Eighteen-year follow-up demonstrates prolonged survival and enhanced quality of life for octogenarians after coronary artery bypass grafting

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Objective: Octogenarians comprise the fastest growing population segment. Numerous reports have documented improved accomplishment of coronary artery bypass grafting in this high-risk cohort. But what is the quality of life after surgery, and how sustainable are the clinical benefits?

Methods: Sequential cross-sectional analyses were performed on 1062 consecutive patients 80 years old and older who underwent isolated on-pump coronary artery bypass grafting at a single institution from 1989 to 2001. After mean follow-up of 3.4 years (1 month–12.6 years), the Short Form 36 quality of life survey was administered to all survivors. Late follow-up for survival was performed after a mean 5.6 years (1 month–17.9 years). Multivariate analyses assessed risk factors associated with operative mortality, Short Form 36 self-assessment, and late survival.

Results: Mean age at operation was 83.1 ± 2.8 years (range, 80–99 years). Overall in-hospital mortality was 9.7%, decreasing progressively to 2.2% during the course of the study. At midterm follow-up, 97.1% of patients were in Canadian Cardiovascular Society class I or II; Short Form 36 scores were comparable to age-adjusted norms in both physical and mental health summary scores. Actuarial survivals were $42.2\% \pm 1.5\%$ at 7 years and $9.9\% \pm 1.4\%$ at 14 years. Median survival was 5.9 years; 5.2 years for male patients and 6.7 for female patients ($P = .004$).

Conclusions: The risk of coronary artery bypass grafting for octogenarians now rivals that of a younger population. Midterm quality of life and long-term survival approach those of the general population. (J Thorac Cardiovasc Surg 2011;141:394-9)

Supplemental material is available online.

Elderly persons represent the fastest growing segment of the population. It is projected that the number of citizens older than 75 years will quadruple in the next 50 years.¹ Nearly 40% of octogenarians have symptomatic cardiovascular disease, which accounts for more than half of the mortality in this age group.² Multiple series have demonstrated the ability to perform cardiac surgery on this cohort with elevated but improving mortality and morbidity.^{3,4} The key questions that must be addressed are as follows: (1) Do the relief of symptoms and improvements in functional status

and quality of life (QOL) warrant the increased risk and expense of surgical therapy in this more fragile elderly population? (2) How sustainable are the clinical benefits? To address these issues, sequential cross-sectional follow-up was conducted consisting of a large cohort of patients 80 years old and older from a single community surgical practice who underwent isolated coronary artery bypass grafting (CABG) for symptomatic coronary artery disease.

MATERIALS AND METHODS

For definitions of terms, see online [Appendix E1](#). This report involves 1062 consecutive patients 80 years old and older who underwent isolated CABG between January 1989 and December 2001. Waiver of informed consent to conduct the study was obtained from the institutional review board. There were 651 men (61.3%) and 411 women (38.7%), with a mean age of 83.1 ± 2.8 years (range, 80–99 years). The coronary and perioperative risk factors and coronary angiographic findings documented in the series are summarized in [Table 1](#).

A patient's preoperative anginal symptoms were as defined by the Canadian Cardiovascular Society (CCS). Patients with unstable angina included those with CCS class III or IV symptoms. There were 64 patients (6.0%) in class II, 502 patients (42.3%) in class III, and 496 patients (46.7%) in class IV.

Operative Data

The operation was performed electively in 832 cases (78.3%), urgently in 162 cases (15.3%) and on an emergency basis in 68 cases (6.4%). A total

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Abbreviations and Acronyms

CABG	= coronary artery bypass grafting
CCS	= Canadian Cardiovascular Society
ITA	= internal thoracic artery
PCI	= percutaneous coronary intervention
QOL	= quality of life
SF-36	= Short Form 36

of 3884 coronary artery grafts were performed (mean, 3.7 per patient; range, 1–6). The left internal thoracic artery (ITA) was used for grafting in 442 cases (41.5%), and its use increased during the course of the study. All operations were performed with the assistance of cardiopulmonary bypass, moderate hypothermia, aortic crossclamping, and cold sanguineous cardioplegic arrest. The mean cardiopulmonary bypass time was 61.2 ± 21.7 minutes (range, 10–240 minutes), and the mean aortic crossclamp time was 31.7 ± 15.8 minutes (range, 4–140 minutes).

