Gender and outcomes after coronary artery bypass grafting: A propensity-matched comparison

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See related articles on pages 1704, 1707, and 2044.

Objective: Our objective is to determine whether gender is a marker or a causal influence for poor outcomes after coronary revascularization.

Methods: Propensity-modeling techniques were used to investigate whether gender adversely impacts outcomes after coronary revascularization. A parsimonious explanatory model was developed by bootstrap bagging with variable selection from 64 baseline and 37 operative variables. Propensity scores were calculated from a logistic model that included the parsimonious model and additional baseline variables. Greedy matching techniques were applied to match female and male patients to the nearest propensity scores. Comparisons were made among the propensity-matched women and men.

Results: Of the 15,597 patients undergoing isolated coronary artery bypass graft surgery, only 26% of the 3596 women were matched on propensity scores with men. Distribution of covariates among the matched pairs was, on average, equal. Postoperative mortality ($P = .76$), neurologic morbidity (global deficit $P = .07$, focal deficit $P = .51$), infection (sepsis $P = .88$), mediastinitis ($P = .18$), renal failure ($P = .84$), intra-aortic balloon pump usage ($P = .61$), and reoperation for bleeding ($P = .10$) were similar among women and men. Occurrence of Q-wave myocardial infarction ($P = < .01$), postoperative inotropic usage ($P = < .01$), and prolonged ventilatory support ($P = .02$) were more common in women compared with propensity-matched men.

Conclusions: The preoperative profiles of women and men are markedly different. Propensity matching women and men was difficult, because only 26% of women were able to be matched with men. However, in well-matched patients, female gender was not associated with increased mortality and had minimal impact on morbidity after coronary artery bypass grafting.

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Risk of morbidity and mortality after coronary artery bypass grafting (CABG) is reported to be higher for women than for men.¹⁻⁸ However, studies examining an independent effect of gender on outcomes after CABG have produced variable results.¹⁻¹⁵ Our objective was to determine whether gender is merely a marker for a high-risk profile or whether it has a causal influence on increased postoperative morbidity and mortality after CABG. This was investigated by applying propensity-modeling techniques to a large database of isolated patients who underwent CABG.

Methods

Patient Population

From January to June 2002, 15,597 patients underwent isolated CABG surgery at the Cleveland Clinic Foundation. All data were prospectively collected and entered into the

Figure 1. Mirrored histogram distribution of propensity scores for women and men, reflective of their preoperative profiles, are dissimilar. Note there is minimal overlap in distribution of propensity scores among the women and men.

computer database by trained database management personnel. Institutional review board approval was obtained from The Cleveland Clinic Foundation to perform research analyses on the institution’s databases,

Statistical Methods

Data for 64 baseline and 37 operative and postoperative variables were collected. The aim of the analysis was to match female and male patients according to baseline characteristics and compare surgical outcomes between the matched groups.

Before matching patients, a parsimonious explanatory model was developed by bootstrap bagging for variable selection.¹⁶ Baseline variables found to be significantly associated with gender were identified.¹⁷ A propensity score, in logit units, was then obtained by calculating the predicted value for each observation from a

logistic model including the variables identified in the parsimonious model plus additional baseline variables, for a total of 68 covariates. These scores represent a summary of baseline characteristic for each observation. Greedy matching techniques were then used to select male counterparts to the female patients by choosing the patient with the nearest propensity score.¹⁸ This resulted in 945 matches (26% of the women and 8% of the men). Univariable comparisons were made among the matched and unmatched groups using the Student *t* and Wilcoxon rank tests for continuous variables and the chi-square and Fisher’s exact tests for categorical variables.

Propensity Score Justification

Associations found through traditional multivariable regression may be misleading because of underrepresentation of 1 covariate of interest within levels of another. Thus, subclassification with propensity scores is used to adjust for confounding background characteristics.¹⁹ To illustrate the advantage of using propensity scores, a logistic model was developed for hospital mortality using the entire original data set irrespective of matching. A parsimonious model was constructed by bagging (bootstrap aggregation) with 200 samples to identify significant covariates in the model. A cluster analysis was then used to identify correlations among them. Variables significant in at least 50% of the samples were placed into the model. The significance of gender was then assessed by first forcing in an indicator variable for female, followed by adding a covariate for the propensity score.

