialized era annual mortality rates remained below 2%, steadily improved each year, and achieved an operative mortality of less than 1% (0.9%) in the final year (Fig 2). Although the STS PROM score was similar between the two time periods, the O/E mortality ratio improved in the specialized era from 1.67 to 1.00. An O/E mortality ratio of less than 1 demonstrates an ability to generate better than expected outcomes in the specialized era, which was not consistently seen previously. Figure 4 illustrates the annual O/E ratio among study groups. Although not statistically different, a clear reduction in variability is seen in annual mortality after our intervention. Examining program performance over time, a cumulative risk-adjusted mortality plot for sequential CABG operations (Fig 5) demonstrates fewer and shorter periods of poor

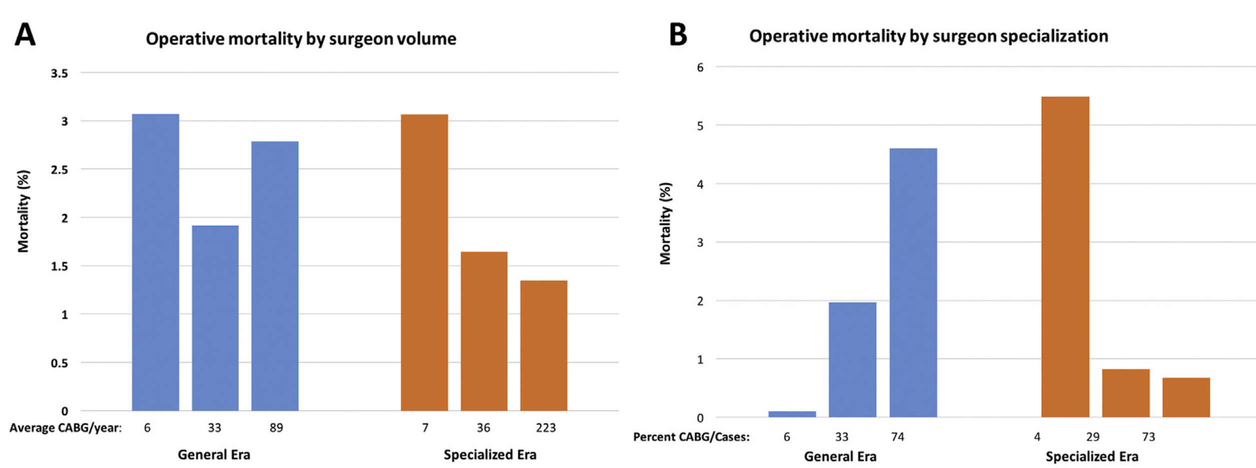

Fig 3. Case volume and degree of subspecialization among surgeons performing coronary artery bypass grafting (CABG) operations. (A) Mortality by low, medium, and high mean annual CABG volume. (B) Mortality by low, medium, and high degree of surgeon specialization in CABG. The degree of specialization was determined by the percentage of isolated CABGs performed among total cardiac operations for a given surgeon.

Table 3. Mortality

Variable	General Era 2002–2012 (n = 3,256)	Specialized Era 2013–2016 (n = 1,283)	*p* Value
Operative mortality, No. (%)	87 (2.67)	19 (1.48)	0.02
Published STS benchmark, %	2.0	2.2	
Observed/expected mortality ratio	1.67	1.00	

No. = number; STS = The Society of Thoracic Surgeons.

surgical performance in the specialized era compared with the generalized era. Over an initial 1,283 cases, subspecialization in CABG surgery as an intervention prevented approximately 5 deaths.

Clinical Outcomes

Various outcomes were also improved subsequent to intervention (Table 4). The rate of stroke with permanent deficit decreased significantly, from 1.6% to 0.7% ($p < 0.0001$). Despite a greater population of patients with chronic lung disease, patients in the specialized era had significantly less instance of prolonged intubation (>24 hours). After improvement of quality review and a programmatic effort to improve blood utilization, postoperative transfusion rates decreased from 49% to 36% ($p < 0.0001$). The specialized era had a 3% increased rate of hospital readmissions.