Data Collection and Management

Perioperative data were obtained by prospective review of each patient's hospital record, catheterization reports, cinematic angiograms, and echocardiography. Follow-up information was obtained through comprehensive questionnaires and by telephone interviews with surviving patients, their family members, or their personal physicians. Follow-up data included activity level, current symptoms, diagnostic tests, occurrence of late cardiac events, medications being taken, and an assessment of QOL. Moreover, patients were asked to describe their anginal status and were ranked according to the CCS classification system.

A patient registration form and a patient follow-up form were completed for each patient in the study at the time of midterm follow-up. These data collection instruments provided standardized reporting of each patient's clinical status before and after the operation. When patients could not be located, the Social Security Death Index database (available at <http://genealogy.rootsweb.com>) was used to obtain patient mortality information. The capability to identify deaths in the Social Security Death Index is between 92% and 99% according to the unique identifiers available.⁵

QOL assessment was conducted with the Short Form 36 (SF-36) developed by Ware and associates.⁶ The SF-36 is a standardized instrument comprised of 36 items designed to measure 8 dimensions of overall health and 2 summary components, a physical health score and a mental health score.

Cross-sectional follow-up was performed in 2001 and included the patient's clinical status and QOL assessment. A second cross-sectional analysis with the Social Security Death Index was conducted in 2007 regarding survival status. Patients who could not be contacted during the course of the study through various means or were not identified in the Social Security Death Index were documented as unavailable for follow-up. A 98.6% follow-up was obtained with 15 patients unavailable for follow-up.

Statistical Analysis

Data are presented as frequency distributions and simple percentages. Values of continuous variables are expressed as mean $\pm$ SD. Univariate analysis of selected preoperative and postoperative discrete variables was accomplished by χ^2 test, the continuity-adjusted χ^2 analysis, or a 2-tailed Fisher's Exact test, with the appropriate degrees of freedom to test for the equality of proportions in the case of categorical variables. Two-sample Student *t* tests (2-tailed) were used to test for the equality of the means of continuous variables. To identify predictors of hospital mortality, a multivariate analysis by forward stepwise logistic regression of preoperative and intraoperative variables was performed. For a listing of covariates used to predict in-hospital mortality, see online Appendix E2. A Cox proportional hazards

regression model was used to discern the influence of multiple clinical variables on late survival. Regression coefficients and odds ratios with 95% confidence intervals were calculated to determine the relative influence of each covariate on the survivor function. Coefficients were computed by the method of maximum likelihood. For a listing of covariates used to predict late mortality, see online Appendix E3. A stepwise multivariate linear regression model was constructed to determine independent predictors of physical and mental health summary scores on the SF-36. For a listing of covariates used to predict physical and mental summary scores, see online Appendix E4).

Patient survival was expressed by actuarial analysis according to the method of Kaplan and Meier, with time zero as the date of operation and late death as the end point (with variability expressed as SEM). Patients alive at the last follow-up were included as right-censored values in the analysis. The equality of survival distribution was tested with the log-rank algorithm. Data collected were analyzed with the biostatistical capabilities of the Number Cruncher Statistical Systems (Kaysville, Utah).

RESULTS

Hospital complications included reoperation for bleeding in 34 patients (3.2%), perioperative myocardial infarction in 16 patients (1.5%), low cardiac output in 172 patients (16.2%), cardiac arrest in 83 patients (7.8%), renal insufficiency in 105 patients (9.8%), respiratory insufficiency in 189 patients (17.8%), cerebrovascular accident in 34 patients (3.2%), and deep sternal infection in 16 patients (1.5%). The overall incidence of postoperative morbidity for the group was acceptable, with most patients (67.0%, *n* = 712) having no hospital complications. The average postoperative stay for patients was 12.1 ± 9.3 days.