Propensity Matching Coronary Reoperations

Coronary revascularization procedures pose an increased risk for both postoperative morbidity and mortality. We investigated whether there were gender differences in this subset of patients with the application of propensity-matching techniques. Of the patients who underwent coronary reoperation, 176 women (36%) and 149 men (5%) were propensity matched. By using the Student

TABLE 1. Baseline continuous variables between matched pairs

Characteristic	Matched females		Matched males		Student <i>t</i> test
	N	Mean ± SD	N	Mean ± SD	<i>P</i> value
Demographics					
Age at surgery (yr)	945	65.6 ± 10.2	945	65.9 ± 10.4	.54
Height (cm)	945	164.4 ± 6.8	945	164.7 ± 11.1	.50
Weight (kg)	945	78.4 ± 16.2	945	77.4 ± 14.9	.18
Body mass index (kg/m ²)	945	29.1 ± 6.0	945	29.0 ± 8.4	.86
Body surface area (m ²)	945	1.8 ± 0.2	945	1.8 ± 0.2	.45
Preoperative laboratory values					
Hematocrit (%)	945	39.5 ± 4.1	945	36.1 ± 5.1	<.01
Bilirubin (mg/dL)	867	0.6 ± 0.4	872	0.6 ± 0.3	.99
Albumin (g/dL)	866	3.9 ± 0.5	871	3.9 ± 0.6	.20
BUN (mg/dL)	945	19.7 ± 10.2	945	19.9 ± 10.8	.61
Serum creatinine (mg/dL)	945	1.2 ± 1.0	945	1.2 ± 1.0	.41
Triglycerides (mg/dL)	450	201.6 ± 183.9	454	201.4 ± 193.5	.98
HDL cholesterol (mg/dL)	453	41.9 ± 12.4	454	42.0 ± 13.4	.85
LDL cholesterol (mg/dL)	442	128.4 ± 43.8	448	125.8 ± 46.0	.40
Red cell mass estimate (L)	945	1.7 ± 0.3	945	1.7 ± 0.3	.24

HDL, High-density lipoprotein; LDL, low-density lipoprotein; BUN, blood urea nitrogen.

TABLE 2. Baseline categoric variables between matched pairs

Characteristic	Female		Male		Chi-square test P value
	N	%	N	%	
Preoperative medication					
ACE inhibitors	249	26	252	27	.88
Antiarrhythmics	119	13	119	13	.99
Beta blockers	534	57	542	57	.71
Calcium channel blockers	335	36	321	34	.50
Statins	26	2.8	16	1.7	.12
Clinical history					
Myocardial infarction	524	56	530	56	.78
Chronic obstructive pulmonary disease	84	8.9	85	9.0	.94
Smoking	566	60	560	59	.78
Heart failure	206	22	219	23	.47
Hypertension	696	74	690	73	.76
Diabetes: insulin treated	170	18	168	18	.90
Diabetes: non-insulin treated	177	19	186	20	.60
Stroke	76	8.0	75	7.9	.93
Peripheral vascular disease	154	16	153	16	.95
Renal disease	23	2.4	11	1.2	.04
Alcohol use	42	4.4	38	4.0	.65
Atrial fibrillation	42	4.4	46	4.9	.66
Unstable angina	366	39	366	39	.99
Preoperative pathology					
Aortic valve regurgitation	52	5.5	63	6.7	.29
Aortic valve stenosis	11	1.2	15	1.6	.43
Mitral valve regurgitation	159	17	176	19	.31
Coronary artery disease					
Any circumflex system disease	799	85	797	85	.94
Any left main disease	376	40	371	40	.81
Any LAD system disease	897	95	892	95	.67
Any RCA system disease	838	89	836	89	.94
Symptoms					
NYHA class					.88
1	116	13	125	14	
2	374	42	366	42	
3	135	15	126	14	
4	260	29	259	30	
Canadian angina class					.93
0	25	2.8	25	2.9	
1	280	32	266	30	
2	422	48	419	48	
3	135	15	138	16	
4	23	2.6	28	3.2	
Emergency surgery	37	3.9	37	3.9	.99
Cardiogenic shock	5	0.53	5	0.53	.99
Intra-aortic balloon pump	923	98	913	97	.17
Ventricular function					
Abnormal left ventricular function	475	50	493	52	.41

ACE, Angiotension-converting enzyme; LAD, left anterior descending; RCA, right coronary artery; NYHA, New York Heart Association.

t and Wilcoxon rank tests for continuous variables and the chi-square and Fisher's exact tests for categoric variables, comparisons were made among the propensity-matched patients who underwent reoperative CABG.

