

How detrimental is reexploration for bleeding after cardiac surgery?



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ABSTRACT

Objective: To establish the risk factors and impact of reexploration for bleeding in a large modern cardiac surgical cohort.

Methods: At a tertiary referral center, baseline, index procedural, reexploration, outcome, and readmission characteristics of 16,793 consecutive adult cardiac surgery patients were prospectively entered into dedicated clinical databases. Correlates of reexploration for bleeding, as well as its association with outcomes and readmission, were examined with multivariable regression models.

Results: The mean patient age was 65.9 ± 12.1 years, and 11,991 patients (71.4%) patients were male. Perioperative mortality was 2.8% (458 of 16,132) in those who did not undergo reexploration for bleeding and 12.0% (81 of 661) in those who underwent reexploration for bleeding, corresponding to an odds ratio of 3.4 ± 0.5 ($P < .001$) over other predictors of mortality, including Euroscore II. Mortality was highest in patients who underwent reexploration after the day of index surgery (odds ratio, 6.4 ± 1.1). Hospital stay was longer in patients who underwent reexploration for bleeding (median, 12 days, vs 7 days in patients who did not undergo reexploration; $P < .001$), to an extent beyond any other correlate. Reexploration for bleeding also was independently associated with new-onset postoperative atrial fibrillation, renal insufficiency, intensive care unit readmission, and wound infection. Risk factors for reexploration for bleeding were tricuspid valve repair, on-pump versus off-pump coronary artery bypass grafting, emergency status, cardiopulmonary bypass (CPB) duration, low body surface area, and lowest CPB hematocrit of $<24\%$.

Conclusions: Reexploration for bleeding is a lethal and morbid complication of cardiac surgery, with a detrimental effect that surpasses that of any other known potentially modifiable risk factor. All efforts should be made to minimize the incidence and burden of reexploration for bleeding, including further research on transfusion management during CPB. (*J Thorac Cardiovasc Surg* 2017;154:927-35)

Heart operations often result in severe bleeding, and reexploration for bleeding remains a well-recognized complication of cardiac surgery, with a reported incidence ranging

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	Observed Mortality (O)	Expected Mortality (E)	O/E Ratio
Not Re-Explored for Bleeding	2.8%	4.1%	0.7
Re-Explored for Bleeding	12%	6.7%	1.8

Reexploration for bleeding and perioperative mortality.

Central Message

Reexploration for bleeding, the correlates of which were examined here, brings an unfavorable reversal of the observed/expected ratio for a given patient. Continued efforts should be made to avoid its occurrence.

Perspective

In this study, reexploration for bleeding was associated with a 3.5-fold increase in hospital mortality. Reexploration for bleeding performed after the day of operation had an even worse prognosis. These detrimental effects were additive to that of blood product transfusions. Reexploration for bleeding was associated with an unfavorable reversal of the observed/expected ratio for a given patient.

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from 2% to 6%.¹⁻⁵ As such, previous studies have examined the relationship between transfusion and mortality after cardiac surgery,⁶ as well as the impact of the timing of reexploration,^{2,4} with several groups promoting earlier reintervention. In this study, we examined the risk factors and impact of reexploration for bleeding in a modern, consecutive cohort of patients that

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Abbreviations and Acronyms

- BSA = body surface area
- CABG = coronary artery bypass grafting
- CI = confidence interval
- CPB = cardiopulmonary bypass
- ICU = intensive care unit
- IQR = interquartile range
- LV = left ventricular
- O/E = observed-to-expected
- OR = odds ratio
- ROC = receiver operating characteristic

encompassed all cardiac surgical procedures, while providing adjustments for baseline characteristics and risk.

We examined the correlates of reexploration for bleeding, and characterized its independent association with hospital outcomes and readmission, in a large consecutive cohort of patients who underwent cardiac surgery at a tertiary center. Our aim was to improve the understanding of reexploration for bleeding after cardiac surgery and to help surgeons, anesthesiologists, and intensive care specialists identify patients at risk for this complication, as well as possibly curtail some of its modifiable risk factors.