The overall in-hospital mortality for the series was 9.7% (97/1062), but it declined during the course of the study, decreasing to 2.2% in the most recent years (Figure 1). Mortalities were 8.8% (57 of 651) for men and 9.7% (40/411) for women (*P* = .59). The elective procedure mortality was 8.3% (64/768), the urgent procedure mortality was 11.0% (16/146), and the emergency and salvage mortality was 33.3% (17/51). A within-group comparison of mortalities for elective versus nonelective procedures revealed a significant difference (*P* = .002). Mortalities were 10.2% (88/948) for first operation and 8.6% (9/105) for reoperation.

To identify independent correlates of hospital mortality, preoperative and intraoperative variables were entered into a forward stepwise logistic regression model. Date of surgery (*P* = .006), arrhythmia (*P* = .004), abnormal ejection fraction (*P* = .010), renal insufficiency (*P* = .001), nonelective surgery (*P* = .015), conduit type (no ITA, *P* = .030), and perfusion time (cardiopulmonary bypass time, *P* = .011) were correlated with in-hospital mortality (Appendix Table E1).

QOL and initial clinical follow-up data were collected for 950 patients discharged from the hospital (98.4%). The initial follow-up ranged from 1.0 months to 12.6 years (mean, 3.4 years). The cumulative follow-up for the series was 3251.2 patient-years.

On completion of the QOL follow-up, many current survivors had clinical and functional improvement and were

TABLE 1. Patient preoperative clinical variables and risk factors for patients 80 years old and older undergoing isolated coronary artery bypass grafting

No. of patients	1062 (100.0%)
Sex (no.)	
Male	651 (61.3%)
Female	411 (38.7%)
Age (y)	
Mean $\pm$ SD	83.1 $\pm$ 2.8
Range	80–99
Coronary risk factors (no.)	
Family history of coronary artery disease	211 (19.9%)
Hypertension	669 (65.8%)
Hyperlipidemia	337 (31.7%)
Smoking history	234 (22.0%)
Diabetes mellitus	277 (26.1%)
Perioperative risk factors (no.)	
Renal dysfunction	141 (13.3%)
Cerebrovascular disease	161 (15.2%)
Peripheral vascular disease	202 (19.0%)
Previous myocardial infarction	609 (57.3%)
History of congestive heart failure	278 (26.2%)
Unstable angina	887 (83.5%)
Coronary angiography (no.)	
Three-vessel disease	953 (89.7%)
Two-vessel disease	94 (8.9%)
Single-vessel disease	15 (1.4%)
Left main disease (>0.5)	323 (30.4%)
Ejection fraction (no.)	
>0.5	434 (40.9%)
$0.3\text{--}0.5$	453 (42.7%)
<0.3	156 (14.7%)
Not determined	19 (1.8%)
Surgical history (no.)	
First operation	948 (89.3%)
Reoperation	114 (10.7%)

conducting their activities of daily living. There were 97.1% of the patients in CCS class I or II at the time of this follow-up, and 78.9% reported similar or improved health status compared with 1 year previously. The freedoms from major adverse cardiac events were $97.7\% \pm 0.8\%$ at 5 years and $96.3\% \pm 4.6\%$ at 10 years.

