Cardiovascular Revascularization Medicine xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Cardiovascular Revascularization Medicine

Operative risk and preoperative hematocrit in bypass graft surgery: Role of gender and blood transfusion

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ARTICLE INFO

Article history:
Received 22 May 2015
Accepted 15 July 2015
Available online xxxx

Keywords:
Blood management
Outcomes
CABG
Gender

ABSTRACT

Background: The association between lower preoperative hematocrit (Hct) and risk for morbidity/mortality after cardiac surgery is well established. We examined whether the impact of low preoperative Hct on outcome is modified by blood transfusion and operative risk in women and men undergoing nonemergent CABG surgery.
Methods: Patients having nonemergent, first-time, isolated CABG were included ($N = 2757$). Logistic regressions assessed effect of hematocrit on major perioperative morbidity/mortality separately by males ($n = 2232$) and females ($n = 525$).
Results: Mean age was 63.2 ± 10.1 years, preoperative hematocrit was 38.9 ± 4.8%, and STS risk score was 1.3 ± 1.8%. Blood transfusion was more likely in female patients (26% vs. 12%, $P < 0.001$). Multivariate analyses revealed that lower body mass index and lower preoperative hematocrit predicted transfusion in males and females, whereas older age (OR = 1.03, $P = 0.017$) also predicted transfusion in females. Major morbidity was also more likely in female patients (12% vs. 7%, $P < 0.001$). In multivariate analyses, blood transfusion was the only predictive factor for major morbidity in females (OR = 4.56, $P < 0.001$). In males, higher body mass index (OR = 1.07, $P < 0.001$), lower hematocrit (OR = 0.94, $P = 0.017$), interaction of STS score with hematocrit (OR = 1.02, $P = 0.045$), and blood transfusion (OR = 9.22, $P < 0.001$) were significant predictors for major morbidity.
Conclusions: This study showed females were more likely to have blood transfusion and major morbidities after nonemergent CABG. Traditional factors that have been found to predict outcomes, such as hematocrit and STS risk, were related only to major morbidity in male patients. However, blood transfusion negatively impacted major outcome after nonemergent CABG surgery across all STS risk levels in both genders.

1. Introduction

Cardiac surgery accounts for the majority of blood transfusions in the United States each year [1,2]. Nearly 50,000 coronary artery bypass graft (CABG) procedures were performed in the United States in 2008 [3], about half of which involved transfusion of blood products [4]. Despite the overall decline in CABG morbidity and mortality since the procedure was first performed [5], a disproportionate number of operative deaths and major adverse outcomes still occur in women who undergo this surgery [6–8]. Women make up less than one-third of all patients undergoing CABG but account for nearly twice as many operative deaths than men [5,6,9]. In light of these statistics, it is not surprising that female gender has been shown to be an independent risk factor for perioperative mortality in isolated CABG [9–12].

Particularly in patients undergoing CABG surgery, the association between preoperative low hematocrit (Hct) and the risk of transfusion and adverse surgical outcomes is well established [13–20]. Low preoperative Hct is one of the most frequent indications for intraoperative transfusion in CABG patients [21], and transfusion is itself a well-known risk factor for adverse outcomes in CABG [22–25]. In this study, we examined whether the impact of low preoperative Hct on outcomes was gender specific for patients undergoing nonemergent isolated CABG, taking blood transfusion and operative risk into account. We hypothesized that the factors that are important in the relationship of Hct and outcomes would differ for male and female patients.

2. Materials and methods

2.1. Study sample

The sample for this observational study consisted of all consecutive patients who underwent nonemergent, first-time, isolated CABG between January 2007 and October 2014 ($N = 2757$). CABG surgery was performed with cardiopulmonary bypass by standard surgical procedure, using a midsternotomy approach. Data were collected prospectively as part of our local Society of Thoracic Surgeons (STS) Adult Cardiac Surgery database, and all patients included in analyses had complete data on the variables of interest. An additional 388 patients met inclusion criteria during this time frame but were missing Hct or STS risk

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http://dx.doi.org/10.1016/j.carrev.2015.07.007
1553-8389/

score values and were excluded from analyses. STS-predicted risk of mortality was calculated for all patients, using the model that was prospectively available at the time of surgery for each patient [26]. This study was approved by our institutional review board, and a waiver of consent was granted (IRB no. 06.022 and 12.055).

The primary outcome was a composite variable that included any major morbidity and was defined as one or more of the following STS-defined events: perioperative myocardial infarction, deep sternal wound infection, permanent stroke, prolonged ventilation (>24 hours), pneumonia, reoperation for bleeding, perioperative renal failure, reoperation for cardiac reasons, and operative mortality (<30 days) [26]. Blood product transfusion was defined as the receipt of any blood product during the intraoperative and postoperative period prior to discharge. Our institutional protocol for blood product transfusion has been described previously [27].

2.2. Statistical analyses

All analyses were conducted using SPSS 17.0 software (SPSS Inc., Chicago, IL), and a two-sided P of <0.05 was considered statistically significant. Continuous data are presented as mean ± standard deviation, and categorical data are presented as frequency (percent), unless otherwise noted. Comparisons of male and female patients on preoperative characteristics and perioperative outcomes were evaluated using chi-square test or Fisher's exact test for categorical variables and Student's t test or Mann–Whitney U test for continuous variables, as appropriate given the assumptions of each test.

Univariate logistic regressions were conducted to examine the unadjusted impact of preoperative Hct on major morbidity. Spline curve graphs were constructed by plotting the predicted probabilities calculated from these analyses against the preoperative Hct level using spline interpolation to illustrate the effects in graphical form separately by gender.