Results

Matching

Of 3596 female patients undergoing CABG, 945 (26%) could be matched with men. This reflects the vast gender

difference in preoperative profiles resulting in little overlap in baseline characteristics among women and men (Figure 1). Baseline characteristics among the propensity-matched groups are listed in Tables 1 and 2. The distribution of age, height, weight, body surface area (BSA), body mass index (BMI), preoperative laboratory values of albumin, bilirubin, blood urea nitrogen, serum creatinine, triglycerides, high- and low-density lipoprotein cholesterol, and red cell mass

TABLE 3. Outcome variables between matched pairs

	Matched females (N = 945)		Matched males (N = 945)		
Continuous variables	Median (25th, 75th percentile)		Median (25th, 75th percentile)		Wilcoxon rank P value
Total minutes myocardial ischemia	63 (44, 81)		67 (49, 84)		<.01
Total no. of units of RBC in OR and ICU	2.0 (0.0, 3.0)		2.0 (0.0, 3.0)		.05
Hours on ventilator in ICU	12 (7.5, 18)		11 (7.3, 17)		.02
Hematocrit in ICU	31 (28, 33)		30 (28, 33)		.01
	Matched females		Matched males		Chi-square test
Categoric variables	N	%	N	%	P value
Coronary endarterectomy	11	1.2	13	1.4	.68
Hospital death	20	2.1	22	2.3	.76
Complications					
Neurologic morbidity					
Encephalopathy	12	1.3	7	7.4	.25
Focal deficit	12	1.3	9	.95	.51
Global deficit	7	0.74	1	0.11	.07 ^F
Pulmonary morbidity					
ARDS	4	0.42	6	0.63	.53
Aspiration pneumonia	1	0.11	7	0.74	.07 ^F
Pneumonia	18	1.9	26	2.8	.22
Pulmonary edema	10	1.1	13	1.4	.53
Tracheostomy	15	1.6	20	2.1	.39
Pulmonary embolus	2	0.21	0	0.0	.50 ^F
Plural effusion	206	22	167	18	.02
Renal morbidity					
Renal failure	13	1.4	12	1.3	.84
Anuria	12	1.3	4	0.42	.05
Renal protective dopamine	167	18	194	21	.11
Infection					
Sternal wound infection	2	0.21	3	0.32	.99 ^F
Mediastinitis	2	0.21	7	0.74	.18 ^F
Septicemia/sepsis	22	2.3	23	2.4	.88
Endocarditis	0	0.0	1	0.11	.99 ^F
Cardiac morbidity					
Low cardiac output	15	1.6	13	1.4	.7
Cardiac arrest	56	5.9	34	3.6	.02
Atrial fibrillation	137	15	128	14	.55
Myocardial infarction	115	12	71	7.5	<.01
Intra/Postoperative IABP	49	5.2	54	5.7	.61
Antiarrhythmics	133	14	148	16	.33
Inotropic agents	339	36	248	26	<.01
Vasopressors	3	0.32	1	0.11	.62 ^F
Multisystem organ failure	7	0.74	5	0.53	.56
Blood product usage					
Intra/postoperative red blood cells	655	69	595	63	<.01
Cryoprecipitate or platelets given	110	12	112	12	.89
Reoperation for bleeding/tamponade	18	1.9	29	3.1	.1

OR, Operating room; F, Fisher's exact test; ICU, intensive care unit; ARDS, acute respiratory distress syndrome; IABP, intra-aortic balloon pump; RBC, red blood cell.

estimates were similar among the matched pairs. Preoperative medication usage, comorbidities such as hypertension and diabetes, and history of stroke and unstable angina were also equally distributed. There were similarities in the distribution for the extent of coronary artery disease, abnormal left ventricular

function, New York Heart Association functional classification, or Canadian angina class among the matched pairs. There was a slightly higher prevalence of preoperative renal disease and higher hematocrits in the propensity-matched women compared with the similarly matched men.

TABLE 4. Baseline continuous variables between unmatched and matched females

Characteristic	Unmatched females		Matched females		Student <i>t</i> test <i>P</i> value
	N	Mean $\pm$ SD	N	Mean $\pm$ SD	
Demographics					
Age at surgery (yr)	2645	67 $\pm$ 10	945	66 $\pm$ 10	<.01
Height (cm)	2645	157 $\pm$ 7.0	945	164 $\pm$ 6.8	<.01
Weight (kg)	2645	71 $\pm$ 15	945	78 $\pm$ 16	<.01
Body mass index (kg/m ²)	2645	29 $\pm$ 6.5	945	29 $\pm$ 6.0	.51
Body surface area (m ²)	2645	1.7 $\pm$ 0.2	945	1.8 $\pm$ 0.2	<.01
Preoperative laboratory values					
Hematocrit (%)	2645	36 $\pm$ 4.1	945	40 $\pm$ 4.1	<.01
Bilirubin (mg/dL)	2430	0.5 $\pm$ 0.3	867	0.6 $\pm$ 0.4	<.01
Albumin (g/dL)	2431	3.9 $\pm$ 0.5	866	3.9 $\pm$ 0.5	<.01
BUN (mg/dL)	2645	19 $\pm$ 11	945	20 $\pm$ 10	.07
Serum creatinine (mg/dL)	2645	1.0 $\pm$ 0.6	945	1.2 $\pm$ 1.0	<.01
Triglycerides (mg/dL)	1299	203 $\pm$ 162	450	202 $\pm$ 184	.89
HDL cholesterol (mg/dL)	1291	46 $\pm$ 14	453	42 $\pm$ 12	<.01
LDL cholesterol (mg/dL)	1274	133 $\pm$ 49	442	128 $\pm$ 44	.07
Red cell mass estimate (L)	2645	1.4 $\pm$ 0.3	945	1.7 $\pm$ 0.3	<.01