QOL assessment was conducted for all survivors willing and able to complete the SF-36 ($n = 545$, 98.2%). Table 2 gives the means and SDs for each of the 8 health scale scores as well as the physical and mental health summary component scores. A comparison of the study group's responses with age-adjusted norms revealed differences between the groups. Age-adjusted norms were significantly higher in physical functioning ($P = .001$) and mental health, although the latter comparison did not achieve statistical significance. The study group scored significantly higher in role physical ($P = .001$), bodily pain ($P = .001$), and role emotional ($P = .004$). In the physical health and mental health summary scores, the study group scored higher in both areas;

FIGURE 1. In-hospital mortality according to year of operation.

however, these differences did not achieve statistical significance. Independent predictors of the physical summary score were age ($P = .014$), diabetes ($P = .001$), and male sex ($P = .001$); for the mental summary score, independent predictors were diabetes ($P = .004$), previous myocardial infarction ($P = .022$), and surgical history ($P = .016$). These findings clearly demonstrate that octogenarians undergoing CABG have a QOL comparable to age-adjusted norms.

Long-term survival follow-up with the Social Security Death Index was performed on 950 hospital survivors. This follow-up ranged from 1 month to 17.9 years (mean 5.6 years). The actuarial survival data for all patients ($n = 1062$) are shown in Figure 2, A. Survivals were $42.2\% \pm 1.5\%$ at 7 years and $9.9\% \pm 1.4\%$ at 14 years. The median survival was 5.9 years. The survivals for patients 80 to 83 years old were $60.5\% \pm 1.9\%$ at 5 years and $27.5\% \pm 1.9\%$ at 10 years, with a median survival of 6.4 years. Survivals for patients 84 years old and older were $48.7\% \pm 2.5\%$ at 5 years and $18.0\% \pm 2.2\%$ at 10 years, with a median survival of 4.9 years. Comparison of survival distribution between these cohorts of patients generated a significant difference ($P = .001$).

A comparison of survival by sex demonstrated survivals for male patients of $52.4\% \pm 2.0\%$ at 5 years and $21.6\% \pm 1.8\%$ at 10 years and survivals for female patients of $62.2\% \pm 2.4\%$ at 5 years and $27.7\% \pm 2.4\%$ at 10 years. This comparison also revealed a significant difference ($P = .004$), demonstrating that women in this study had an enhanced survival relative to men. The median survivals were 5.2 years for male patients and 6.7 years for female patients (Figure 2, B; compare with http://www.cdc.gov/nchs/data/nvsr/nvsr57/nvsr57_14.pdf, page 26).

To identify independent predictors of late death, a Cox proportional hazards regression model was created to

TABLE 2. Short Form 36 quality of life health status scale scores for patients 80 old and older undergoing isolated coronary artery bypass grafting versus age-adjusted norms

Scale	Study group (n = 545)	Age-adjusted norm (n = 264)	P value
Physical functioning	44.9 ± 30.2	53.2 ± 30.0	.001
Role—physical	61.5 ± 44.7	45.3 ± 42.0	.001
Bodily pain	71.0 ± 27.9	60.9 ± 26.0	.001
General health	57.8 ± 21.4	56.7 ± 21.2	.492
Vitality	51.4 ± 21.4	50.4 ± 23.6	.547
Social functioning	76.0 ± 29.1	73.9 ± 28.8	.335
Role—emotional	72.2 ± 41.2	63.2 ± 43.0	.004
Mental health	71.5 ± 19.7	74.0 ± 20.2	.094
Summary scores			
Physical health	39.0 ± 11.1	37.9 ± 11.2	.188
Mental health	50.9 ± 10.5	50.4 ± 11.7	.541

measure the effects of various prognostic factors on time to response (operation to late death). Cox regression analysis demonstrated the independent effects of 8 covariates on late death: age ($P = .001$), male sex ($P = .004$), peripheral vascular disease ($P = .001$), congestive heart failure ($P = .001$), cerebrovascular accident ($P = .001$), preoperative renal insufficiency ($P = .003$), postoperative renal insufficiency ($P = .002$), and postoperative pulmonary insufficiency ($P = .005$; [Appendix Table E2](#)).

DISCUSSION

With an aging population, many of whom have coronary artery disease, the question of optimal management in a time of rising health care costs and decreasing resources becomes of paramount importance. From the data presented here, surgical revascularization can be offered with decreasing in-hospital mortality, excellent interim QOL, and a long-term survival that rivals that of the general population. To appreciate the contribution that these findings can make to the difficult decision-making algorithm, it is important to address both the strengths and limitations of the available information.

