Planned Versus Unplanned Reexplorations for Bleeding: A Comparison of Morbidity and Mortality

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Background. **Mediastinal reexplorations for bleeding are associated with significant morbidity and mortality. This study hypothesized that bleeding patients who undergo delayed chest closure after an initial operation experience similar outcomes in comparison with patients who have initial chest closure and later require an unplanned reexploration.**

Methods. **This study included all patients in the Johns Hopkins University School of Medicine (Baltimore, MD) institutional Society of Thoracic Surgeons (STS) database who underwent cardiac surgical procedures or thoracic transplantation from 2011 to June 2014, had an intraoperative red blood cell transfusion requirement of 2 units or more, and required mediastinal reexploration for bleeding. Reexplorations were classified as planned (temporary chest closure for a planned "second look") or unplanned (initial sternal closure and subsequent reexploration). The two groups were then propensity matched. The primary outcome was 30-day mortality. Secondary outcomes were major complication rates, hospital length of stay, duration of mechanical ventilation, and incidence of postoperative pneumonia and cardiac arrest.**

Results. **Among 3,293 patients, 110 (3.3%) met inclusion criteria and required mediastinal reexploration for bleeding. This group included 62 planned (56%) and 48 unplanned (44%) reexplorations. After propensity matching 30 pairs of patients across 16 variables, operative mortality rates were comparable (37% vs 37%; $p = 1.00$) between unplanned and planned reexploration cohorts. There were no differences in rates of deep sternal wound infection, renal failure, postoperative hospital length of stay, pneumonia, or cardiac arrest, with the exception of a higher rate of prolonged intubation (93% vs 53%; $p < 0.01$) in the planned reexploration group.**

Conclusions. **Delayed sternal closure is a safe alternative to initial definitive chest closure when concern exists for postoperative bleeding.**

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Mediastinal reexplorations complicate 3% to 5% of cardiac surgical procedures and commonly follow excessive bleeding, cardiac tamponade, or a combination of both [1–3]. Previous studies identified reoperative cardiac surgical procedures [4], older age [5, 6], peripheral vascular disease [5], and urgent or emergent need for surgical intervention [5, 6] as risk factors for reexploration for bleeding. Although reexploration represents a potentially lifesaving intervention, it is associated with substantial morbidity, including the risk of deep sternal wound infection (DSWI), and death [3, 5].

In the setting of postoperative hemorrhage, the decision to perform surgical reexploration after initial sternal closure is often based on clinical judgment, balancing the likelihood of identifying and eliminating the source of bleeding with the probability of safely controlling hemorrhage and preventing cardiac tamponade without intervention. At our own institution (Johns Hopkins University School of Medicine, Baltimore, MD), surgical sources of bleeding have been identified in only 50% of patients who underwent unplanned reexplorations for bleeding, comparable to previously published rates of 50% to 75% [2, 4, 7, 8].

Ott and colleagues [9] were the first to describe delayed sternal closure as a measure to combat postoperative bleeding diatheses. Nonetheless, concerns over DSWI and its associated morbidity and mortality have perpetuated surgeons' reluctance to leave patients with "open" chests (temporary sternal closure), sometimes even in the presence of unresolved hemorrhage [4, 5, 10]. Debate remains about the safest method of managing patients with intraoperative coagulopathy, specifically whether or not to delay definitive sternal closure.

No study has compared outcomes among bleeding patients who are intentionally left with an open chest at the time of the index operation with outcomes among

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bleeding patients who have initial chest closure and who subsequently undergo surgical reexploration for postoperative hemorrhage. Our hypothesis was that bleeding patients left with temporary chest closure for a planned mediastinal reexploration would experience similar outcomes in comparison with patients with initial chest closure who subsequently required unplanned reexploration for bleeding.

