Management and Prevention of Cardiovascular Hemorrhage Associated With Mediastinitis

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Objective
To elucidate the causes of cardiovascular hemorrhage associated with mediastinitis and to review recommendations for prevention and treatment.

Summary Background Data
Mediastinal debridement with immediate or early coverage using healthy, vascularized tissue has lead to greatly reduced morbidity and mortality for patients with mediastinitis. Myocardial hemorrhage has been anecdotally reported.

Patients and Methods
Over a 36-month period, 7 patients developed massive cardiovascular bleeding after undergoing debridement for poststernotomy mediastinitis. Causes included puncture or erosion by a sternal edge in three and tearing at the myocardial–sternal interface in four.

Results
Five patients survived and remain infection-free at an average of 24 months of follow-up. In these patients, ventricular defects were closed with pledged sutures and muscle transposition was used concomitantly to reinforce the repair. This involved a slide of the left pectoralis major muscle and turnover of the right pectoralis in three patients, bilateral sliding in one patient, and bilateral pectoralis and an omental flap in one patient who required additional coverage of the lower mediastinum.

Conclusions
When a patient who has undergone mediastinal debridement shows evidence of significant bleeding, we recommend application of pressure for control of hemorrhage, expeditious return to an operating room with available cardiopulmonary bypass, and immediate muscle coverage with healthy, well-vascularized tissue. Finally, early sternectomy might largely prevent this life-threatening complication.
Mediastinitis is a dreaded complication of cardiac surgery. A minority of these patients develop massive bleeding. During the 36-month period from June 1991 to June 1994, approximately 8400 patients underwent median sternotomy at the authors' institutions. Of these, 114 patients developed mediastinitis, and massive myocardial bleeding ensued in 7. Five patients survived to be discharged home infection-free and neurologically intact. Of the two who died, one expired before return to the operating room and the second had a ventricular tear that extended into the pulmonary artery.

We undertook this retrospective study to elucidate the causes of this complication and to review therapeutic interventions for avoidance and treatment.

PATIENTS AND METHODS

All patients had significant purulent mediastinitis and underwent debridement and packing of the wound with the expectation of a more extensive debridement and muscle flap closure at a later time. Most of these patients developed bleeding shortly after debridement, 3 patients within 3 hours and 3 others within the first 25 hours (Table 1). One patient developed bleeding 4 days after pectoralis flap reconstruction.

Surgical Management

Patients had immediate reoperation when hemorrhage was recognized. Control of the myocardial hemorrhage was initially undertaken by compression in 6 patients (patient 1 [Table 1] died during an attempt to oversew the right ventricle in the recovery room). In the five patients who survived, extracorporeal circulation was instituted via cannulation of the femoral vessels (the two patients died before placement on cardiopulmonary bypass), and ventricular defects were closed with pledgeted sutures. Muscle transposition was used concomitantly to reinforce repairs as well as to cover the mediastinum after meticulous debridement to healthy, well-vascularized tissue. This involved a slide of the left pectoralis major muscle and turnover of the right pectoralis in three patients, bilateral sliding flaps in one patient, and bilateral pectoralis and an omental flap in one patient who required additional coverage of the lower mediastinum.

Illustrative Case Reports

Case 1 (patient 5, Table 1): This 55-year-old man with coronary artery disease, insulin-dependent diabetes mellitus, and renal insufficiency requiring chronic peritoneal dialysis underwent triple coronary artery bypass grafting (including left internal mammary artery to LAD) for unstable angina. He was discharged home on postoperative day 6 but was readmitted with wound drainage and an unstable sternum on postoperative day 13. The next day, he was taken to the operating room, where he underwent removal of wires, irrigation, and debridement and packing of the wound. He was moved to a recovery room stretcher and tubes were withdrawn. Before leaving the operating room, he was noted to take a deep breath and cough; at this point, he began to bleed heavily into his dressing.

The patient was returned to the surgical table, bleeding was controlled by compression, and cardiopulmonary bypass was established via his right groin. A large tear in the right ventricle was repaired with interrupted 2-0 Tevdek sutures placed through Teflon pledges (Fig. 1A). The cardiac surgeon observed that on reexploration, the heart and surrounding soft tissues were adherent to the sternum; when the sternum was spread apart, the hole in the heart tended to gape. The cardiac surgeon felt that the tear was secondary to mechanical forces at the myocardial–sternal interface.

