

## Incidence and Outcomes of Re-Exploration in Adult Cardiac Surgery at A Tertiary Care Hospital

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### ABSTRACT

#### Introduction

Postoperative bleeding is a significant complication following cardiac surgery, with a global re-exploration incidence of 2-5%. This study aims to investigate re-exploration rates, risk factors, and outcomes within the unique context of a tertiary care center in Nepal.

#### Methods

In this retrospective, single-center study, we analyzed all consecutive adult patients ( $\geq 18$  years) who underwent cardiac surgery with cardiopulmonary bypass (CPB) at the Manmohan Cardiothoracic Vascular and Transplant Centre (Nepal) between 2018-2021. Data on demographics, clinical characteristics, operative details, re-exploration, and outcomes were extracted from medical records. Statistical analysis included descriptive statistics, chi-square tests, independent samples t-tests, and logistic regression.

#### Results

Of 720 patients, 56 (7.8%) required re-exploration for bleeding. Emergency procedures were strongly associated with higher re-exploration ( $p < 0.05$ ). Non-surgical bleeding was the primary cause in 42.9% of cases. Independent risk factors included preoperative deranged LFTs (OR=2.1, 95% CI: 1.2-3.7), elevated creatinine ( $> 1.5$  mg/dL, OR= 3.2, 95% CI: 1.8-5.6), prolonged CPB time ( $> 120$  min), and substantial transfusion requirements. Modified Bentall's procedures had the highest re-exploration rate (21.4%). Re-explored patients experienced higher AKI rates (87.5%), longer hospitalizations (13.6 vs. 7.2 days,  $p < 0.001$ ), and increased in-hospital mortality confined to emergency cases (1.94%).

#### Conclusion

Emergency procedures had higher rate of re-exploration. Preoperative deranged LFTs, elevated creatinine, prolonged CPB time, and substantial transfusion requirements were independent risk factors for re-exploration. Re-explored cases experienced higher complication. In-hospital mortality were confined to emergency cases only.

#### Keywords

*Bleeding; cardiac surgery; emergency surgery; modified Bentall's procedure; re-exploration*

## INTRODUCTION

Cardiac surgery, despite its lifesaving potential, carries a risk of postoperative bleeding necessitating re-exploration in 2-5% of cases globally.<sup>1</sup> This complication arises from diverse causes, including cardiopulmonary bypass (CPB)-related bleeding, surgical site leakage, and coagulopathies exacerbated by the procedure itself.<sup>2</sup> Excessive bleeding, exceeding 2 liters within 24 hours, affects 5-7% of patients and warrants re-exploration in up to 4.2%.<sup>3</sup> Coagulopathy, driven by blood loss, factor depletion, and hemodilution, is a significant risk factor for severe hemorrhage.<sup>4,5</sup> Established criteria, such as those by Kirklin and Barratt-Boyes, inform re-exploration decisions, while viscoelastic hemostatic assays (VHA) and routine coagulation tests (RCoT) aid in detecting nonsurgical bleeding sources.<sup>6,7,8</sup>

Re-exploration carries substantial risks, including infections, transfusion reactions, respiratory complications, increased costs, and renal dysfunction. Patient-related risk factors include advanced age, pre-existing renal insufficiency, reduced ejection fraction, preoperative anticoagulant and antiplatelet therapy use, and peripheral vascular disease. Prolonged bypass time and urgent surgical status also contribute to higher re-exploration risk and subsequent intensive care stays, increasing morbidity and mortality.<sup>9</sup>

A paucity of data exists regarding re-exploration within the Nepalese context. This study addresses this knowledge gap by investigating the incidence, risk factors, and outcomes of re-exploration in adult cardiac surgery patients at a tertiary care center in Nepal. Understanding these factors within the Nepali healthcare system is crucial for developing targeted interventions and improving patient outcomes.

## METHODS

This study employed a retrospective, single-center cohort design to investigate the incidence, risk factors, and outcomes of re-exploration in adult cardiac surgery patients at the Manmohan Cardiothoracic Vascular and Transplant Centre (MCVTC), Institute of Medicine (IOM), Kathmandu, Nepal. We included all consecutive adult patients ( $\geq 18$  years) who underwent cardiac surgery requiring cardiopulmonary bypass (CPB) at MCVTC between Jan 1, 2018, and Dec 31, 2021. Patients were excluded if they underwent cardiac surgery without CPB or surgery for congenital heart defects.

