

Right ventricular laceration caused by sternal wire fracture following cardiac surgery: A case report

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April 16, 2024

Abstract

Resternotomy for bleeding remains a significant complication with increased rates of morbidity and mortality. Right ventricular laceration from fractured sternal wires is rare cause of postoperative bleeding. A 68-year-old man presented for coronary artery bypass grafting (CABG). Postoperatively, he had a chronic obstructive pulmonary disease (COPD) exacerbation. He initially responded to treatment, and shortly after mobilizing, acutely decompensated hemodynamically. A bedside echo revealed significant pericardial effusion. The patient was taken urgently for re-exploration with a diagnosis of cardiac tamponade. All sternal wires were fractured, and a right ventricular laceration was identified. The laceration was repaired, and the patient recovered well postoperatively. Postoperative hemorrhage can occur in cardiac surgical patients, but rarely is the cause laceration secondary to sternal wire fracture. Alternative sternal closure techniques should be considered in this and other high-risk groups of patients. Patients with sternal dehiscence should be monitored closely and definitive management should not be postponed.

Right ventricular laceration caused by sternal wire fracture following cardiac surgery: A case report

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Running Title: RV Laceration Sternal Wire

Word count: 1500

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Abstract

Resternotomy for bleeding remains a significant complication with increased rates of morbidity and mortality. Right ventricular laceration from fractured sternal wires is rare cause of postoperative bleeding. A 68-year-old man presented for coronary artery bypass grafting (CABG). Postoperatively, he had a chronic obstructive pulmonary disease (COPD) exacerbation. He initially responded to treatment, and shortly after mobilizing, acutely decompensated hemodynamically. A bedside echo revealed significant pericardial effusion. The patient was taken urgently for re-exploration with a diagnosis of cardiac tamponade. All sternal wires were fractured, and a right ventricular laceration was identified. The laceration was repaired, and the patient recovered well postoperatively. Postoperative hemorrhage can occur in cardiac surgical patients, but rarely is the cause laceration secondary to sternal wire fracture. Alternative sternal closure techniques should be considered in this and other high-risk groups of patients. Patients with sternal dehiscence should be monitored closely and definitive management should not be postponed.

Keywords: Heart surgery, right ventricle, laceration, complication, sternal wire

Background

Resternotomy for bleeding and cardiac tamponade following coronary artery bypass grafting (CABG) remains as high as 2-6%.^{5,9} This remains a significant complication leading to prolonged cardiovascular intensive care unit (CVICU) stay.⁷ Resternotomy patients have been found to experience mortality rates as high as 22%.¹² While bleeding and cardiac tamponade post cardiac surgery is typically attributed to coagulopathy or surgical hemostasis, reports of right ventricular (RV) laceration secondary to sternal wire fractures are exceedingly rare.^{6,10} Informed consent was obtained for the following case report. International review board approval and clinical trial registration were not applicable.

Case Presentation

A 68-year-old male presented with six months of progressive exertional chest pain radiating to the neck. His past medical history includes diabetes type II, a myocardial infarction 20 years prior, COPD, gastroesophageal reflux disease, gout, dyslipidemia, and a retinal detachment repair. He was found to have three-vessel coronary artery disease on cardiac catheterization and subsequently underwent triple CABG using left internal mammary artery and saphenous vein grafts via median sternotomy. The sternum was closed using six No.6 steel wires in a figure 8 fashion. The chest tubes drained 410 mL in total and were removed. The patient was stable and was transferred from the cardiovascular intensive care unit (CVICU) to the ward.

On post-operative day four, the patient was transferred back to the CVICU due to increasing respiratory requirements, in what appeared to be a COPD exacerbation. The patient improved with medical therapy. On postoperative day six, the patient's sternum was noted to be unstable on physical exam with no evidence of sternal wound infection. Chest x-ray revealed a fractured sternal wire (figure 1). The patient was scheduled for repair of his sternal dehiscence the following day. While awaiting reoperation, the patient was ambulating with minimal assist and developed shortness of breath, became pale with cool extremities, and had bleeding from his sternal incision. Repeat chest x-ray showed new left pleural effusion (figure 2) and bedside echocardiogram showed a significant pericardial effusion. The patient was resuscitated with fluids, received two units of packed red blood cells (pRBC), and was started on norepinephrine. He was taken emergently to the operating room for re-exploration. On re-exploration, there were large mediastinal clots and all sternal wires were fractured with an injury to the free wall of the RV. The laceration was successfully repaired using a pledgeted 4-0 prolene suture. The patient was transfused a single unit of pRBC intra-operatively and was transferred to the CVICU with stable hemodynamics. He was successfully extubated the next day and discharged home 15 days after his initial procedure.

Discussion

Postoperative hemorrhage in cardiac surgical patients have been associated with surgical team experience, effects of hemodilution, hypothermia, inadequate reversal of heparin, thrombocytopenia, impaired platelet function, deletion of coagulation factors, and fibrinolysis.^{1,6,10} However, RV laceration from a fractured sternal wire is rare. One other case by Gong et al discusses fatal bleeding due to sternal steel wire fracture. Similarly, the cause of sternal wire fracture was thought to be due to increased cough in this case.

There are different methods used for sternotomy closure including a series of wires or a figure-of-eight method. With all types of sternal closure, there is some movement of the sternal halves under physiological loads, but with regimented sternal precautions complications are minimal.⁴ The mechanism of sternal fracture is generally thought to be caused by patient movement, but a recent study in the Journal of Orthopedic Research performed a biomechanical evaluation on the role of cerclage wire failure. Sternal wires have a material yield or failure strength, which if surpassed leads to deformities of the material.² If sternal wires are to remain the gold standard for sternotomy closure, new techniques and/or materials must be developed to ensure tensile strength is not surpassed.

Risk factors for sternal dehiscence include COPD, re-operative surgery, renal failure, diabetes, chronic steroid use, morbid obesity, concurrent infection and acquired or iatrogenic immunosuppression. Our patient had an existing diagnosis of COPD, which brings to question whether an alternative method should have been used as primary closure.

A one-year follow-up of the ZipFix (Johnson and Johnson, New Brunswick, NJ) trial showed greater clinical advantages with regards to pain and sternal dehiscence post-surgery by using sternal ZipFix compared to conventional steel wire closure.⁸ Recent studies suggest that rigid plate fixation may lead to reduced sternal complications in high risk patients, improved perioperative survival, decreased length of hospital stay, improved pain and activity management with improved osteosynthesis.^{3,7,11} While other innovative techniques of sternal closure have been discussed such as reinforced wires, sternal plating and cables; none of these methods have been found to be reliable techniques or cost efficient when compared to sternal wires.^{3,4}

Conclusions

Although the patient was stable at the time of sternal dehiscence and wire fracture, he acutely decompensated prior to the planned procedure. