Impact of Gender on Arterial Revascularization Strategies for Coronary Artery Bypass Grafting

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Background. **There are significant gender differences in arterial revascularization approaches in coronary operations. This study addressed these differences to determine whether discrepancies are related to underlying risk profiles or systematic gender bias.**

Methods. **Changes in gender-specific rates of revascularization approaches were determined in 19,557 patients undergoing isolated coronary artery bypass grafting (CABG). A propensity-balanced group was generated on a subset of 1,254 CABG patients based on 45 pretreatment covariates to assess rates in matched groups (627 patients per group).**

Results. **In the entire cohort, male gender was associated with increased bilateral internal thoracic artery (BITA) use (odds ratio, 1.667; 95% confidence interval [CI], 1.166 to 2.386; $p = 0.005$). Multiple-arterial grafting increased yearly in both genders, but the rate of increase in BITA use was greater in men (1.59%/year [95% CI, 1.56 to 1.63] vs 1.37%/year [95% CI, 1.30 to 1.45], $p < 0.001$) as was the use of 3 arteries (1.16%/year [95% CI, 1.13 to 1.20] vs 0.73%/year [95% CI, 0.67 to 0.80), $p < 0.001$) and the use of any 2 arteries (2.34%/year (95% CI, 2.32 to 2.35) vs 1.92%/year [95% CI, 1.90 to 1.95], $p < 0.001$). In the propensity-matched group, there was no difference in BITA use (male: 31.9%, female: 30.1%; $p = 0.502$), BITA use in low-risk patients (male: 46.4%, female: 38.0%; $p = 0.126$), or radial artery use (male: 44.5%, female: 44.1%; $p = 0.994$), but use of 3 arteries was greater in men (10.5% vs 7.3%, $p = 0.048$).**

Conclusions. **Women receive less complete multiple arterial coronary revascularization than men. This is likely related to later presentation of coronary artery disease in women with higher comorbidity profiles; however, when matched, bias may still exist limiting the option of grafting with 3 arteries to women.**

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Coronary artery disease (CAD) is a leading cause of death of women in Western society; however, the gender effect has traditionally been underappreciated [1]. Despite major advances in the diagnosis and treatment of CAD, little progress has been made in improving the outcomes of CAD in women compared with men [1, 2]. These outcomes include an increased mortality rate, with women having a higher incidence of death immediately (weeks) after an acute myocardial infarction (MI) and CABG as well as higher rates of heart failure within 5 years after a MI [2, 3]. Thus, there is a pressing need to understand more about our approaches to CAD in women.

An important area of potential gender bias in the treatment of CAD relates to revascularization approaches. Coronary artery bypass grafting (CABG) is considered the gold standard in the treatment of extensive CAD, conferring excellent control of symptoms and prolongation of life [4, 5]. However, there is evidence to suggest that both the referral and surgical revascularization rates of women with CAD are less than men [6–8]. Men receive greater access to effective cardiac treatments, including medications and revascularization, while women go misdiagnosed for many years, accruing a higher burden of CAD and comorbidities [6–11]. These findings have remained unexplained and are currently the subject of interest and controversy [6, 12–14].

Furthermore, the strategies for surgical coronary revascularization may also differ between genders. The internal thoracic artery (ITA) is widely accepted as the conduit of choice for left anterior descending artery grafting in CABG operations [15] owing to superior long-term patency rates and improved cardiac outcomes [12, 13, 16, 17]. There is also strong evidence supporting

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the beneficial effect of bilateral ITA (BITA) grafting on long-term survival in CABG patients [13, 18, 19]. However, BITA grafting appears to be underused in women. According to The Society of Thoracic Surgeons (STS) Adult Cardiac Surgery Database, only 2.3% of women undergoing CABG from 2002 to 2005 received BITA grafting vs 4.7% of men [13, 20].

The Ottawa Heart Institute maintains a database of patients who have undergone CABG since 1990 from a large metropolitan area in which it has been the sole provider of cardiac surgical services. The use of single and multiple arterial revascularization has evolved steadily; thus, this data set provides an ideal means to explore the dynamics of these strategies to determine whether gender bias exists. We also sought to establish whether factors other than gender may contribute to differences in the rates of arterial revascularization.

