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Original Research

Incidence, risk factors, and prognostic impact of re-exploration for bleeding after cardiac surgery: A retrospective cohort study

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ABSTRACT

Background: Postoperative re-exploration for bleeding (RB) is a frequent complication following cardiac surgery. We aim to assess incidence, risk factors, and prognostic significance of RB in a large cohort of cardiac patients.
Materials and methods: We reviewed prospectively collected data for all patients who underwent cardiac surgery at our institution from 2007 to 2015. Logistic regression analysis was used to identify independent predictors of RB and specific outcomes. Propensity matching using a 1:1-ratio compared outcomes of patients who had RB with patients who did not.
Results: During the study period, 7381 patients underwent cardiac operations. Of them, 189 (2.6%) underwent RB. RB was an independent predictor of in-hospital mortality (Odds Ratio (OR):2.62 Confidence Interval (CI):1.38–4.96; $p = 0.003$), major adverse events (OR:3.94, CI:2.79–5.62; $p < 0.001$), gastrointestinal events (OR:3.54 CI:1.73–7.24), renal failure (OR:2.44, CI:1.23–4.82), prolonged ventilation (OR:3.83, CI:2.60–5.62, $p < 0.001$), and sepsis (OR:2.50, CI:1.03–6.04, $p = 0.043$). Preoperative shock (OR:3.68, CI:1.66–8.13; $p = 0.001$), congestive heart failure (OR:1.70 CI:1.24–2.32; $p = 0.001$), and urgent and emergent status (OR:2.27, CI:1.65–3.12 and OR:3.57, CI:1.89–6.75; $p < 0.001$ for both) were predictors of RB operative mortality. Operative mortality, incidence of major adverse events, gastrointestinal events, and respiratory failure were all significantly higher in the propensity matched RB group ($p = 0.050$, $p < 0.001$, $p = 0.046$, and $p < 0.001$ respectively).
Conclusions: RB significantly increases in-hospital mortality and morbidity after cardiac surgery.

1. Introduction

Post operative bleeding requiring surgical re-exploration [Re-exploration for bleeding (RB)] is a frequent complication following cardiac surgery with reported incidence between 2% and 6% [1,2]. Higher mortality and increased morbidity from adverse events such as renal failure, increased length of stay, sepsis, and mortality have all been related to postoperative bleeding [3–7]. Time to intervention, volume bled, and patient factors all play a role in determining patient outcomes [8]. The severity of complications associated with post-operative bleeding underlies the need for better understanding of and identification of risk factors for postoperative RB. We aim to assess incidence, risk factors, and prognostic significance of RB in a large contemporary cohort of cardiac surgery patients at our institution.

2. Materials and methods

Our institutional New York State cardiac surgery database was examined for all patients undergoing cardiac surgery from 2007 to 2015. Individual need for consent was waved. Definitions for variables and outcomes are according to the 2015 New York State guidelines [9]. Two independent reviewers examined, organized, and extracted data according to variables of interest. The work has been reported in line with the STROCSS criteria [8].

The primary outcome was in-hospital mortality. Secondary outcomes were: stroke (neurological deficit of abrupt onset caused by disturbance in blood supply to the brain without resolution within 24-h), myocardial infarct (new Q-wave occurring within 48-h), deep sternal wound infection (infection within 30-days involving deep soft tissue and one of: i: purulent drainage, ii: spontaneous dehisces, iii: abscess or evidence of infection, iv: diagnosis by a surgeon or attending

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Table 1
Preoperative characteristics in overall population.