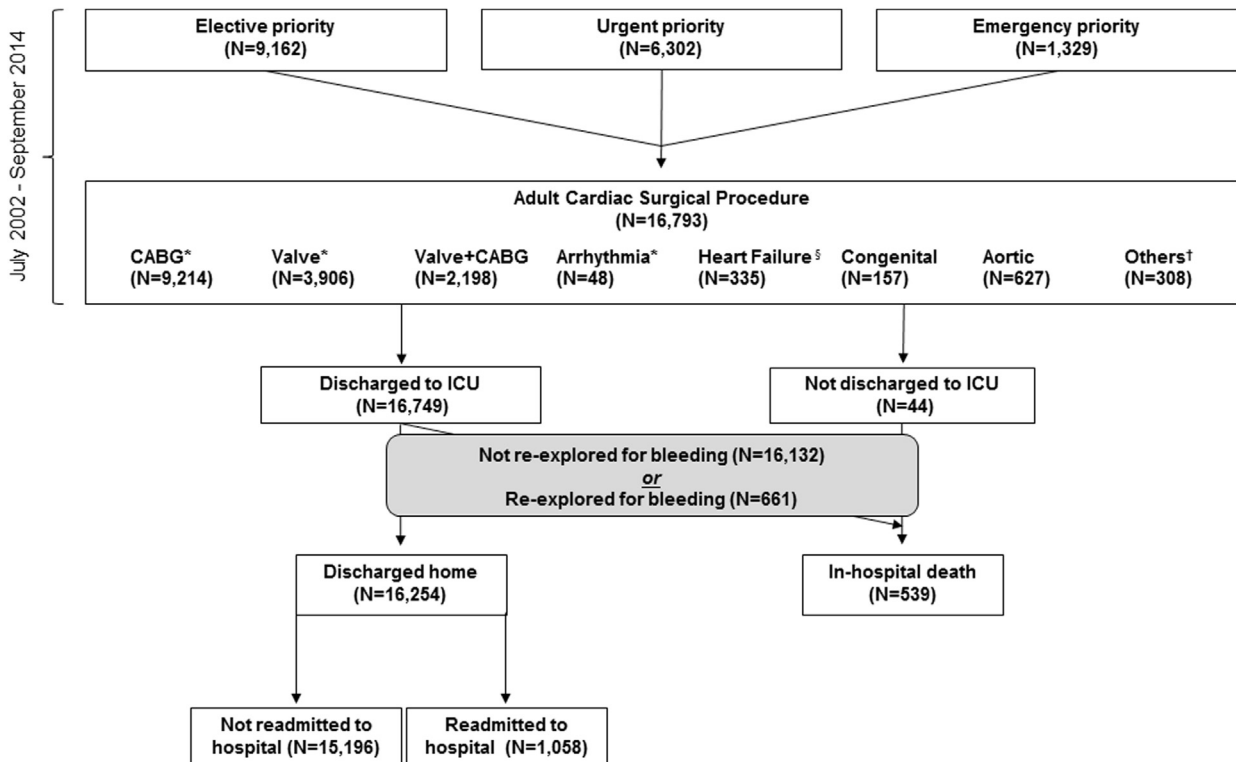
METHODS

Patients and Definitions

Figure 1 depicts the study flow chart. A total of 16,793 consecutive patients underwent an index adult cardiac surgical procedure performed by 1 of 11 surgeons at the University of Ottawa Heart Institute, between July 2, 2002, and September 23, 2014. Postoperatively, patients were cared for in a closed dedicated cardiac surgical intensive care unit (ICU) staffed by intensive care-trained cardiac anesthesiologists, and when stable were transferred to a cardiac surgery ward, where they recovered until discharge.

Data were prospectively entered into 4 dedicated databases, which were cross-referenced and complemented with one another with regard to accurate classification of the index operation, the occurrence of reexploration for bleeding, and the patients' baseline characteristics, including risk score. Operative priority was determined prospectively; urgent priority was an index cardiac operation deemed necessary during the same hospital admission that led to diagnosis or the latest reevaluation. Emergency priority indicated an operation performed either immediately or within 24 hours of diagnosis or a change in the patient's condition. In Figure 1, "heart failure" surgeries comprise heart transplantation, mechanical heart assistance/ventricular assist device, or other operations for cardiomyopathy, and "others" includes pericardiectomy, cardiac tumor resection, pulmonary thromboendarterectomy or embolectomy, and other noncategorized operations.

Surgery was performed with cardiopulmonary bypass (CPB) unless indicated otherwise; when applicable, the allocation of off-pump bypass surgery corresponded to the "as-treated" approach. For cardioplegia, crystalloid was used until June 2005, with blood cardioplegia used thereafter. An intraoperative intravenous tranexamic acid infusion protocol was used routinely unless contraindications, unusual circumstances, or personal



* Denotes isolated CABG, isolated valve replacement/repair, or isolated arrhythmia surgery
 § Denotes heart transplantation, mechanical heart assistance, or other operations for cardiomyopathy
 † Denotes pericardiectomy, cardiac tumor resection, pulmonary thromboendarterectomy or embolectomy, or other non-categorized operations

FIGURE 1. Study flow chart. CABG, Cardiopulmonary bypass; ICU, intensive care unit.

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