This report presents the largest single-center follow-up study of octogenarians undergoing isolated CABG in a community hospital, and among the longest. It demonstrates what can be accomplished (and likely is being accomplished) in community hospitals across the country. Because this study reflects the work of a single surgical group in a specific setting, there is certainly a selection bias underlying both the referral base and surgical decision-making process. Because of the absence of data regarding patients not referred or not accepted for surgery, an algorithm for patient selection cannot be created. The clear delineation of risk factors for both in-hospital and late mortality, however, certainly helps to define a population at increased risk for diminished clinical benefits. Moreover, retrospective data demonstrate a survival advantage and cost benefit of surgical

FIGURE 2. A, Actuarial survival of patients 80 years old and older after coronary artery bypass grafting. B, Comparison of actuarial survival between male and female patients 80 years old and older after coronary artery bypass grafting.

versus medical management for octogenarians with coronary artery disease.^{7,8}

Both prospective randomized trials and large observational studies have shown comparable survival and superior QOL at 1 year for interventional treatment (surgery or percutaneous coronary intervention [PCI]) versus medical treatment in this cohort.⁹⁻¹¹ Within this context, the decreasing surgical mortality and excellent QOL demonstrated in this study would seem to suggest the need for further investigation with a larger patient population, rather than with a procedure-based database. This would better define the selection criteria for different therapeutic interventions in an elderly population.

In this consecutive longitudinal series, all patients received a single therapeutic intervention. This permits the evaluation of outcomes through time without the introduction of multiple confounding variables. Moreover, these findings serve as a baseline measurement against which alternative approaches can be evaluated. Medical management, interventional therapy, and surgical care are all rapidly evolving. In fact, the decreasing mortality that was observed in this study has been reported elsewhere, leading some researchers to conclude that age alone is no longer a significant predictor of mortality.¹²

Absence of a comparable younger cohort of patients does not permit this sort of comparison, although for the period

studied, even within this cohort, age was a significant predictor of in-hospital mortality. Sample size limitation did not permit us to reasonably predict whether the reduced mortality observed in the most recent years of the study would predispose toward the loss of age as a significant predictor. Nonetheless, what clearly appears to be emerging is the concept of “physiologic” rather than “chronologic” age as a more relevant variable for patient evaluation. The data do not permit us to determine whether it is improved surgical, intensive care, and medical management or refined patient selection that accounts for the dramatic improvement in mortality. Indeed, there was no prospective or standardized methodology for patient selection. These decisions may well have evolved with time, just as surgical technique did with the documented increasing use of the ITA. Certainly the fact that the rate of complications in general did not decline while mortality did suggests that improvements in intensive care may have contributed to improved perioperative survival. Moreover, given that the risk profile of patients referred for surgery certainly increased, in an age of aggressive PCI, it is reasonable to assume that multiple factors in addition to patient selection account for these results.

The trend toward reduced mortality observed in this study mirrors that observed nationally for CABG during a similar period.¹³ Moreover, previous studies of CABG in octogenarians, both by this group and nationally, confirm lower mortality among patients receiving left ITA grafts.^{14,15} The increasing use of the left ITA graft with time may have accounted in part for the drop in mortality reported. Regardless of the reasons, the observation emerges from this data that in-hospital mortality in this elderly cohort now approaches that expected for CABG in the general population. The impact of this finding on the risk to benefit ratio used to make therapeutic decisions should not be underestimated.

The introduction of off-pump surgery has more recently been proposed as a potential method for reducing surgical mortality and morbidity in the elderly population. Although the results compared with more conventional on-pump surgeries have been mixed,¹⁶ most studies have demonstrated improvements in operative morbidity and mortality with the off-pump technique.¹⁷ No difference in QOL, however, has been discernible.¹⁸ The effects that innovative hybrid procedures and minimal extracorporeal circulation systems might have in further reducing surgical morbidity and improving outcomes have not yet been defined.