Outcomes Comparison

Postoperative morbidity and mortality outcomes among the propensity-matched pairs are displayed in Table 3. The occurrence of postoperative mortality, neurologic morbidity, infection, arrhythmias, renal failure, intra-aortic balloon pump (IABP) usage, and reoperation for bleeding and tamponade were similar between the propensity-matched pairs. However, women had shorter myocardial ischemic time, received more intraoperative and intensive care unit (ICU) red blood cell transfusions, required longer postoperative ventilatory support in the ICU, and had more postoperative myocardial infarctions, cardiac arrests, and pleural effusions. Women also required greater use of inotropic support in the postoperative period.

Unmatched Women

The unmatched women represented a distinct group compared with the matched women and men (Tables 4 and 5). The distribution of propensity scores among the women who were propensity matched with men and the women (74%) who were unable to be matched on propensity scores with men is displayed in Figure 2. Unmatched women were older and shorter, weighed less, and had a smaller BSA and BMI. The unmatched women had lower preoperative hematocrits, bilirubin, albumin, serum creatinine, and estimates of red blood cell mass. Their triglyceride and low-density lipoprotein cholesterol values were also less favorable. The unmatched women smoked cigarettes and drank alcohol less frequently, had less preoperative renal disease, and had a higher prevalence of preoperative IABP usage than the matched women.

Unadjusted comparisons of mortality and morbidity outcomes for the matched and unmatched women were similar with respect to in-hospital mortality, postoperative neuro-

logic and pulmonary morbidity, renal failure, inotropic usage, and reoperation for bleeding and tamponade. The unmatched women received more intraoperative and ICU red blood cell transfusions than matched women (Table 6).

Total Population of Women and Men

Unadjusted comparisons. Unadjusted postoperative morbidity and mortality outcomes among the 3596 women and 12,001 men are presented in Table 7. Women not only had a higher postoperative mortality compared with men (women 2.4% vs men 1.4%) but also had a greater occurrence of all major postoperative morbidities, such as neurologic, pulmonary, renal, and cardiac morbidities, postoperative septicemia, multisystem organ failure, and use of red blood cell products.

Multivariable logistic regression for postoperative mortality. The factors independently associated with postoperative mortality in the multivariable logistic model are presented in Table 8. Advanced age, history of peripheral vascular disease and heart failure, previous bypass graft disease, major perioperative blood transfusion, and abnormal left ventricular function were all associated with in-hospital mortality. Less hyperlipidemia, ramus stenosis, and albumin were associated with a lower probability of in-hospital death. After accounting for these factors, female gender was statistically significant ($P = .04$) but unreliable (6% probability that $P < .05$ in the bootstrap aggregation). After further adjustments for propensity score, its P value became .1695. There was no significant interaction between age and gender in the multivariable model ($P = .5$).

Reoperative Coronary Artery Bypass Grafting

Postoperative morbidity and mortality outcomes among the propensity-matched women and men who underwent coro-

TABLE 5. Baseline categoric variables between unmatched and matched females

Characteristic	Unmatched females		Matched females		Chi-square test P value
	N	%	N	%	
Preoperative medication					
ACE inhibitors	772	29	249	26	.10
Antiarrhythmics	343	13	119	13	.77
Beta blockers	1553	59	534	57	.24
Calcium channel blockers	879	33	335	36	.22
Diabetic agent	287	11	89	9.4	.22
Statins	58	2.2	26	2.8	.33
Clinical history					
Myocardial infarction	1376	52	524	56	.07
Chronic obstructive pulmonary disease	213	8.1	84	8.9	.42
Smoking	1013	38	566	60	<.01
Heart failure	621	24	206	22	.29
Hypertension	2025	77	696	74	.07
Diabetes: insulin treated	541	21	170	18	.10
Diabetes: non-insulin treated	476	18	177	19	.62
Stroke	204	7.7	76	8.0	.75
Peripheral vascular disease	413	16	154	16	.62
Renal disease	19	0.72	23	2.4	<.01
Alcohol use	55	2.1	42	4.4	<.01
Atrial fibrillation	142	5.4	42	4.4	.27
Unstable angina	1120	42	366	39	.05
Preoperative pathology					
Aortic valve regurgitation	161	6.1	52	5.5	.51
Aortic valve stenosis	48	12	11	1.2	.18
Mitral valve regurgitation	553	21	159	17	<.01
Coronary anatomy					
Any circumflex system disease	2154	82	799	85	.04
Any left main disease	995	38	376	40	.26
Any LAD system disease	2494	95	897	95	.55
Any RCA system disease	2303	88	838	89	.27
Symptoms					
NYHA class					
1	336	14	116	13	.33
2	964	39	374	42	
3	413	17	135	15	
4	773	31	260	29	
Canadian angina class					
0	54	2.2	25	2.8	.21
1	787	32	280	32	
2	1118	45	422	48	
3	455	18	135	15	
4	71	2.9	23	2.6	
Emergency surgery	106	4.0	37	3.9	.90
Cardiogenic shock	15	0.6	5	0.5	.89
Intra-aortic balloon pump	106	4.0	22	2.3	.02
Ventricular function					
Abnormal left ventricular function	1264	48	475	50	.19

