Changes Over Time in Risk Profiles of Patients Who Undergo Coronary Artery Bypass Graft Surgery

The Veterans Affairs Surgical Quality Improvement Program (VASQIP)

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importance

Today's coronary artery bypass grafting (CABG) population appears to comprise sicker patients than in the past; however, little is known about the change in the risk profile.

Objective

To evaluate the change with time in the risk profile of patients who undergo CABG.

Design, Setting, and Participants

Retrospective review of records from the Veterans Affairs (VA) Surgical Quality Improvement Program (VASQIP); 65,097 patients who underwent isolated primary CABG from October 1, 1997, to April 30, 2011, were evaluated.

Main Outcomes and Measures

Trends in risk profiles, surgical volume, and modern outcomes in the VA system. We determined the significance of changes in age and major comorbidities across time with simple linear regression analysis and evaluated the rates of perioperative mortality (30-day or in-hospital) and VASQIP predicted risk of mortality trends over time.

Results

From 1997 to 2011, there were increases in mean (SD) patient age (63.1 [9.4] vs 64.3 [7.8] years; \( R^2 = 0.34; P = .02\)) and body mass index (28.3 [5.1] vs 30.1 [5.8]; \( R^2 = 0.95 \)). There were also increases in the prevalence of diabetes mellitus (32.8% vs 41.3%; \( R^2 = 0.82 \)), preoperative New York Heart Association (NYHA) class III or IV heart failure status (14.3% vs 34.2%; \( R^2 = 0.74 \)), and left main coronary artery disease (26.0% vs 32.8%; \( R^2 = 0.82 \)) (all \( P < .001 \)). There was a decrease in the prevalence of advanced angina severity (Canadian Cardiovascular Society class III or IV) (\( R^2 = 0.95 \)), previous myocardial infarction (\( R^2 = 0.82 \)), and low ejection fraction (\( R^2 = 0.88 \)) (all \( P < .05 \)). There was no significant change in the prevalence of cerebrovascular and peripheral vascular disease, chronic obstructive pulmonary disease, or 3-vessel coronary artery disease. Perioperative mortality rates and the VASQIP predicted risk of mortality, respectively, decreased with time (3.2% and 3.1% vs 1.7% and 1.6%). From 2004 to 2011, there was a significant increase in the prevalence of previous percutaneous coronary intervention (18.6% to 29.2%; \( R^2 = 0.82; P = .002 \)). Overall CABG volume decreased (5551 in 1998 vs 3857 in 2012; \( R^2 = 0.95; P < .001 \)).

Conclusions and Relevance

From 1997 to 2011, there was a progressive increase in the prevalence of obesity, diabetes, left main coronary artery disease, and advanced NYHA heart failure class among VA patients undergoing CABG. The prevalence of previous myocardial infarction, low ejection fraction, and advanced angina decreased, perhaps because of earlier surgical referral, improvement in medical management, or a shift in patient selection for CABG. Operative mortality also decreased with time. These trends confirm the general perception of significant, ongoing improvement in the care of patients who undergo CABG in the VA, despite an older, sicker population.
Recent reductions in mortality due to coronary artery disease (CAD) in the United States have been attributed to epidemiologic factors and better overall medical care, including advanced CAD revascularization strategies with percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG). The trend toward improved survival has been accompanied by a decline in the number of CABG operations performed annually in the United States over the past decade. This decrease in surgical referrals may represent a decreased need for CABG because of improved results of noninvasive treatment as well as a shift in patient selection for surgery, but the availability of less-invasive alternatives with advanced PCI stenting techniques is thought to play an important role. A general perception persists among cardiac surgeons that current patients referred for coronary surgery are more likely to have undergone PCI before undergoing definitive CABG revascularization and are generally older and sicker than were patients who underwent CABG in the past.

However, to our knowledge, few studies have documented recent trends in age and risk profiles for patients in the United States who receive CABG. One report, based on the Society of Thoracic Surgeons Adult Cardiac Surgery Database, confirmed an increase in the proportion of patients who had PCI before being referred for CABG in 2000 to 2009 and also showed an increase in some risk factors, such as diabetes mellitus and chronic obstructive pulmonary disease (COPD), but not much change in age. They also confirmed a recent ongoing trend toward reduced CABG morbidity and mortality rates, with an associated decrease in the predicted risk of mortality (PROM) on the Society of Thoracic Surgeons’ risk-adjustment model. However, a reduced PROM is not necessarily a true indication of a reduction in comorbidities because the models are designed to evolve to reflect current outcomes. Ongoing improvement in outcomes is more likely the result of improved surgical care than preoperative factors alone. The effect of scrutinized outcome reporting may also play a large role in patient selection for CABG, with surgeons carefully choosing their patients in an attempt to maintain the best possible outcomes; this practice has unknown effects on the risk-factor profiles of current patients undergoing CABG.

