Coronary Artery Bypass Operations for Elderly Patients in California, 2003 to 2008

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Background. **Coronary artery bypass grafting (CABG) is no longer rare for elderly patients. This study evaluates operative mortality and the effects of off-pump CABG (OPCAB) on mortality for elderly Californians between 2003 and 2008.**

Methods. **All isolated CABGs in California for 2003 to 2008 were classified into cohorts by age: (1) younger than 75, (2) 75 to 84, and (3) 85 or older. Multivariable logistic regression models were developed for operative mortality. Trend analyses for observed and predicted mortality, and observed-to-expected mortality ratios were performed. The "recycled predictions" method was used to assess the effect of OPCAB on operative mortality.**

Results. **Among 101,710 isolated CABGs between 2003 and 2008, 22.0% were in cohort 2 and 2.3% were in cohort 3. Predicted mortality was unchanged for cohorts 2 and 3 (all $p > 0.05$), but observed-to-expected mortality ratios declined from 0.958 to 0.633 for cohort 2 ($p = 0.021$) and from 1.027 to 0.965 for cohort 3 ($p = 0.168$). The proportion of OPCAB for patients aged 75 years or older increased from 25.0% to 29.1% between 2003 and 2008. The adjusted odds ratio for operative mortality for OPCAB in patients aged 75 years or older was 0.752 (95% confidence interval, 0.650 to 0.871; $p < 0.001$) compared with on-pump CABG for the same age cohort.**

Conclusions. **In California, overall predicted mortality was unchanged for elderly patients between 2003 and 2008, but operative mortality significantly decreased for patients aged 75 to 84. Improvement for CABG patients aged 85 years or older was insignificant. The increase in the number of OPCAB patients was associated with decreased mortality for elderly patients.**

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Advanced age is an important risk factor for mortality and morbidity in patients undergoing coronary artery bypass grafting (CABG) operations. Concern regarding the increased operative risk of elderly patients is reflected in The Society of Thoracic Surgeons 2008 risk model. For example, the estimated odds ratio for operative mortality in patients undergoing isolated CABG is 4.7 in those aged 80 years compared with those aged 50 years [1]. However, with advances in medical care and increasing life expectancy, CABG is no longer uncommon in elderly patients with multivessel coronary artery disease. Thus, there have been a variety of reports of CABG outcomes in elderly patients, including octogenarians, nonagenarians, and centenarians [2–12]. The aim of this study was to investigate the trend in operative mortality of elderly patients who underwent isolated CABG between 2003 and 2008 in California and to explore the effect of off-pump bypass (OPCAB) operations on operative mortality for elderly patients.

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Material and Methods

This study was approved by the Committee for the Protection of Human Subjects of the California Health and Human Services Agency on June 3, 2011 (Project # 04–08–58).

Source

Data were obtained from the California Coronary Artery Bypass Graft Outcomes Reporting Program (CCORP) data registry on patients who underwent CABG operations between 2003 and 2008. Beginning in 2003, California state law has required that all state-licensed hospitals that perform isolated and nonisolated CABG report their cases to CCORP. Isolated CABG is defined as CABG performed without other major procedures during the same operation, including valve repair, carotid endarterectomy, or aortic, lung, or ventricular operations.

The CCORP clinical data registry uses a subset of data elements collected by The Society of Thoracic Surgeons for its Adult Cardiac Surgery Database. After data submission by hospitals, CCORP performs validation procedures, including verification of complete submissions using the statewide hospital patient discharge data, verification of deaths using the state's death registry, and an annual independent medical record audit of selected hospitals. It takes about 2 years from data being submit-

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Abbreviations and Acronyms

CABG = coronary artery bypass grafting
CCB = conventional on-pump coronary bypass
CCORP = California Coronary Artery Bypass Graft Outcomes Reporting Program
CI = confidence interval
CVA = cerebrovascular accident
MI = myocardial infarction
O/E = observed-to-expected ratio
OPCAB = off-pump coronary artery bypass grafting
OR = odds ratio
OSHPD = California Office of Statewide Health Planning and Development
PCI = percutaneous coronary intervention
VF = ventricular fibrillation
Vfib = ventricular fibrillation
VT = ventricular tachycardia
Vtach = ventricular tachycardia

ted by each hospital performing CABGs to the completion of data cleaning, on-site audit, and validation. The program produces hospital and surgeon-specific report cards based on risk-adjusted operative mortality rates. A detailed description of the CCORP data collection methods and analysis has been documented elsewhere [13].