nary reoperations are presented in Table 9. Women had a lower postoperative mortality compared with similarly matched men (women 2.3% vs men 6.7%). The occurrence of major postoperative morbidities were similar among the propensity-matched groups except for a greater use of antiarrhythmics in men (women 11% vs men 23%).

Discussion

Nature of the Debate

Many studies examining gender differences outcomes after CABG report a higher unadjusted postoperative morbidity and mortality for women compared with men.¹⁻⁹ The debate has centered on whether gender differences in outcome are attributable to female gender per se or to a higher preva-

Figure 2. Mirrored histogram displaying distribution of propensity scores among matched and unmatched women.

lence of unfavorable risk factors in women. A number of investigations report that gender has no influence on adverse postoperative outcomes after CABG after adjusting for gender dissimilarities in preoperative risk.^{3,7,9,14,15} An equivalent number of investigations report an increase in postoperative risk for women, despite application of risk-adjustment strategies.^{1,2,4,6} Finally, a few investigations report no difference in operative mortality even with statistically significant gender differences in the preoperative risk profiles.¹⁰⁻¹³

Two large investigations report that female gender is an independent predictor of adverse outcome after CABG within certain subgroups of patients who underwent CABG.^{1,2} Edwards and colleagues¹ analyzed the data from 247,760 men and 97,153 women from the Society of Thoracic Surgeons National Cardiac Surgery database. Women were older, presented more commonly for non-elective procedures, and were reported to have a higher prevalence of preoperative comorbid conditions, such as diabetes, hypertension, and peripheral vascular disease. Female gender was an independent predictor of postoperative death within all of their defined risk groups except within the group with an operative risk of death greater than 30%. By use of the Multicenter National Cardiovascular Network database, Vaccarino and colleagues² examined the in-hospital mortality for 36,009 men and 15,178 women who underwent CABG surgery from 1993 to 1999. They reported that women aged less than 50 years were at 3 times greater risk of postoperative mortality compared with men of similar age groupings. After adjusting for a number of preoperative comorbid conditions, women aged less than 50 years had twice the likelihood of postoperative death. Gender differences for in-hospital mortality were less marked in the older age subgroups. Our multivariable model for in-hospital mortality on the data set of 15,587 patients did not find a significant interaction between age and gender.

Conflicting results among published studies with regard to the influence of gender on postoperative morbidity and mortality after CABG are influenced by a number of factors: dissimilar study designs and data collection methods, different study sample sizes, and variable application of statistical methods to analyze the data sets. Most of the investigations are nonrandomized observational studies from large databases, which inherently entail systematic differences in baseline characteristics between women and men. Differing approaches to risk adjustment and the model-selection processes among these investigations can also lead to variability in the final model chosen.²⁰

Our investigation of 15,597 patients who underwent CABG found that a majority of women (74%) are so distinctly different from men in their preoperative profiles that they were unable to be matched on propensity scores with men. Although standard diagnostic procedures for regression would not reveal an imbalanced representation of the levels of one covariate within the levels of another, subclassification by propensity makes this imbalance evident. This demonstrates an advantage of propensity modeling over regression adjustment in that the investigator may find that there is effectively no overlap in the distributions of covariates among the groups under investigation. Application of regression adjustment in this circumstance would result in problems in drawing valid conclusions from the data without making assumptions that involve extrapolation.^{19,21} To demonstrate this concept, we examined the entire data set of patients and applied multivariable logistic regression techniques to determine if there were gender differences in postoperative mortality. Among the variables selected for the final model, female gender was a significant predictor of mortality after CABG. In the propensity-matched patients, postoperative mortality was similar among the women and men. In fact, after the logistic model was adjusted by the weights established by the propensity score, gender did not remain in the model for mortality.