Patients and Methods

Patient Selection

We identified all adult patients undergoing a cardiac operation or thoracic transplantation at our institution from 2011 to June 2014. We used our institutional The Society of Thoracic Surgeons (STS) database to assess preoperative risk factors and operative characteristics. To meet inclusion criteria for bleeding, patients had to satisfy an intraoperative packed red blood cell (pRBC) transfusion requirement of 2 units or more. Patients requiring mediastinal reexploration were then grouped into two categories based on the results of a manual chart review: planned, indicating that patients underwent temporary chest closure during the initial operation for a planned second-look procedure (ie, "left open"); or unplanned, indicating that patients initially underwent sternal closure and subsequently required reopening of the chest for exploration. Patients who experienced intentional delayed chest closure as a result of depressed cardiac function, tissue edema, or the need for extracorporeal support were excluded from this study. These criteria were delineated by manually reviewing the surgeon's operative notes. Patients who required unplanned reexploration during a subsequent hospital admission (different from the admission for the index operation) were also excluded. Institutional Review Board approval was granted by Johns Hopkins University for this study.

Outcomes

The primary outcome of this study was operative mortality, defined by The STS as one death within 30 days of operation or during the index hospitalization. Secondary outcomes included rates of major postoperative complications (stroke, new-onset renal failure [a serum creatinine level 300% of baseline, a creatinine level of >4.0 mg/dL with a minimum rise of 0.5 mg/dL, or a new hemodialysis requirement], prolonged intubation (>24 hours), and DSWI), duration of mechanical ventilation, postoperative hospital length of stay (LOS; from operation to discharge), and rates of postoperative pneumonia and cardiac arrest.

Operative Procedures and Technique

At our institution, mediastinal reexplorations were undertaken when, after correction of coagulopathy, a patient's chest tube output remained persistently high. We use an output of greater than 200 mL/hour for 3 consecutive hours as a trigger to escalate the aggressiveness of our interventions. However, in patients with evidence of tamponade physiology or hemodynamic perturbations, the decision to reexplore surgically may occur before a threshold chest tube output is reached. Patients who have previously undergone sternotomy or those receiving preoperative antiplatelet therapy are aggressively resuscitated with blood products before reexploration is pursued.

It is our institutional preference to perform mediastinal reexplorations in the operating room. However, patients who suffer cardiac arrest or are hemodynamically unstable and who will not tolerate transport to the operating room undergo surgical reexploration in the intensive care unit (ICU). The goals of ICU reexplorations are threefold: to evacuate mediastinal clot and relieve life-threatening cardiac tamponade, to control ongoing mediastinal bleeding, and to stabilize the patient for transport to the operating room. Alternatively, patients with postoperative hemorrhage who remain hemodynamically stable are taken to the operating room on the basis of triage.

Regarding temporary chest closure after the index operation, our institutional practice is to pack the mediastinum with sterile laparotomy pads and 4×4 sterile gauze. Our preference is to close the patient's skin with interrupted 2-0 or 3-0 nylon sutures. Alternatively, we use an Esmarch bandage or AlloDerm tissue matrix (Life Cell, Bridgewater, NJ) to bridge the skin defect across the mediastinum when skin closure is not preferable. We then cover the chest with a sterile surgical towel and drape the entire chest with an occlusive Ioban (3M, Maplewood, MN) sterile adhesive layer. In these patients, perioperative antibiotic prophylaxis with cefazolin (1 or 2 g every 8 hours) or vancomycin (dosed by trough levels) in patients with penicillin allergies was continued until definitive chest closure was performed.

Planned mediastinal reexplorations with sternal closure were performed in the operating room after patients showed evidence of hemodynamic stability, cessation of hemorrhage, and a fluid balance that would permit safe closure. Rarely, patients with open chests continued to bleed or had ongoing hemodynamic lability and ultimately required repeat reexploration in the ICU. For planned reexplorations, a cardiac surgical team was present that included an attending cardiac surgeon, a cardiac surgical fellow, and a surgical technician. Anesthesia was provided by a dedicated cardiac anesthesia team. All patients were cared for by the same team of anesthesiologists, perfusionists, cardiac surgeons, and intensivists.

Statistical Analysis

All statistical analysis was performed using STATA 12.0 software (StataCorp, College Station, TX). Descriptive analysis was performed using Student's t tests or rank-sum tests, or both, for continuous variables according to distribution and χ^2 tests for categorical variables. Significance was defined as a p value <0.05 for all tests.

Propensity scores were calculated using a nonparsimonious logistic regression model for the treatment of planned versus unplanned reexploration based on