The patient’s intraoperative course was complicated by a cardiac arrest requiring manual chest compression and electrical pacing. Continued bleeding through the repaired suture line required use of cardiopulmonary bypass for blood collection. Right turnover and left slide pectoralis muscle flaps were elevated (Fig. 1B). The myocardial repair was reinforced with the pectoralis flaps and fibrin glue, resulting in adequate hemostasis (Figs. 1C and 1D). The patient’s postoperative course was benign, and he was discharged home 18 days after treatment of the hemorrhage. At 24-month follow-up, he remains infection-free.

Case 2 (patient 6, Table 1): This 58-year-old woman with hypertension, diabetes mellitus, and chronic obstructive pulmonary disease underwent quadruple coronary artery bypass grafting for unstable angina. Pulmonary insufficiency required reintubation on postoperative day 2. On postoperative day 5, she was noted to have sternal drainage and was treated with vancomycin and gentamicin and serial debridements. Her postoperative course was marked by chronic carbon dioxide retention, pulmonary insufficiency requiring prolonged ventilatory support, and difficulty in control of diabetes mellitus. After multiple minor sternal wound debridesments with little progress toward healing, the patient was returned to the operating room for a more extensive debridement on postoperative day 33. This debridement concentrated mainly on the soft tissues. In addition, the sternal wires were removed and the wound was packed. The following day, the patient underwent further sternal debridement, this time back to bleeding bone, and the mediastinum was reconstructed.

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<table>
<thead>
<tr>
<th>Patient Number</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>Operation</th>
<th>Time from CABG to Debridement (days)</th>
<th>Time from Debridement to Hemorrhage</th>
<th>Location of Tear</th>
<th>Apparent Cause</th>
<th>Cultures</th>
<th>Coverage</th>
<th>Number of Hospital Days After Hemorrhage</th>
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<td>F</td>
<td>CABG × 2</td>
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<td>3 hr</td>
<td>Right ventricle</td>
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<td>Staphylococcus epidermidis klebsiella</td>
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<td>*</td>
<td>Death</td>
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<td>CABG × 3</td>
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<td>Right ventricle</td>
<td>Sternal edge puncture or erosion</td>
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<tr>
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<td>59</td>
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<td>12 hr</td>
<td>Right ventricle</td>
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<td>Tethering leading to tearing</td>
<td>MRSA</td>
<td>Bilateral pectoralis</td>
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* Patient died before hemorrhage controlled.
CABG = coronary artery bypass graft.
with bilateral pectoralis flaps. Four days later, increased bleeding was noted from the drains. The patient was restricted to bed rest, and shortly thereafter a hematoma was noted. The patient was returned to the operating room. The wound was opened and the flaps were re-elevated. A mediastinal hematoma was evacuated, and a right ventricular tear was noted. The patient was placed on cardiopulmonary bypass through the left groin and the tear was repaired with 2-0 Tevdec sutures through Teflon pledgets. The heart was densely adherent to the left sternum, and it was the cardiac surgeon’s opinion that this had led to the right ventricular tear. The patient’s postoperative course was complicated by pneumonia (methicillin-resistant \textit{Staphylococcus aureus}) and a groin wound infection requiring multiple debridements, prolonged intravenous antibiotic administration, and respiratory support. The patient’s mediastinum, however, subsequently healed without further difficulty.

**RESULTS**

All patients who survived to be placed on cardiopulmonary bypass survived to be discharged from the hospital. Their median hospital stay was 24 days (range 14–47 days). No patient encountered further bleeding episodes. Complications included prolonged ventilatory support, urinary tract infections and pneumonia (one gram-negative, one methicillin-resistant \textit{Staphylococcus aureus}), ventricular tachycardia (in three), respiratory failure (in two), and groin wound infection with \textit{Proteus} (in one). One patient required return to the operating room for irrigation and debridement of subpectoral collections with takedown and reinsetting of pectoralis major flaps.