Data were retrospectively extracted from standardized hospital medical records. We collected the following variables: age, sex, cardiac diagnosis, left ventricular ejection fraction (LVEF), preoperative serum creatinine, use of antiplatelet

or anticoagulant medications, peripheral vascular disease, prior cardiac surgery, type of surgery, CPB time, cross-clamp time, indication for re-exploration, chest tube drainage volume (within 24 hours), blood product transfusions, acute kidney injury (AKI, defined by KDIGO criteria), need for continuous renal replacement therapy (CRRT), hospital length of stay, and in-hospital mortality.

Descriptive statistics (means, medians, standard deviations, and percentages) summarized patient characteristics. Categorical variables were compared using the chi-square test or Fisher's exact test, while continuous variables were compared using the independent samples t-test or Mann-Whitney U test. Potential risk factors for re-exploration were assessed using logistic regression analysis. A p-value  $< 0.05$  was considered statistically significant. Data were analysed using SPSS software (version 25, IBM Corp).

The Institutional Review Board of the Institute of Medicine approved the study. The need for informed consent was waived due to the retrospective nature of the study. All patient data were de-identified to ensure confidentiality.

## RESULTS

Out of 720 patients undergoing cardiac surgery, 56 (7.8%) required re-exploration for bleeding. The re-explored group had a mean age of  $58.4 \pm 11.2$  years (range 21-76 years) and a male predominance (63.2%,  $n=35$ ). Emergency procedures were associated with a significantly higher re-exploration rate (8.9%,  $n=32$ ) compared to elective surgeries ( $p < 0.05$ , chi-square test).

The most frequent cause of re-exploration was non-surgical bleeding (42.9%,  $n=24$ ), followed by cannulation site bleeding (38.9%,  $n=22$ ), graft oozing (14.3%,  $n=8$ ), sternal bleeding (11.1%,  $n=6$ ), and anastomotic sources (5.4%,  $n=3$ ) [Figure 1]. Intriguingly, 41.1% ( $n=23$ ) of re-explorations failed

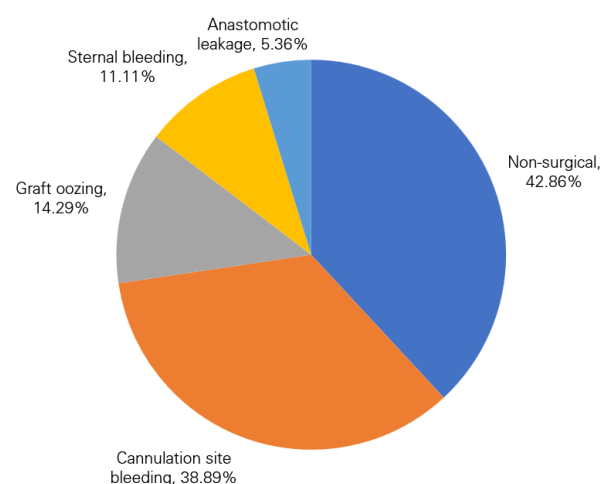


Figure 1. Causes of re-exploration

**Table 1.** Procedure-specific re-exploration rates following cardiac surgery

Procedure	Number	Rate (%)
Modified Bentall's	6	21.4
Ascending aorta replacement	3	12.5
Valve replacement(s)	30	9.5
Coronary artery bypass grafting	17	4.8

to identify a discrete surgical source, emphasizing the multifactorial nature of postoperative bleeding and potential coagulopathies.

Preoperative deranged liver function tests (OR=2.1, 95% CI: 1.2-3.7,  $p=0.01$ ) and elevated creatinine (>1.5 mg/dL, OR=3.2, 95% CI: 1.8-5.6,  $p < 0.001$ ) were independently associated with increased re-exploration risk. Intraoperatively, prolonged cardiopulmonary bypass (CPB) time exceeding 120 minutes and significant blood transfusion requirements (>5 units) were also strong predictors. Mean CPB time was significantly longer in the re-explored group (155.6  $\pm$  45.2 minutes vs. 112.3  $\pm$  38.9 minutes,  $p < 0.001$ , independent t-test).

Among re-explored patients, 87.5% (n=49) developed postoperative acute kidney injury, of which 7.14% (n=4) required dialysis. Risk factors for acute kidney injury included age over 70 years (50%, n=28), prolonged cardiopulmonary bypass duration (30.36%, n=17), significant ICU transfusion (8.93%, n=5), and baseline creatinine over 1.5mg/dL (8.93%, n=5).

The overall in-hospital mortality rate was 1.94% (n=14), confined to emergency cases. Re-explored patients experienced notably longer hospitalizations (mean 13.6  $\pm$  8.7 days vs. 7.2  $\pm$  3.1 days,  $p < 0.001$ ).