It may be reasonable to conclude that because of the fragility of and incremental risk of surgery in this elderly population PCI, with its attendant improvements, might represent a more prudent alternative. Long-term survival of octogenarians with multivessel disease, however, has been shown to be improved with CABG versus PCI.¹⁹ This finding may be related to the relationship between completeness of revascularization and improved survival in oc-

togenarians.²⁰ Although this study did not measure completeness of revascularization, it may be hypothesized that with an average graft/patient ratio of 3.7, the extent of myocardial revascularization may well have contributed to the favorable long-term survival. Unfortunately, there are no data available regarding any effects of evolving medical therapy that the patients may have experienced. Nor was there any information regarding social or other support systems that may have affected long-term survival and QOL.

Although our data do not permit a comparison of preoperative versus postoperative assessment of QOL, such improvement in this population has been well documented.²¹ Moreover, the low incidence of major adverse cardiac events and the transition from 89% of patients in CCS class III or IV preoperatively to 97.1% in CCS class I or II at the time of midterm follow-up demonstrates a marked improvement in this cohort. The remarkably low incidence of major adverse cardiac events may also reflect a reluctance to reintervene in elderly patients who have already undergone “maximum” myocardial revascularization. These data must be viewed with caution, because they were collected retrospectively from patients or families, rather than prospectively from medical records. The improved CCS statuses and good functional outcomes reported here indicate, however, that these patients not only have long-term survival but also return to an acceptable premorbid lifestyle in the mainstream of society.

Cardiac studies have demonstrated that physiologic parameters frequently do not correlate well with patient perception of health status. In fact, the opposite seems to be the case—patient perception of health status may be a powerful predictor of long-term mortality.²² It therefore becomes extremely important in the assessment of long-term outcomes with any therapeutic intervention to address separately the issues of clinical parameters and patient perception of QOL.

In this elderly high-risk population with multiple potential presenting comorbidities and unrelated health problems, the issue becomes even more compelling. Coronary artery disease itself carries a well-documented burden of depressed patient perception of QOL,²³ so our findings that both physical and mental health summary scores were comparable to those of age-matched control subjects are remarkable. The comparison was actually with patients 75 years old and older, and because the SF-36 scores decline with age, the reported scores may be better than would be expected from a more closely age-matched control group.

Our specific finding of diminished physical functioning but improved perception of bodily pain and role physical may seem unusual; however, this is consistent with the findings of others²⁴ and may reflect the underlying burden of disease rather than a limitation imposed by the surgery. Of particular interest in our study was the homogeneity of positive findings with time. Most of the research in this area

centers on patient perception 1 to 2 years after surgery. Although practical considerations did not permit us to conduct the late follow-up that was conducted on mortality, our mid-term follow-up spanned from 1 month to 12.6 years, with a mean of 3.4 years. Even so, date of surgery did not significantly impact QOL scores, providing further support for the durability of these results.

Although the predictors of QOL perception differed between the physical and mental health components, the powerful influence of diabetes was manifest in both summary scores. Interestingly, age and sex, which are well known as predictors of physical QOL perception, were not found to be predictive of the mental health summary score. The effect of previous myocardial infarction and previous surgery on perception of mental health well-being was somewhat unique in this study and merits further investigation.

As encouraging as these outcomes may be, the exigencies of modern health care have forced a paradigm shift. It is no longer sufficient merely to determine what is possible. With health care costs rising faster than the growth in the economy, we as a society are being challenged to evaluate whether a given intervention is financially viable as well as clinically feasible. Clearly, despite the improvements demonstrated with time, surgery in this elderly cohort is associated with longer hospital stays and is therefore more costly. Although this analysis lacks a cost-benefit model to study the financial effects, the data presented provide information essential to thoughtful evaluation of benefit and expense. Indeed, in light of the benefits of surgery for even unsuitable candidates, this therapy may represent an overall cost saving.⁷

In summary, this study demonstrates that CABG can be performed in a community setting on patients 80 years old and older with an increasingly acceptable and declining mortality, the expectation of sustainably improved patient-perceived QOL, and survival comparable to that of the age-matched general population. These findings provide clarity and focus to the search for optimal therapy through surgical intervention in this increasingly prevalent and challenging group of patients.