The veteran patient population is unique and has an increased prevalence of various risk factors when it is compared with the general population of patients referred for CABG. The Veterans Affairs (VA) system, a single-payer system, also has a different approach to patient management than does the US health care system at large; in the VA system, it is possible that more collaboration between physicians can occur without the strain of billing and productivity concerns. This led us to ask: Are the veteran patients who have recently undergone CABG older and sicker than similar patients in the past? Alternatively, have risk factors decreased, possibly because of changes in patient selection?

To answer these questions, we looked at a large national database of US veteran patients who underwent CABG surgery and examined the trend in risk profiles. In addition, we evaluated trends in surgical volume and modern outcomes in the VA system. We hypothesized that the trend would be toward older and sicker patients over time.
was a slight increase in the mean (SD) patient age (63.1 [9.4] years in 1997 vs 64.3 [7.8] years in 2011; P = .02) and a more substantial increase in the BMI (28.3 [5.1] vs 30.1 [5.8]) and prevalence of diabetes (32.8% vs 41.3%), New York Heart Association class III or IV heart failure status (14.3% vs 34.2%), and left main CAD (26.0% vs 32.8%) (P < .001 for all). However, there

was a decrease in the prevalence of advanced angina severity (78.6% Canadian Cardiovascular Society class III or IV vs 54.8% in 2011), previous myocardial infarction (55.4% vs 48.7%), and low (<34%) ejection fraction (12.0% vs 6.6%) (P < .001 for all). There was a significant (P = .04) trend toward a decrease in the number of current smokers (31.1% vs 27.3%). An increased number of patients with independent functional status was documented (89.1% vs 93.1%; P < .001). The number of cases with urgent priority increased (10.6% vs 16.4 %), but the number of emergency cases decreased (6.4% vs 2.8%) (both P < .001).

There was no significant change in the prevalence of cerebrovascular and peripheral vascular disease, COPD, or 3-vessel CAD. The percentage of women was low (1%) throughout the study period, without a significant change over time. Female sex was not associated with an increased risk for operative death or complications on multivariate analysis. We also evaluated geographic differences by comparing the Northeast, Southeast, West, Central, and Middle South regions and racial and ethnic variation. Compared with the other 4 regions combined, the Northeast had a lower prevalence of diabetes (15.4% vs 16.7%; P = .009), the West had a lower prevalence of smoking (26.8% vs 30.1%; P < .001), and the Central Region had a higher mean BMI (29.5 [5.5] vs 29.2 [5.4]; P < .001). Race and ethnicity data were available only after 2004. The Southeast and Middle South combined had a higher number of African American patients (12.8%) than did the other regions (6.8%) (P < .001), and the Southeast and West combined had a higher number of Hispanic patients (10.5%) than did the other regions (5.1%) (P < .001). In multivariate models used to evaluate predictors for adverse outcomes, race and ethnicity were not significant predictors, but geographic area was a significant predictor.

Detailed data concerning the prevalence of previous PCIs were not available in the VA database until 2004. From 2004 to 2011, there was a significant increase in the number of patients who had undergone previous PCI (P = .002) (Figure 2). During the same period and over the course of the entire study, there was a trend toward a reduced volume of CABG operations in the VA system, from 5551 operations in 1998 to 3857 procedures in 2010. Perioperative mortality rates and VASQIP PROM decreased with time, being 3.2% and 3.1%, respectively, in 1997, compared with 1.7% and 1.6%, respectively, in 2011 (Figure 3). Overall morbidity rates and rates of specific complications also decreased.

**Early Cohort vs Later Cohort**

The early cohort included 23,155 patients who underwent isolated CABG from October 1, 1997, to December 31, 2003. The later cohort included 31,942 patients who underwent isolated CABG from January 1, 2004, to April 30, 2011. Table 1 compares the 2 cohorts. By using this method to evaluate the database, we confirmed the trends reported in Figure 1, except that a significant decrease in peripheral vascular disease was seen; moreover, the change in age and the number of current smokers was not significant with this method. Table 2 reports the outcomes for the 2 cohorts. The mortality rate decreased from 3.0% in the early cohort to 1.9% in the later cohort.