Patients and Methods

Patient Population and Data

The Ottawa Health Science Network Research Ethics Board approved the analysis of this deidentified data, which had been prospectively collected before and after the operation. Individual patient consent was waived. The study population consisted of patients undergoing CABG between January 1990 and March 2015. Prospective clinical data are routinely collected during surgical admission and form part of the Cardiac Surgery and Cardiac Anesthesia databases.

Target vessel size and quality were measured intraoperatively using calibrated coronary probes and recorded on a standardized computer-generated operative note. All data were reviewed retrospectively. Full demographic patient data were not available before August 2004; thus, the propensity-matched cohort was derived from patients in the database between August 2004 and March 2015. Since 1990, 15 surgeons have been active at various times performing coronary revascularization. The incidence of BITA revascularization in each practice varied significantly, between 2% and 70%, for elective coronary operations. However, the use of BITA grafting was more homogeneous between surgeons in later years of the study.

Statistical Analysis

Continuous variables are reported as mean ± SD or median and interquartile range (IQR) for nonnormally distributed variables. Categoric variables are reported as counts and percentages. Student *t* tests or Wilcoxon rank sum tests were used to compare continuous variables between gender groups. Differences for categoric variables were compared with χ^2 tests. A multivariable regression analysis was completed using the covariates of year of operation, patient age, body mass index (BMI), and operative priority. Pairwise correlation was used to assess the relationship between factors influencing the use of BITA over time.

A propensity score was derived for each patient since August 2004 using 45 covariates derived from the database as predictors (Supplemental Table 1), with gender (in those who received BITA) as the outcome in a logistic regression model. One-to-one matching was used with a caliper width of 0.01 without replacement. No imputation was used because data were complete in more than 99.5% of patients.

Results

Clinical Characteristics

The flow of patients in the study is demonstrated in Figure 1. The total population undergoing coronary revascularization of any form since 1990 was 23,962 patients, comprising 18,969 men (77.9%) and 5,383 women (22.1%). Cases were excluded if they involved a reoperation with the primary operation before 1990 (n = 1,328). Isolated CABG was completed in 20,175 (89.1%), whereas 2,459 (10.9%) underwent CABG as a secondary procedure to aortic or mitral valve repair/replacement, or other procedures such as thoracic aortic operations. A higher proportion of women underwent combined procedures (13.7% vs 10.0%, $p < 0.001$). Patients undergoing combined procedures and isolated CABG with 1 distal anastomosis (n = 618) were further excluded for a final population of 19,557 patients (primary analysis cohort [PAC]). Of this group, 7,027 underwent operations after August 2004 and were used for the collection of the propensity-matched cohort (PMC).

PAC Assessment

In the PAC, the percentages of men and women undergoing BITA over time in all patients and in low-risk patients (elective, age <70 years) are illustrated in Figures 2 and 3. The percentages of men and women undergoing double- or triple-arterial grafting are illustrated in

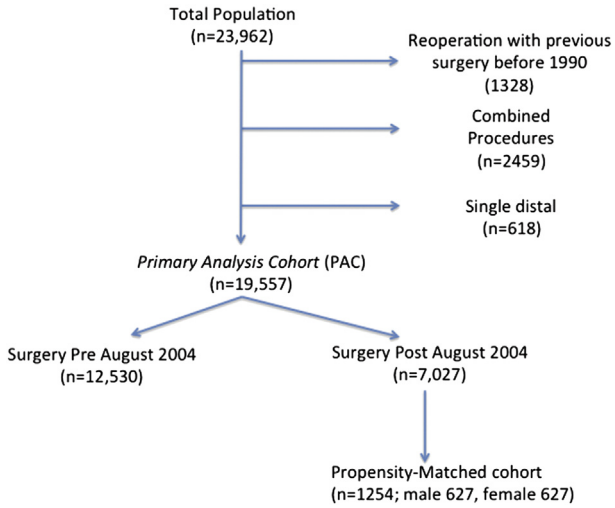

Fig 1. Derivation of the primary analysis cohort (PAC) and the propensity-matched cohort (PMC) of patients between January 1990 and 2016.