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APPENDIX E1. Definition of Terms

Preoperative Variables

Hypertension was defined as blood pressure (≥ 140 mm Hg systolic or ≥ 90 mm Hg diastolic) on 2 occasions or current antihypertensive medication. *Hypercholesterolemia* was defined as a cholesterol level greater than 200 mg/dL on admission to the hospital. *Renal insufficiency* was defined as a documented history of renal failure with a creatinine level of 2.0 mg/dL or greater or current dialysis.

Surgical Urgency

Elective surgery was defined as an operation that could be deferred without increased risk of compromised cardiac outcome. *Urgent surgery* was defined as an operation required within 48 hours in an effort to prevent further clinical deterioration. *Emergency surgery* was defined as surgery for a patient with intractable angina or heart failure not responsive to aggressive clinical measures, a patient with impending infarction, or a patient in whom decompensation occurred in the cardiac catheterization laboratory, with measures such as defibrillation, extended cardiac massage, balloon counterpulsation, or inotropic support required.

Postoperative Variables

Respiratory insufficiency was defined requirement for ventilatory support for longer than 48 hours, tracheostomy, or both. *Cerebrovascular accident* was defined as a neurologic deficit that remained unresolved and was seen for more than 24 hours. *Perioperative myocardial infarction* was defined as a new onset of Q waves with or without elevation of myocardial enzymes or a substantial elevation of myocardial enzymes alone. *Renal insufficiency* was defined as a documented history of renal failure with a creatinine of 2.0 mg/dL or greater or current dialysis. *Low cardiac output syndrome* was defined as clinical evidence of hypotension, oliguria, and peripheral vascular constriction with normal or supranormal left ventricular filling pressure or a measured cardiac index of less than $2 \text{ L}/(\text{min} \cdot \text{m}^2)$, necessitating the administration of catecholamines, use of an intra-aortic balloon pump, or both. *Deep sternal infection* was defined as instability of the sternum with positive wound cultures necessitating an additional surgical procedure, such as incision and drainage, débridement, or secondary closure. *In-hospital mortality* was defined as death occurring during the operation or the hospitalization in which the procedure was performed, or death occurring after discharge from the hospital but within 30 days of the surgical procedure, unless the cause was clearly unrelated to the operation.

Major Adverse Cardiac Events

Major adverse cardiac events included the combined incidence of nonfatal myocardial infarction, PCI, and reoperation for coronary artery disease.

SF-36

SF-36 refers to the Short Form 36, a standardized instrument comprising 36 items designed to measure 8 dimensions of overall health.⁶ These include physical functioning, social functioning, role limitations attributed to emotional problems, mental health, vitality (energy/fatigue), bodily pain, and general health perception. For each dimension, item scores are computed, totaled and converted into a scale, which ranges from 0 for worst health to 100 representing best health. Two summary components—a physical health summary and mental health summary score—are also computed.