Comment

Various studies examining isolated CABGs present mixed results regarding the effect of hospital or surgeon volume and specialization on clinical outcomes. We present outcomes of a focused, multidisciplinary effort at improving CABG outcomes through specialization. Our intervention led to a decrease in operative mortality, decreased O/E mortality ratio, and prevented approximately 5 deaths compared with our historical control. We found many operative factors and clinical outcomes were significantly improved. Although there is literature examining surgeon specialization, we describe the development of a specialized program and team dedicated to coronary surgery.

Studies have tried to unravel the mechanisms behind volume or specialization effect on surgical outcomes. Although it might simply be that repetition improves results, many factors likely contribute to the critical difference between CABG programs with 1% versus 2% mortality. Studies looking at high-volume centers of excellence found hospital volume effects on outcomes were mediated by volumes of individual surgeons and increased resources available [1]. Sahni and colleagues [2] used Medicare data to demonstrate surgeon specialization, more so than surgeon volume, offered a 15% reduced risk of operative mortality in CABG. Ch'ng and colleagues [3] examined 20,000 isolated CABGs and showed no difference in outcome depending on surgeon volume or specialization. We present a much higher degree of surgeon subspecialization (>70%) than these two conflicting reports as well as an examination of the nonsurgeon program factors that can affect outcome.

There are several potential explanations for our findings. It is possible that decreased process variability, strengthened mentoring, and intensified quality review allowed surgeons the best possible outcomes for their efforts. It is unlikely volume alone, but rather programmatic shifts in care and accountability among team members, resulted in better outcomes. In the more recent era, outcomes of the program director, mentored junior

Fig 4. Observed-to-expected operative mortality per year.

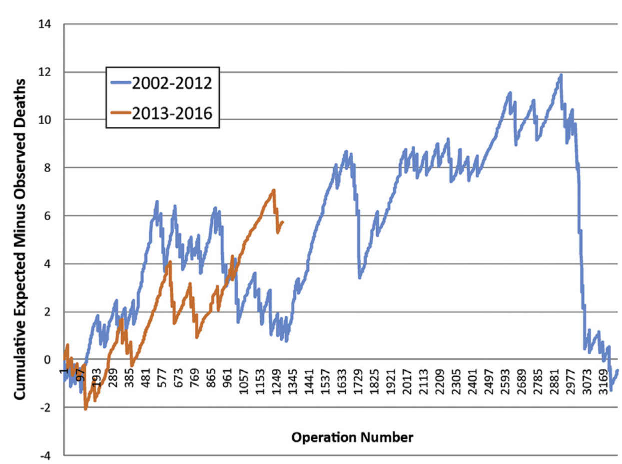

Fig 5. Cumulative risk-adjusted mortality plot for sequential coronary artery bypass grafting operations.

Table 4. Postoperative Complications

Variable[a]	General Era 2002–2012 (n = 3,256)	Specialized Era 2013–2016 (n = 1,283)	*p* Value
Reoperation for bleeding	97 (3)	28 (2)	0.16
Intra-op or post-op IABP	148 (4.6)	34 (2.7)	0.004
Permanent stroke	51 (1.6)	9 (0.7)	<0.0001
Observed/expected ratio	0.9	0.53	
Published STS benchmark, %	1.3	1.3	
Prolonged ventilation	525 (16)	143 (11)	<0.0001
Observed/expected ratio	1.7	1	
Published STS benchmark, %	9.7	7.9	
Deep sternal wound infection	20 (0.6)	8 (0.6)	0.66
Observed/expected ratio	1	1.5	
Published STS benchmark, %	0.3	0.3	
Renal failure	40 (2)	23 (2)	0.15
Observed/expected ratio	0.3	0.49	
Published STS benchmark, %	2.4	2.1	
Cardiac arrest	72 (2)	30 (2)	0.14
Peri-op myocardial infarction	11 (0.34)	3 (0.23)	0.64
Post-op transfusion	1,589 (49)	461 (36)	<0.0001
Length of stay, days	8 ± 8	7 ± 5	0.7
Published STS benchmark, days	9.2	9.3	
Readmission	221 (7)	124 (10)	<0.0001

[a] Data are presented as mean ± SD, number (%), or as indicated.

IABP = intraaortic balloon pump; Intra-op = intraoperative; Peri-op = perioperative; Post-op = postoperative; STS = The Society of Thoracic Surgeons.

surgeons, and the program as a whole consistently improved each year, a trend that was not seen previously. Our intervention included abandoning advanced robotic and off-pump techniques, which have been shown to carry a steep learning curve [15, 16].