**Discussion**

Our study revealed trends toward increased age and prevalence of comorbidities in VA patients who underwent CABG over nearly 14 years, from October 1, 1997, to April 30, 2011. The trend toward older age was similarly shown in a recent study of the Society of Thoracic Surgeons’ database, in which age marginally increased among US patients who underwent CABG from 2000 to 2009.4

Our study confirmed an increase in the number of patients who underwent CABG after previous PCI, as well as a decline in operative volume over the same time. Although the exact cause and effect is unclear, an increased prevalence of previous PCI and advanced congestive heart failure (CHF) may indicate that patients are referred for surgical evaluation later in the course of their CAD, more often after failed PCI. However, improved medical management before surgery may be suggested by the data showing a reduction in the prevalence of advanced angina, previous myocardial infarction, and low ejection fraction. The increased prevalence of advanced CHF is difficult to reconcile with the decreased prevalence of a low ejection fraction unless one considers...
that the CHF class is a functional consideration. Thus, wors-
ening CHF may also be related to patients’ inability to toler-
ate their heart condition, perhaps because of increased age
and noncardiac comorbidities.

The increased prevalence of diabetes noted in our study
may reflect improved consideration of evidence-based guide-
lines for surgical referral as a result of recent trials12-16 show-
ing improved outcomes for CABG compared with PCI revas-
cularization in patients with diabetes. Therefore, our data may
represent improved understanding of the evolving indica-
tions for surgical revascularization and of the risk-benefit analy-
sis for particular patient groups.

Although we largely confirmed the perception that the
CABG patient population in the VA system has become older
and sicker, we found that some comorbidities were reduced,
such as current smoking. This factor probably reflects a gen-
eral US trend toward decreased smoking, an epidemiologic
change rather than a risk-factor change specific to the CABG
population. Other factors, such as COPD and cerebrovascular
disease, showed no significant change in our study. Neverthe-
less, we confirmed certain risk-factor profile characteristics that
are specific to veterans. Comparison of our study population
with those described in other reports, such as a recent eval-
ation of the Society of Thoracic Surgeons’ database,9 shows that
our population had a high prevalence of COPD, current smok-
ing, peripheral vascular disease, cerebrovascular disease, and
male sex; all of these factors were more prevalent in our vet-
eran population than in the general US CABG population.

Regardless of the risk-factor trends, the observed morbid-
ity and mortality rates have continued to improve in the VA
system as they have in the Society of Thoracic Surgeons’ da-
tabase. Medical and surgical care for patients with CAD have
evolved over time, resulting in better understanding of fac-
tors that affect surgical indications, patient selection, preop-
erative optimization, and perioperative care. The trends ob-
served in this study may best be explained by further consid-
ering the process-related improvements that have oc-
curred during the past decade.

First, let us consider how potential improvements in pre-
operative care, patient selection, and medical management of
CAD may have affected the CABG patient population. Better
understanding of the effects and appropriate use of medica-

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Figure 3. Trends in Outcomes for Veterans Administration Patients Who Underwent Coronary Artery Bypass Grafting From 1997 to 2011

Simple linear regression analysis was used.
instead of emergently. The proportion of patients who need bilized preoperatively and, thus, to undergo surgery urgently for operative morbidity and mortality. Our results indicate that emergency surgery is one of the most important risk factors for urgent cases. Cardiologists and cardiac surgeons now know that the issue of frailty as a surgical risk factor, and surgeons are becoming more keenly aware of the effect of poor functional status on outcome. Perhaps patients with these characteristics receive better treatment with fewer invasive interventions.

Furthermore, let us consider how operative and postoperative care have improved considerably over time. Each of the 42 cardiac surgical programs currently in the VA system has been carefully vetted and undergoes continuous quality monitoring. Intraoperative techniques for CABG have been widely evaluated and scrutinized throughout the medical literature, resulting in multiple concomitant areas of improvement, such as better selection and management of patients, better perioperative care, and better surgical techniques. These improvements have resulted in a decrease in emergency CABG cases but an increase in urgent cases. Cardiologists and cardiac surgeons now know that emergency surgery is one of the most important risk factors for operative morbidity and mortality. Our results indicate that more patients are currently able to have their condition stabilized preoperatively and, thus, to undergo surgery urgently instead of emergently. The proportion of patients who need surgery emergently should further decrease as knowledge and experience increase.

Improved patient selection is also likely reflected in our study by the trend toward an increased prevalence of independent functional status. Recent studies have discussed the issue of frailty as a surgical risk factor, and surgeons are becoming more keenly aware of the effect of poor functional status on outcome. Perhaps patients with these characteristics receive better treatment with fewer invasive interventions.