	Overall (n = 7381)	No Bleeding requiring reoperation (n = 7192)	Bleeding requiring reoperation (n = 189)	p value
Age, mean ± SD	67.2 ± 14.5	67.3 ± 14.5	65.3 ± 15.3	0.072
Female sex	2627 (35.6)	2572 (35.8)	55 (29.1)	0.059
Ethnicity				
White	490 (6.6)	476 (6.6)	14 (7.4)	0.900
Black, African American, Hispanic	6890 (93.3)	6715 (93.4)	175 (92.6)	
Medicaid	930 (12.6)	898 (12.5)	32 (16.9)	0.069
Previous cardiac surgery	1123 (15.2)	1085 (15.1)	38 (20.1)	0.058
Previous myocardial infarct				
within 24-h	44 (0.6)	42 (0.6)	2 (1.1)	0.403
over 24-h	1281 (17.4)	1242 (17.3)	39 (20.6)	0.228
History of any cerebrovascular event	843 (11.4)	830 (11.5)	13 (6.9)	0.046
Shock	75 (1.0)	67 (0.9)	8 (4.2)	< 0.001
Peripheral vascular disease	1941 (26.3)	1892 (26.3)	49 (25.9)	0.906
Congestive heart failure, current	2373 (32.2)	2285 (31.8)	88 (46.6)	< 0.001
BNP, three times normal	684 (9.3)	655 (9.1)	29 (15.3)	0.004
Chronic lung disease	608 (8.2)	590 (8.2)	18 (9.5)	0.515
Diabetes	1587 (21.5)	1548 (21.5)	39 (20.6)	0.769
Hepatic failure	20 (0.3)	18 (0.3)	2 (1.1)	0.035
Renal failure, dialysis	198 (2.7)	187 (2.6)	11 (5.8)	0.007
Surgery priority level				
Elective	4585 (62.1)	4512 (62.7)	73 (38.6)	< 0.001
Urgent	2330 (31.6)	2434 (33.8)	96 (50.8)	
Emergent	249 (3.4)	229 (3.2)	20 (10.6)	
CCA angina class within one week				
Symptomatic	1449 (19.6)	1391 (19.3)	58 (30.7)	< 0.001
No symptoms	5805 (78.6)	5674 (78.9)	131 (69.3)	
Stent thrombosis	44 (0.6)	41 (0.6)	3 (1.6)	0.073
Active endocarditis	139 (1.9)	132 (1.8)	7 (3.7)	0.062
Aortic stenosis, severe	2196 (29.8)	2154 (29.9)	42 (22.2)	0.022
Mitral stenosis, severe	140 (1.9)	134 (1.9)	6 (3.2)	0.192
Tricuspid stenosis, severe	11 (0.1)	11 (0.2)	0 (0)	0.591
Aortic incompetence, severe	861 (11.7)	830 (11.5)	31 (16.4)	0.040
Mitral incompetence, severe	1254 (17.0)	1219 (16.9)	35 (18.5)	0.571
Tricuspid incompetence, severe	293 (4.0)	285 (4.0)	8 (4.2)	0.851
Left main trunk				
≤50% stenosis	6825 (92.5)	6652 (92.5)	173 (91.5)	0.623
> 50% stenosis	556 (7.5)	540 (7.5)	16 (8.5)	
Emergency transfer to OR after diagnostic catheterization	81 (1.1)	71 (1.0)	10 (5.3)	< 0.001
Previous PCI	1079 (14.6)	1050 (14.6)	29 (15.3)	0.775
Ejection Fraction	50.3 ± 12.5	50.4 ± 12.4	47.0 ± 15.6	< 0.001
Creatinine	50.3 ± 12.5	1.2 ± 1.5	1.4 ± 1.0	0.118

Data presented as n (%), unless otherwise noted. CCA: Canadian Cardiovascular Angina, BNP: B-type natriuretic peptide, OR: operating room.

physician), sepsis (within the first 48-h presence of the systemic inflammatory response syndrome resulting from proven infection), gastrointestinal (GI) event (bleeding, pancreatitis requiring nasogastric tube suctioning, cholecystitis requiring removal or drainage, mesenteric ischemia requiring exploration, hepatic failure, prolonged ileus, clostridium difficile infection), renal failure (new need for dialysis), prolonged ventilation (ventilator dependence ≥72-h), unplanned cardiac re-intervention (any unplanned cardiac reoperation or PCI that was required as a result of surgery), and a composite outcome for any major post-operative adverse event (MAE), (MAE: operative death and any previously listed postoperative complication).

Departmental criteria for re-operation for bleeding are chest tube output greater than 1-L within 12-h of surgery or objective signs of cardiac tamponade or surgical bleeding.

2.1. Statistical analysis

Data were stored using Microsoft Excel software [Microsoft, Redmond, Wash] and analyzed using IBM SPSS Statistics version 22 [IBM, Armonk, NY], R version 2.15.2 [R Foundation for Statistical Computing and twang package Ridgeway, McCaffrey, Morral 2006].

For baseline characteristics, variables are summarized as mean for continuous and percentage for categorical. Data from the study population were compared using $\mathbf{X}^2$ for categorical variables and Student t-test for continuous.

Univariate and multivariate analysis for RB, in-hospital death, MAE, stroke, myocardial infarct, deep sternal wound infection, sepsis, GI-events, renal failure, prolonged ventilator dependence, sepsis, and unplanned cardiac re-intervention were computed to determine significant pre- and peri-operative predictors of such events. The resulting regression models included the following variables: RB (for all outcomes except RB), age, sex, previous cardiac surgery, shock, congestive heart failure (CHF), surgical priority, angina class, emergent transfer to the operating room after diagnostic catheterization, history of cerebrovascular event (CVA), total operative time, intra-operative blood transfusion, ejection fraction, aortic stenosis, aortic insufficiency, chronic lung disease, hepatic failure, renal failure, entire procedure off-pump, Medicaid, previous myocardial infarct, and active endocarditis.

Thoracoabdominal aortic (TAAA) and descending aortic aneurysms (DTA) and ventricular assist device (VAD) surgeries are known for having increased risk of RB, therefore separate models examining the above mentioned outcomes were run excluding these patients.

Propensity score matching (PSM) was used to minimize cofounders [10]. PSM was performed according to a prescribed method [11], and matching was conducted using a logistic regression estimation algorithm and nearest neighbor matching without replacement and a caliper of 0.05. Evaluation of balance before and after matching was done by the assessment of standardized differences. Standardized differences