Off-pump mortality was 2.5% in the general era and 1.5% in the specialized era. Totally robotic CABG in the general era had a mortality of 2.2%, whereas the recent simplified robotic use had a mortality of 1.6%. Mortality in the general era was constant or increased as surgeon volume or specialization increased (Fig 3) and has remained consistently low (<1.4%) among more specialized surgeons since 2013. Many surgeons in the general era operated independently and with high variation in practice, diminishing the effects of team specialization. The improved mortality seen with increasing surgeon volume and specialization in the more recent period likely demonstrates the effects of team and program specialization.

A possible confounder of our results is the distribution of emergent/salvage cases to on-call surgeons. Whether a higher percentage of elective cases inflated the outcomes of the specialized coronary surgeons is difficult to know. Mortality results for elective cases in both time periods parallel results in the larger cohort (1.3% vs 2.4%). Similarly, if cardiogenic shock patients are removed from the cohort, mortality is 1.3% versus 2.2%. Interestingly, when mortality is examined among only emergent/salvage cases, it improved with subspecialization from 15% to 9%, suggesting improved decision making in high-risk cases. The O/E ratio among emergent cases was similar between the two periods, 1.0 in the general era and 1.2 in the specialized era. Although some on-call surgeons may have the risk of an emergent/salvage case more frequently, the group as a whole performed better.

During the specialization era, subspecialization in all areas of adult cardiac surgery at our institution grew. Other surgeons specialized in mitral valve, aortic valve, aortic, and transplant surgery. With this model, our global volumes have increased as outcomes have improved. The high mortality seen in 2012 represents a potential outlier. Removal of 2012 data reduces the general era mortality to 2.3%, which remains higher than the 1.4% in the specialized era. Yearly mortality data (Figs 4, 5) and the spike in deaths seen in 2012 reveals the high variability of results in the general era. A lack of consistent results makes any surgeon or program vulnerable to unexpected bad outcomes or program closure and may represent a benefit of specialization in coronary surgery.

Although significant, the operative mortality difference is subtle. It is the context of current CABG practice [12] that makes the reduction in mortality from 2.7% to 1.4% meaningful. Isolated CABG is the most common cardiac operation performed, with more than 153,000 cases in 2015 [5]. The difference between 2% and 1% mortality nationally could translate to more than 1,500 patient lives. In addition, coronary programs in the United States are designated as a 1-, 2-, or 3-star program depending on operative mortality, with only 10% achieving a 3-star rating. Without a mortality rate close to 1%, a low star rating risks loss of referrals and site closure, making this relatively minute difference in statistics significant.

Among operative outcomes, the stroke rate decreased in the specialized era despite use of a 2-clamp technique. As many studies have found [17], it is possible that a second aortic manipulation increases the risk of stroke. Our results support work by Araque and colleagues [18] showing a stable stroke rate with partial aortic occlusion for the proximal anastomoses. This deliberate standardization of technique also likely contributed to reduced cross-clamp times without increasing the risk of stroke.

Coronary subspecialization improved surgical training as well [19]. Partial aortic clamping for proximal anastomoses gives more time off CPB to get young surgeons sewing earlier in their training. Each trainee spends 3 months per year embedded in the coronary service, without distraction from other specialties. The trainees provide important oversight and continuity in patient care and gain a concentrated clinical education. Although it is possible that subspecialization in surgery may hinder surgical education, we have experienced the opposite and have used specialization to enrich education in all areas of cardiac surgery.

Given the apparent trend toward subspecialization throughout cardiac surgery, it is important to note potential negatives of specialization. In our program, surgeons not specializing in coronary surgery still had to do emergent/salvage CABGs while on-call and incurred a higher operative mortality. Coverage of partnering surgeons is a reality. In addition, many programs will not have high volumes of CABG cases for each surgeon. If everyone has their niche practice, are we doing a disservice to acute patients who require a well-rounded surgeon to handle their emergency?