With the application of propensity score methods, baseline characteristics can be summarized as a single score that approximates the background characteristics for the individual patient.²² Tables 1 and 2 demonstrate that covariates are, in general, balanced between the women and men, similar to the balance achieved in a randomized controlled trial. This allows for a “fair” comparison between women and men with regard to morbidity and mortality outcomes after CABG.²³

Principal Findings

We report similar mortality among the propensity-matched women and men undergoing CABG. Despite similar preoperative BSA, BMI, red blood cell mass, and rate of reop-

TABLE 6. Outcome variables between unmatched and matched females

	Unmatched females (N = 2645)		Matched females (N = 945)		
	Median (25th, 75th percentile)		Median (25th, 75th percentile)		Wilcoxon rank P value
Continuous variables					
Total minutes myocardial ischemia	61 (42, 80)		63 (44, 81)		.08
Total no. of units of RBC in OR and ICU	2.0 (1.0, 4.0)		2.0 (0.0, 3.0)		<.01
Hours on ventilator in ICU	12 (7.9, 18)		12 (7.5, 18)		.15
Hematocrit in ICU	31 (28, 33)		31 (28, 33)		.88
	Unmatched females		Matched females		Chi-square test
Categoric variables	N	%	N	%	P value
Coronary endarterectomy	19	0.72	11	1.2	.20
Hospital death	67	2.5	20	2.1	.47
Complications					
Neurologic morbidity					
Encephalopathy	30	1.1	12	1.3	.74
Focal deficit	42	1.6	12	1.3	.49
Global deficit	14	0.53	7	0.74	.46
Pulmonary morbidity					
ARDS	22	0.83	4	0.42	.20
Aspiration pneumonia	8	0.30	1	0.11	.46 ^F
Pneumonia	51	1.9	18	1.9	.96
Pulmonary edema	47	1.8	10	1.1	.13
Tracheostomy	49	1.9	15	1.6	.6
Pulmonary embolus	0	0.0	2	0.21	.07 ^F
Plural effusion	575	22	206	22	.97
Renal morbidity					
Renal failure	37	1.4	13	1.4	.96
Anuria	28	1.1	12	1.3	.6
Renal protective dopamine	447	17	167	18	.59
Infection					
Sternal wound infection	11	0.42	2	0.21	.53 ^F
Mediastinitis	16	0.60	2	0.21	.18 ^F
Septicemia/sepsis	73	2.8	22	2.3	.48
Endocarditis	2	0.076	0	0.0	.99 ^F
Cardiac morbidity					
Low cardiac output	54	2.0	15	1.6	.38
Cardiac arrest	112	4.2	56	5.9	.04
Atrial fibrillation	422	16	137	15	.29
Intra/postoperative IABP	167	6.3	49	5.2	.21
Myocardial infarction	264	10	115	12	.06
Antiarrhythmics	363	14	133	14	.79
Inotropic agents	859	33	339	36	.06
Vasopressors	4	0.15	3	0.32	.39 ^F
Multisystem organ failure	27	1.0	7	0.74	.45
Blood product usage					
Intraop/postoperative red blood cells	2066	78	655	69	<.01
Cryoprecipitate or platelets given	355	13	110	12	.16
Reoperation for bleeding/tamponade	78	3.0	18	1.9	.09

eration for bleeding, women were transfused with red blood cells at a higher rate compared with propensity-matched men. Women required longer postoperative ventilatory support, which, in part, may be related to the amount of intraoperative narcotics and benzodiazepines administered. There were also more cardiac arrests, postoperative myocardial infarctions, and intraoperative inotropic agents ad-

ministered in the propensity-matched women compared with the men. The increase in cardiac events in the propensity-matched women is similar to what has been shown from other investigations. Brandrup-Wogensen and colleagues,⁴ in a study of 2129 patients undergoing CABG in western Sweden, reported that women had more indirect signs of myocardial injury after coronary revascularization.