APPENDIX E2. Covariates Used to Predict In-Hospital Mortality

Preoperative Variables

1. Age
2. Arrhythmia
3. Cerebrovascular disease
4. Congestive heart failure
5. Date of surgery
6. Diabetes
7. Diseased vessels
8. Dyslipidemia
9. Ejection fraction
10. Family history of coronary artery disease
11. Hypertension
12. Intra-aortic balloon pump
13. Male sex
14. Peripheral vascular disease
15. Previous myocardial infarction
16. Previous PCI
17. Renal insufficiency
18. Surgical history
19. Surgical urgency
20. Unstable angina

Intraoperative Variables

21. Conduit
22. Distal grafts
23. Perfusion time (in minutes)

APPENDIX E3. Covariates Used to Predict Late Mortality

Preoperative Variables

1. Age
2. Arrhythmia
3. Cerebrovascular disease
4. Congestive heart failure
5. Date of surgery
6. Diabetes
7. Diseased vessels

8. Family history of coronary artery disease
9. Hyperlipidemia
10. Hypertension
11. Intra-aortic balloon pump
12. Male sex
13. Peripheral vascular disease
14. Previous myocardial infarction
15. Previous PCI
16. Renal insufficiency
17. Surgical history
18. Surgical urgency
19. Unstable angina

Intraoperative Variables

20. Conduit
21. Distal grafts
22. Perfusion time (in minutes)

Postoperative Variables

23. Atrial fibrillation
24. Cardiac arrest
25. Cerebrovascular accident
26. Low cardiac output
27. Perioperative myocardial infarction
28. Pulmonary insufficiency
29. Renal insufficiency
30. Reoperation for bleeding

APPENDIX E4. Covariates Used to Predict Physical and Mental Summary Scores on the SF-36**Preoperative Variables**

1. Age
2. Diabetes
3. Diseased vessels
4. Dyslipidemia
5. Family history of coronary artery disease
6. Hypertension
7. Intra-aortic balloon pump
8. Male sex
9. Previous myocardial infarction
10. Renal disease
11. Surgical history
12. Surgical urgency
13. Unstable angina

Postoperative Variables

14. Atrial fibrillation
15. Cardiac arrest
16. Cerebrovascular accident
17. Low cardiac output
18. Perioperative myocardial infarction
19. Respiratory insufficiency
20. Renal insufficiency
21. Reoperation for bleeding

APPENDIX TABLE E1. Multivariate analysis of preoperative and intraoperative variables associated with in-hospital mortality among patients 80 years old and older undergoing isolated coronary artery bypass grafting

Predictor	β Estimate	SE	χ^2	<i>P</i> value*	Odds ratio	95% Confidence interval
Preoperative						
Date of surgery	−0.0002	.0001	7.54	.006	1.0	1.0–1.0
Arrhythmia	0.6809	.2289	8.52	.004	2.0	1.3–3.1
Abnormal ejection fraction	0.6228	.2494	6.61	.010	1.9	1.1–3.0
Renal insufficiency (creatinine ≥ 2.0 mg/dL)	0.9048	.2581	11.26	.001	2.5	1.5–4.1
Nonelective surgical urgency	0.6010	.2406	5.93	.015	1.8	1.1–2.9
Intraoperative						
Conduit (saphenous vein)	0.5448	.2554	4.73	.030	1.7	1.0–2.8
Perfusion time	0.0117	.0044	6.50	.011	1.0	1.0–1.0

*Only significant differences ($P < .05$) are listed.**APPENDIX TABLE E2. Preoperative, intraoperative and postoperative variables influencing late mortality as evidenced by Cox regression analysis in patients 80 years old and older undergoing isolated coronary artery bypass surgery grafting**

Predictor	Regression coefficient	SE	Relative hazard	<i>P</i> value*
Preoperative				
Male sex	0.2811	0.0979	1.3245	.004
Age	0.0601	0.0148	1.0619	.001
Congestive heart failure	0.4414	0.1002	1.5549	.001
Peripheral vascular disease	0.4210	0.1031	1.5234	.001
Renal insufficiency (creatinine ≥ 2.0 mg/dL)	0.5105	0.1182	1.6661	.001
Cerebrovascular accident	1.1061	0.2146	3.0224	.001
Postoperative				
Respiratory insufficiency	0.6766	0.1142	1.9671	.001
Renal insufficiency (creatinine ≥ 2.0 mg/dL)	0.7237	0.1338	2.0620	.001

*Only significant variables ($P < .050$) are listed.