Multivariate logistic regressions examining predictors for blood product transfusion selected a priori were conducted separately by gender and included the predictor variables of age, body mass index (BMI), STS risk score, preoperative Hct, and the interaction of STS risk score with preoperative Hct. Similarly, multivariate logistic regressions that examined the predictors for major morbidity selected a priori were conducted separately by gender and included the predictor variables of age, BMI, STS risk score, preoperative Hct, and the interaction of STS risk score with preoperative Hct. In a second step of the multivariate analyses examining predictors for major morbidity, blood product transfusion was added to these gender-specific models as a predictor for major morbidity. All regression equations were conducted using the "Enter" method.

3. Results

The mean age of the patients in this sample was 63.2 ± 10.1 years, the mean STS risk score was 1.3 ± 1.8%, and 19% of patients were female. The female patients were older (65 vs. 63 years, $P < 0.001$) and had greater STS operative risk (2.3% vs. 1.1%, $P < 0.001$) and lower preoperative Hct (35.4% vs. 39.7%, $P < 0.001$) than male patients (Table 1). Female patients also had a higher prevalence of preoperative comorbid conditions such as diabetes, hypertension, and previous cerebrovascular accident ($P < 0.001$).

3.1. Blood transfusion

Blood transfusion at any point during hospital stay was more likely in female patients than in male patients (26% vs. 12%, $P < 0.001$), and this relationship remained when patients were divided into those receiving intraoperative (15% vs. 6%, $P < 0.001$) and postoperative (18% vs. 9%, $P < 0.001$) blood products. Red blood cells (RBC) were more likely to be transfused in female patients than in male patients (26% vs. 10%, $P < 0.001$), but females and males were similar on non-RBC blood product transfusion (9% vs. 8%, $P = 0.362$). Multivariate regression analyses by gender revealed that lower BMI (odds ratio [OR] = 0.94, 95% confidence interval [CI] = 0.91–0.96, $P < 0.001$) and lower preoperative Hct (OR = 0.87, 95% CI = 0.84–0.91, $P < 0.001$) were predictive of blood transfusion in male patients, whereas older age (OR = 1.03, 95% CI = 1.01–1.05, $P = 0.017$), lower BMI (OR = 0.95, 95% CI = 0.91–0.98, $P = 0.003$), and lower Hct (OR = 0.86, 95% CI = 0.80–0.92, $P < 0.001$) were predictive of blood transfusion in female patients.

3.2. Major morbidity

Incidence of major morbidity was greater in female patients than in male patients (12% vs. 7%, $P < 0.001$). Among patients who experienced an event classified as a major morbidity ($n = 212$), 70% had a single event, whereas the other 30% had more than one event. No differences were seen in the percentages of females and males who experienced multiple major events (33% vs. 29%, $P = 0.600$). When the incidences of individual outcomes included in the composite of major morbidity were compared, operative mortality was found to be similar for female and male patients (1.1% vs. 0.7%, $P = 0.266$), but females had a greater incidence of permanent stroke (2.3% vs. 0.7%, $P = 0.001$) and prolonged ventilation (>24 hours; 7% vs. 4%, $P < 0.001$) than male patients (Table 2). The observed-to-expected (O/E) ratio for operative mortality for the total sample was 0.57; the O/E ratio was 0.49 for females and 0.60 for males.

Table 1
Patient characteristics by gender.

Characteristic	All Patients ($N = 2757$)	Male ($n = 2232$)	Female ($n = 525$)	P
Age (years)	63.2 ± 10.1	62.7 ± 9.9	65.1 ± 10.4	<0.001
STS-predicted mortality risk (%)	1.3 ± 1.8	1.1 ± 1.4	2.3 ± 2.9	<0.001
Preoperative Hct (%)	38.9 ± 4.8	39.7 ± 4.5	35.4 ± 4.5	<0.001
BMI (kg/m^2)	29.3 ± 5.6	29.2 ± 5.3	29.7 ± 6.8	0.077
Ejection fraction (%)	53.6 ± 11.6	53.4 ± 11.5	54.4 ± 11.9	0.077
Ejection fraction <30%	111 (4)	94 (4)	17 (3)	0.307
Congestive heart failure	310 (11)	219 (10)	91 (17)	<0.001
Hypertension	2259 (82)	1801 (81)	458 (87)	<0.001
Dyslipidemia	2364 (86)	1906 (85)	458 (87)	0.277
Diabetes mellitus	1132 (41)	861 (39)	271 (52)	<0.001
Chronic pulmonary disease	555 (20)	435 (20)	120 (23)	0.083
Peripheral vascular disease	282 (10)	219 (10)	63 (12)	0.137
Previous cerebrovascular accident	151 (5)	105 (5)	46 (9)	<0.001
Preoperative creatinine >2 mg/dL	126 (5)	91 (4)	35 (7)	0.011
Dialysis	79 (3)	53 (2)	26 (5)	0.001
Cardiopulmonary bypass time (min)	90.1 ± 26.6	91.0 ± 26.8	85.8 ± 25.2	<0.001
Urgent status	1491 (54)	1186 (53)	305 (58)	0.040

Please cite this article as: Ad N, et al, Operative risk and preoperative hematocrit in bypass graft surgery: Role of gender and blood transfusion, Cardiovasc Revasc Med (2015), http://dx.doi.org/10.1016/j.carrev.2015.07.007