Table 1 demonstrates the frequency and percentage of re-explorations within a cohort of patients who underwent various cardiac procedures. Modified Bentall's procedures exhibited the highest re-exploration rate at 21.4%. This was followed by ascending aorta replacement (12.5%), valve replacement(s) (9.5%), and coronary artery bypass grafting (CABG, 4.8%).

As illustrated in Figure 1, the distribution of etiologies for re-exploration due to postoperative bleeding revealed a predominance of non-surgical sources not amenable to surgical control (42.86%, n=24). Cannulation site bleeding followed closely as the second most frequent cause (38.89%, n=22), with graft oozing (14.29%, n=8), sternal bleeding (11.11%, n=6), and anastomotic bleeding (5.36%, n=3) representing the remaining etiologies. These findings highlight the importance of maintaining a high index of suspicion for postoperative bleeding, even in the absence of a readily identifiable surgical

source, to facilitate timely intervention. Further investigation into preventive strategies is warranted to minimize hemorrhagic complications and subsequent blood transfusion requirements in the post-operative cardiac surgery setting.

## DISCUSSION

Our retrospective analysis revealed an 8% re-exploration incidence following open heart surgery, with re-exploration decisions guided by the Kirklin/Barratt-Boyes criteria.<sup>5</sup> Emergency surgery was strongly associated with a higher re-exploration rate, particularly in modified Bentall procedures and ascending aortic replacements. Key predisposing factors included late presentation of aortic dissection, coagulopathy (PT-INR >1.5) in elderly patients<sup>10</sup> with deranged liver function tests (LFT), and pre-existing hemodynamic instability.<sup>11</sup> The urgency of these procedures often precluded optimal preoperative management, contributing to postoperative bleeding complications requiring massive transfusions and the development of acute kidney injury (AKI).<sup>11</sup>

The intricate nature of cardiac surgery, particularly those involving cardiopulmonary bypass (CPB), disrupts normal hemostatic mechanisms. Resulting thrombocytopenia, anticoagulation requirements, platelet dysfunction, fibrinolytic pathways, and interactions with antithrombotic agents predispose patients to microvascular bleeding.<sup>8</sup> Traditionally, surgical factors are prioritized in re-exploration decisions; however, our study emphasizes nonsurgical bleeding as the primary cause in 42% of cases. This finding was especially pronounced in geriatric patients with elevated INR (>1.5). Hypothermia-induced coagulopathy in this cohort<sup>12</sup> further exacerbates the risk of the interconnected triad of acidosis, hypothermia, and impaired coagulation. Despotis et al. highlight the prevalence of excessive bleeding after CPB (11%), underscoring the need to consider nonsurgical etiologies for this complication.<sup>13,14</sup> Our data challenge the tendency to overlook nonsurgical causes and stress the necessity of proactive coagulation assessment and timely blood product management.<sup>15</sup> Integrating viscoelastic testing could guide more nuanced decisions regarding re-exploration by differentiating between surgical and nonsurgical bleeding sources.

A significant postoperative challenge is de novo dialysis-requiring kidney failure following cardiac surgery, a recognized factor in elevated morbidity and mortality.<sup>16</sup> While dialysis is required by less than 12% of cardiac surgery patients with acute kidney injury (AKI),<sup>16,17</sup> AKI associated with cardiopulmonary bypass (CPB) demonstrates a marked 8.2-fold increase in in-hospital mortality.<sup>18,1</sup> Our study revealed a concerning 88% incidence of AKI following re-exploration, with 87.7% necessitating

continuous renal replacement therapy (CRRT). This suggests a concerning association between re-exploration, severe renal injury, and protracted hospitalization. This elevated AKI risk likely stems from the hemodynamic instability and compromised renal perfusion frequently accompanying post-cardiotomy hemorrhage. Proactive AKI identification and intervention measures are crucial within this high-risk population.

In agreement with Choong et al.,<sup>20</sup> our findings highlight the criticality of timely re-exploration. Delays exceeding 12 hours were associated with an escalation of adverse outcomes, including increased blood product requirements, progressive coagulopathy, and mortality. Notably, despite re-exploration within 6-12 hours following class II hemorrhage with hemodynamic instability, elderly patients undergoing emergency surgery still experienced a 2% mortality rate. This illustrates the complex interplay of risk factors shaping outcomes in this cohort.

## CONCLUSION

Emergency procedures had higher rate of re-exploration. Preoperative deranged LFTs, elevated creatinine, prolonged CPB time, and substantial transfusion requirements were independent risk factors for re-exploration. Re-explored cases experienced higher complication. In-hospital mortality occurred in emergency cases only.

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## CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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