Organisms cultured from the mediastinal wounds included \textit{Staphylococcus epidermidis, Pseudomonas aeruginosa, Klebsiella pneumoniae}, and methicillin-resistant \textit{Staphylococcus aureus}. All 5 patients have subsequently been infection-free for a follow-up time averaging 24 months (range 16 months–3 years).

**DISCUSSION**

Extensive infection of sternotomy wounds may predispose to erosion and necrosis of the free cardiac wall, resulting in hemorrhage. Critical review of our experience with massive myocardial bleeding associated with sepsis after median sternotomy suggests that mechanical forces at the myocardial–sternal interface are active in creation of this entity. The most likely causes of bleeding include...
puncture or erosion by a sternal edge and tearing at the interface when the sternum moves with changes in intrathoracic volume from breathing or coughing. The phenomenon of tearing is similar to that encountered in reoperative median sternotomy, in which separation of the sternal halves before adequate mobilization of the soft tissues from the sternum may lead to right ventricular or great vessel tearing and hemorrhage (Fig. 2).\(^1,2\) We believe that patients who have relatively great sternal excursions with respiration are at greatest risk.

The first successful management of cardiac rupture was reported by FitzGibbon et al. in 1972.\(^3\) Recently, authors have described the use of intrathoracic muscle flaps in the surgical management of hemorrhage from the great vessels. Muscle flaps, including pectoralis, serratus, and latissimus, may be brought into the chest between the ribs. Arterial prostheses in the great vessel locations have been covered with a relatively high success rate.\(^4\)

Papp et al.\(^5\) demonstrated the utility of muscle flaps for the repair of experimentally induced defects of the ventricular myocardium in dogs. In their study, early and late healing of all flaps was uncomplicated, and there were no late complications of aneurysm formation or electrical abnormalities of the heart.

Muscle flap coverage stabilizes the chest wall and provides a favorable milieu for vein graft protection, myocardial preservation, and wound healing.\(^6-9\) Despite the positive attributes of early coverage, myocardial hemorrhage can also occur subsequently, as illustrated by case 2.

Our experience suggests that cardiac tearing or laceration associated with mediastinitis may be avoided by cautious wide detachment of the heart from the anterior chest wall, avoidance of sharp sternal edges, meticulous wound debridement, and early coverage with healthy, well-vascularized tissue. In the event of myocardial bleeding, many patients may be saved by repair of the myocardial defect, reinforcement of the closure with well-vascularized muscle, and coverage of the mediastinum with healthy tissue. We favor the use of pledgets made from autologous pericardium when available, thereby avoiding foreign material such as Teflon. In our experience, the pectoralis major and rectus muscles are particularly well suited for reinforcing defects in the right ventricle after repair.

The practice of delayed sternal closure results in few mechanical complications, and this fact may help to elucidate the cause of myocardial hemorrhage in the patients here. Intraoperative closure of the median sternotomy after cardiac surgery in patients with complications (including severe postoperative bleeding and poor cardiac function caused by myocardial edema and cardiac dilation) may lead to critical and possibly fatal deterioration of hemodynamic function.\(^10\) Delayed closure usually involves splitting the sternum open with a section of heavy-gauge chest tube and covering the wound temporarily with a sheet of rubber latex and the dressing. Among 40 series comprising more than 500 patients, only 1 instance of myocardial hemorrhage has been reported, suggesting that a briefly open mediastinum is itself rarely the proximate cause of myocardial hemorrhage.\(^11\) Rather, necrosis from infection, combined with mechanical forces that lead to tearing or puncture of the myocardium, is paramount.

Whenever a patient who has undergone mediastinal debridement has evidence of significant bleeding, we recommend application of pressure for initial control of hemorrhage and expeditious return to an operating room with available cardiopulmonary bypass. The groin should be included in the steriley prepared field to facilitate this. We favor immediate muscle coverage in stable patients who have sustained myocardial hemorrhage. Patients in extremis after myocardial repair should be brought back for flap coverage as soon as they are judged medically fit.
We recommend avoidance of sharp sternal edges at debridement, careful wide detachment of the myocardium and associated structures from the posterior sternum, and, during dressing changes, placement of packing to isolate the heart from the sternum. Finally, because these seven cases were thought to result from interaction between the myocardium and sternum in the early postdebridement period, early sternectomy might have largely prevented this life-threatening complication in our series.

References