TABLE 7. Comparison of outcome variables matching: Total population

Continuous variables	Females (N = 3596)		Males (N = 12,001)		Wilcoxon rank
	Median (25th, 75th percentile)		Median (25th, 75th percentile)		P value
Total minutes myocardial ischemia	62 (43, 80)		70 (51, 88)		<.01
Total no. of units of RBC in OR and ICU	2.0 (1.0, 4.0)		0.0 (0.0, 2.0)		<.01
Minutes on ventilator in ICU	12 (7.8, 18)		10 (6.7, 16)		<.01
Hematocrit in ICU	31 (28, 33)		31 (28, 34)		<.01
Categoric variables	Females		Males		Chi-square test
	N	%	N	%	P value
Coronary endarterectomy	30	0.83	165	1.4	.01
Hospital death	87	2.4	170	1.4	<.01
Complications					
Neurologic morbidity					
Encephalopathy	42	1.2	115	0.96	.27
Focal deficit	54	1.5	114	0.95	<.01
Global deficit	21	0.58	27	0.22	<.01
Pulmonary morbidity					
ARDS	26	0.72	73	0.61	.45
Aspiration pneumonia	9	0.25	48	0.4	.19
Pneumonia	69	1.9	197	1.6	.26
Pulmonary edema	57	1.6	118	0.98	<.01
Tracheostomy	64	1.8	133	1.1	<.01
Pulmonary embolus	2	0.06	8	0.07	.99 ^F
Plural effusion	782	22	1810	15	<.01
Renal morbidity					
Renal failure	50	1.4	78	0.65	<.01
Anuria	40	1.1	54	0.45	<.01
Renal protective dopamine	614	17	2069	17	.82
Infection					
Sternal wound infection	13	0.36	32	0.27	.35
Mediastinitis	18	0.5	44	0.37	.26
Septicemia/sepsis	95	2.6	198	1.7	<.01
Endocarditis	2	0.06	2	0.02	.23 ^F
Cardiac morbidity					
Low cardiac output	69	1.9	105	0.87	<.01
Cardiac arrest	168	4.7	406	3.4	<.01
Atrial fibrillation	559	16	1537	13	<.01
Intra/postoperative IABP	381	11	1070	8.9	<.01
Myocardial infarction	216	6	576	4.8	<.01
Antiarrhythmics	497	14	1693	14	.66
Inotropic agents	1202	33	3138	26	<.01
Vasopressors	7	0.19	30	0.25	.55
Multisystem organ failure	34	0.95	54	0.45	<.01
Blood product usage					
Intra/postoperative red blood cells	2725	76	5425	45	<.01
Cryoprecipitate or platelets given	466	13	1367	11	.01
Reoperation for bleeding/tamponade	97	2.7	284	2.4	.26

Their female patients had more frequent use of circulatory support with an IABP and greater use of postcardiopulmonary bypass inotropics. Christakis and colleagues⁶ found that female gender was an independent predictor of postoperative mortality and low cardiac output syndrome in their investigation of 7025 patients undergoing isolated CABG from 1990 to 1994. Women had a higher occurrence of postoperative myocardial infarction and need for IABP assistance.⁶ Woods and

colleagues,³ in their prospective cohort study of 5324 patients who underwent CABG, reported that female gender was not an independent predictor of mortality; however, they did find that it was associated with an increase in low cardiac output conditions after revascularization. Finally, Abramov and colleagues¹¹ reported that female gender was a weak independent predictor of perioperative myocardial infarction and IABP usage, but not for mortality after CABG.

TABLE 8. Factors associated with hospital death (parsimonious model)

Probability of hospital death	Factor	Estimate $\pm$ SE	P	Bagging (%)*
	Intercept	-2.62 ± 0.61	<.001	—
Higher	Female†	0.30 ± 0.15	.042	6
Higher	Age ²	0.75 ± 0.14	<.001	100
Lower	Preoperative albumin	-0.94 ± 0.13	<.001	74
Higher	History of peripheral vascular disease	0.69 ± 0.15	<.001	66
Lower	Hyperlipidemia	-0.55 ± 0.16	<.001	66
Higher	History of heart failure	0.57 ± 0.15	<.001	59
Lower	Ramus stenosis	-0.011 ± 0.0037	.0033	82
Higher	Previous bypass graft disease	0.83 ± 0.15	<.001	74
Higher	Major blood transfusion	3.28 ± 0.18	<.001	100
Higher	Abnormal left ventricular function	0.40 ± 0.15	.0083	77

*Frequency of occurrence in bagging samples, indicating the reliability of obtaining $P < .05$.

†When propensity score was added to the covariates, gender was no longer significant with a P value of .17.

Outcomes in Unmatched Women

Recognizing that a majority of women were unable to be matched on propensity scores with men, we further examined this group of unmatched women and compared them with the propensity-matched women. The unmatched women had a distinctly different preoperative profile compared with the matched women. They had a large number of variables that typify the preoperative profile of the female patient undergoing CABG: lower hematocrits and red blood cell mass, shorter stature, lower bilirubin, increased triglycerides, higher high-density lipoprotein cholesterol, and less prevalence of smoking cigarettes and drinking alcohol.¹⁷ Despite these differences in profiles, the unadjusted postoperative mortality and morbidity outcomes were similar.