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as the use of internal mammary artery and other arterial grafts, limited pump time, complete revascularization when feasible, blood conservation, use of hemostatic agents, improved sternal reconstruction methods that limit sternal wound breakdown, off-pump surgery when appropriate, and epicardial ultrasonography to guide cannulation. Many factors combined have led to improved technical expertise, resulting in increased operative success as further experience has been gained.

Postoperative care has also evolved and improved. Cardiac surgery has been carefully scrutinized for decades, and outcomes reporting has been accompanied by process improvement. When a complication occurs, experienced cardiac surgeons are often able to manage the situation and prevent mortality; this success is reflected in mortality rates that have improved more than morbidity rates. During the past decade, improved critical care has resulted from better nursing care, understanding and use of vasoactive medications, glucose control, arrhythmia management, ventilator management, prevention of arterial line complications, and infection control. Thus, the effect of age and comorbidity is further mitigated by meticulous postoperative care.

One limitation of our study is that it was retrospective and therefore subject to bias. We cannot track the number of patients who were not selected for CABG. In addition, we did not track the number of veteran patients referred to hospitals outside the VA system for CABG, and this also may bias the results of our study. In the future, fee-basis claims data could be used to study outside referrals. Another limitation of the study is that because of the nature of the veteran population, approximately 99% of the patients were male, and our results are not necessarily generalizable to the overall CABG population in the United States. In addition, the available database does not capture all pertinent factors. However, our study is strengthened by the inclusion of a large number of patients whose data were obtained from a nonvoluntary, multi-institutional national database as well as by the ability to evaluate the unique veteran patient population.

Further investigations should include longer follow-up observation times and analysis of risk factors that have the strongest effect on patient survival as well as further investigation of trends and outcomes in the use of PCI and surgical revascularization. Future clinical care goals that might emerge from this and other outcome studies could be to enhance collaboration with cardiologists to improve patient selection for PCI vs CABG in accordance with the national appropriateness criteria guidelines for revascularization. In addition, for CABG to compete effectively with PCI as the optimal revascularization strategy for most patients with multivessel CAD, cardiac surgeons must continue to strive to decrease the rates of postoperative stroke and other complications.

Table 2. Outcomes

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total (N = 65 097)</th>
<th>1997-2003 (n = 32 155)</th>
<th>2004-2011 (n = 31 942)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative death</td>
<td>1589 (2.4)</td>
<td>977 (3.0)</td>
<td>612 (1.9)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>PROM, mean (SD)</td>
<td>2.5 (3.1)</td>
<td>3.0 (3.6)</td>
<td>2.0 (2.4)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>O/E ratios, mean (SD)</td>
<td>0.99 (0.12)</td>
<td>0.99 (0.10)</td>
<td>0.99 (0.15)</td>
<td>.98</td>
</tr>
<tr>
<td>Acute renal failure</td>
<td>697 (1.1)</td>
<td>355 (1.1)</td>
<td>342 (1.1)</td>
<td>&gt;.99</td>
</tr>
<tr>
<td>Mediastinitis</td>
<td>694 (1.1)</td>
<td>406 (1.2)</td>
<td>288 (0.90)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Ventilator use for &gt;48 h</td>
<td>4194 (6.4)</td>
<td>2048 (6.2)</td>
<td>2146 (6.7)</td>
<td>.005</td>
</tr>
<tr>
<td>Reoperation for bleeding</td>
<td>1422 (2.2)</td>
<td>794 (2.4)</td>
<td>628 (2.0)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Stroke</td>
<td>932 (1.4)</td>
<td>521 (1.6)</td>
<td>411 (1.3)</td>
<td>.002</td>
</tr>
<tr>
<td>All complications*</td>
<td>7004 (10.8)</td>
<td>3645 (11.0)</td>
<td>3359 (10.5)</td>
<td>&lt;.049</td>
</tr>
</tbody>
</table>

Abbreviations: O/E, observed/expected; PROM, predicted risk of mortality.
* Includes the presence of at least 1 of the following conditions: cardiac arrest, endocarditis, renal failure, mediastinitis, reoperation for bleeding, ventilator use for more than 48 hours, second cardiopulmonary bypass, coma, or stroke.

Conclusions

Our study showed a general trend toward older and sicker patients undergoing CABG in the VA population along with a reduction in CABG volume and an increase in the proportion of patients who had a previous PCI. Operative outcomes continue to show improvement with time.