All isolated CABG cases in the CCORP database between 2003 and 2008 were classified into three cohorts by age in years: (1) younger than 75, (2) 75 to 84, and (3) 85 or older. Operative mortality was defined as a patient who died at hospital discharge or after discharge but within 30 days of CABG. To investigate the effect of OPCAB on operative mortality in the elderly, we categorized those "combined" procedures—in which OPCAB procedures were converted to conventional coronary bypass (CCB) intraoperatively—as OPCAB based on the intention-to-treat principle.

Statistical Analyses

We performed the Cochran-Armitage trend test to compare historical change in case volume and observed operative mortality for patients by age cohorts between 2003 and 2008. To compare the patient demographic and clinical risk profile between 2003 and 2008, we used the χ^2 test for categoric variables and Student t test for continuous variables. To avoid prediction bias, we developed a multivariable logistic regression model with 2-year combined data (2003 and 2004) and applied the model to each year between 2003 and 2008 for computation of predicted operative mortality for each patient. We computed mean expected mortality and the observed-to-expected (O/E) mortality ratios by age cohort for each year between 2003 and 2008 and used the general linear regression model to test the differences in observed mortality, expected mortality, and O/E mortality ratio for the elderly cohorts between 2003 and 2008.

We then added OPCAB to the multivariable risk model and used the "recycled predictions" method to compute and compare the mean risk-adjusted operative mortality rates between OPCAB and CCB for elderly patients. The method of recycled predictions produces the marginal effect that measures the expected instantaneous change in the dependent variable (ie, operative mortality) as a function of a change in a certain explanatory variable (ie, OPCAB vs CCB) while keeping all the other covariates constant [14, 15]. By using the recycled predictions method for the first run, we assumed CCB was performed in all elderly patients, and for the second run, we assumed OPCAB was performed. All differences in statistical analysis were considered significant if p was less than 0.05. All data analyses were conducted with SAS 9.2 software (SAS Institute, Cary, NC).

Results

Among 101,710 patients who underwent isolated CABGs between 2003 and 2008 in California, 76,934 (75.6%) were in cohort 1 (age <75 years), 22,398 (22.0%) were in cohort 2 (age 75–84 years), and 2,378 (2.3%) were in cohort 3 (age ≥85 years). The annual volume of isolated CABG for all ages fell by 34.4% from 21,276 in 2003 to 13,957 in 2008, and the total number of elderly patients (aged ≥75 years) undergoing isolated CABG also decreased from 5,356 in 2003 to 3,264 in 2008, a 39% reduction over 6 years (Cochran-Armitage trend test $p < 0.0001$). However, the proportion of patients aged 85 or older among all isolated CABGs increased slightly, from 2.2% to 2.4% ($p = 0.013$), for the same period.

Cohorts 2 and 3 had a higher prevalence in 2008 than in 2003 for the following: age 85 or older, nonwhite race, hypertension, dialysis, cerebrovascular disease, diabetes, severe chronic lung disease, immunosuppressive treatment, atrial fibrillation, prior percutaneous coronary intervention, left main stenosis exceeding 75%, and moderate–severe mitral insufficiency (all $p < 0.05$). In 2008, however, elderly patients had a lower prevalence of emergency or salvage CABG, myocardial infarction (MI) within 24 hours of CABG, heart block, one or more prior cardiac operations, or cardiogenic shock (all $p < 0.05$; Table 1).

A multivariable logistic regression model for predicting operative mortality was developed using 2003 and 2004 combined isolated CABGs (n = 40,377). The model included 24 demographic and clinical risk factors (Fig 1) and had a C statistic of 0.817, indicating good discrimination, and $p = 0.145$ for the Hosmer-Lemeshow test, indicating an acceptable data calibration. The risk model showed 19 factors were significant for operative mortality (all $p < 0.05$). Among these, body mass index of less than 18.5 kg/m^2, emergency or salvage status, creatinine level, severe chronic lung disease, arrhythmia ventricular tachycardia/ventricular fibrillation, and cardiogenic shock were the most significant risk factors, with odds ratios exceeding 2.0. The risk model was validated with CCORP 2005 to 2008 data (n = 61,333) and had a C statistic of 0.810.