Limitations

The primary end point of operative mortality does not account for graft durability. Further work would be necessary to determine whether subspecialization in coronary surgery leads to improved quality of operation. Although, STS risk scores were the same, the generalized era had an increased incidence of renal failure, peripheral vascular disease, New York Heart Association III or IV heart failure, and presentation of shock that may have affected results. The specialized era had increased incidence of diabetes and cerebrovascular disease, factors contributing to morbidity but not necessarily mortality. In addition, the significant reduction in operative mortality demonstrated did not translate to a significant reduction in the O/E mortality ratio. The degree to which these differences in baseline characteristics might have confounded our results is unknown.

Accounting for possible selection bias in this study is difficult. Although STS PPROM scores were the same, the unblinded intervention in the specialized era introduces potential unmonitored factors and pressures that could have steered surgeons away from high-risk patients, further broadening the possible differences between the two groups.

Another limitation of this study is that we present fewer patient numbers than other studies examining case volume and specialization. When examining a 1% to 2% operative mortality, even 1 case can change the statistical significance. Larger studies [20–23] can often determine procedure volume hinge points for surgeons or hospitals. Because these data are a single center's examination of yearly trends, we cannot conclude that the interventions describe here will prove beneficial in all situations.

Conclusion

Our experience suggests that it is not simply case volume that can improve isolated CABG outcomes but rather a more focused surgeon, team, and program. Without the program development seen in other areas, such as transplant, congenital, or valve surgery, CABG surgeons may be vulnerable to variable outcomes. Through designated leadership of a coronary surgery program, standardization of all aspects of coronary care, and rigorous quality review, the lofty goal of less than 1% operative mortality can be consistently achieved.

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INVITED COMMENTARY

In this prescient single-institution study, Watkins and colleagues [1] initiated a subspecialized coronary surgery program comparing the procedures performed before (2002 to 2013) with those performed after implementation of the program (2013 to 2016). They showed that bilateral internal mammary artery utilization increased, operations were faster, major adverse events occurred less often, and operative survival improved. The ratio of observed to expected mortality using The Society of Thoracic Surgeons Predicted Risk of Mortality dropped from 1.67 during the nonspecialized era to 1.00 after inception of a specialty coronary surgery program.

Program changes included a dedicated program director responsible for standardization of surgical technique and preoperative and postoperative care protocols, as well as monthly quality assurance reviews. This study emphasizes the equal importance of the "before," the "during," and the "after" aspects of any surgical procedure—it is not just "the operation" that affects patient outcome.

In the years before coronary surgery specialization, outcomes were variable, but when operative mortality peaked in 2012, it prompted the inception of a specialty coronary surgery program, which was coincident with increased public reporting of surgical outcomes across the United States. Although reporting was not mandatory at the time in the home state of this center, the potential threat of public review (as opposed to peer review) could not help but influence cardiac surgeons' desire for improvement.

Watkins and colleagues [1] have shown the necessity and benefits of continuous quality review, and most importantly, the involvement of all disciplines. If problems are not identified, they cannot be addressed. This continuous quality review provides cardiologists, surgeons, and health care workers valuable feedback on their work. Raising awareness may be the main factor at the root of all the improvements implemented by this group. These authors have shown that, with experience and heightened attention to the operation, results improve—when this operation is not treated as "just a CABG."

This study shows excellent early-day results of a subspecialty program and demonstrates all aspects to be taken into consideration. Improvement of any surgical procedure due to subspecialization does not happen overnight. As in the example of mitral valve repair for pure mitral regurgitation, advancement of the procedure took decades not years. Although still in the early days (3 years) for this program, their coronary surgery results are so improved that this study deserves widespread exposure to spread the message.

It is interesting that coronary surgery volumes increased during the era of subspecialization: in the first era, average coronary procedures numbered 325.6 per year; and in the specialty time frame, operations increased to 427.6 per year. That represents an increase of 31.3% in only 3 years of the new program. In recent years, most cardiac surgery centers in North America have either a static or declining incidence of coronary surgery [2–4]. This finding of increased surgical volumes (as outcomes improved) are reminiscent of the quote from the 1989 movie "Field of Dreams" starring Kevin Costner: "If you build it, he will come." Likewise, if arterial grafting were to increase with dedicated specialty programs such as this, coronary artery bypass graft surgery (CABG) could return to its rightful ascendancy. I am aware of a cardiac surgery center where

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