Outcomes in Propensity-Matched Coronary Reoperations

Patients undergoing coronary reoperations represent a subgroup of patients who are reported to be at increased risk of postoperative morbidity and mortality.²⁴⁻²⁶ The preoperative risk profile for patients undergoing coronary reoperations has been typified by patients who are more frequently male, with more left ventricular dysfunction, with a greater Canadian Cardiovascular Society symptom class, and who present more commonly for urgent surgery compared with patients undergoing primary CABG.²⁶ In particular, female gender has been reported to be an independent predictor of increased postoperative mortality after reoperative CABG. Aidala and colleagues,²⁴ in a small retrospective study, reported an 11.4% mortality for patients undergoing reoperative CABG versus a 3.2% mortality for patients undergoing primary operations. They reported that female gender was a risk factor for postoperative mortality. Weintraub and colleagues,²⁵ from their database of 2030 coronary reoperations, reported that female gender was correlated with in-hospital death both in the univariable and multivariable

analyses. Although Yau and colleagues²⁶ did not report female gender to be an independent predictor of postoperative mortality in 1230 patients undergoing reoperative CABG, they reported that it was an independent predictor of postoperative low cardiac output syndrome. We report that among the propensity-matched pairs undergoing coronary reoperations, women have a lower postoperative mortality compared with similarly matched men. Postoperative morbidity was similar among well-matched women and men undergoing coronary reoperations.

Limitations

One of the limitations of this observational investigation was that there may have been unmeasured confounding variables that impacted the propensity matching of women and men who underwent CABG. In addition, the amount of anesthetic medications administered intraoperatively was not a measured variable. The omission of this information may have impacted the findings of gender differences in the duration of postoperative ventilatory support observed in this investigation. Furthermore, we did not record data on all “processes of care” in the operating room. For example, complications from repeat sternotomy, such as graft excision or right ventricular damage, were not recorded variables. This lack of information may have influenced the observed gender differences in postoperative mortality for the propensity-matched patients who underwent reoperative CABG.

Conclusions

Dissimilarities in profiles may contribute to the debate about gender differences in outcome after coronary revascularization. In well-matched patients, female gender was not a risk factor for in-hospital mortality and had minimal impact on postoperative morbidity.

TABLE 9. Comparison of outcomes for matched patients with at least one coronary reoperation

Continuous variables	Matched females (N = 176)		Matched males (N = 149)		Wilcoxon rank <i>P</i> value
	Median (25th, 75th percentile)		Median (25th, 75th percentile)		
Total minutes myocardial ischemia	76 (52, 100)		80 (55, 103)		.24
Total no. of units of RBC in OR and ICU	2.0 (1.0, 4.5)		3.0 (1.0, 5.0)		.63
Minutes on ventilator in ICU	13 (8.7, 23)		13 (7.4, 21)		.27
Hematocrit in ICU	31 (28, 33)		30 (28, 33)		.07

Categoric variables	Matched females		Matched males		Chi-square test <i>P</i> value
	N	%	N	%	
Coronary endarterectomy	2	1.1	4	2.7	.42 ^F
Hospital death	4	2.3	10	6.7	.05
Complications					
Neurologic morbidity					
Encephalopathy	1	0.57	2	1.3	.60 ^F
Focal deficit	2	1.1	4	2.7	.42 ^F
Global deficit	2	1.1	0	0	.50 ^F
Pulmonary morbidity					
ARDS	2	1.1	3	2	.66 ^F
Aspiration pneumonia	0	0	2	1.3	.21 ^F
Pneumonia	5	2.8	8	5.4	.25
Pulmonary edema	2	1.1	4	2.7	.42 ^F
Tracheostomy	4	2.3	7	4.7	.23
Pulmonary embolus	1	0.57	0	0	.99 ^F
Plural effusion	43	24	38	26	.82
Renal morbidity					
Renal failure	3	1.7	2	1.3	.99 ^F
Anuria	3	1.7	1	0.67	.63 ^F
Renal protective dopamine	46	26	49	33	.18
Infection					
Sternal wound infection	0	0	1	0.67	.46 ^F
Mediastinitis	1	0.57	2	1.3	.60 ^F
Septicemia/sepsis	4	2.3	7	4.7	.23
Cardiac morbidity					
Low cardiac output	4	2.3	7	4.7	.23
Cardiac arrest	13	7.4	10	6.7	.81
Atrial fibrillation	27	15	32	22	.15
Intra/postoperative IABP	13	7.4	16	11	.29
Myocardial infarction	41	23	35	24	.97
Antiarrhythmics	20	11	34	23	.006
Inotropic agents	98	56	72	48	.19
Vasopressors	1	0.57	0	0	.99 ^F
Multisystem organ failure	3	1.7	3	2	.99 ^F
Blood product usage					
Intra/postoperative red blood cells	142	81	116	78	.53
Cryoprecipitate or platelets given	46	26	47	32	.28
Reoperation for bleeding/tamponade	4	2.3	5	3.4	.74 ^F

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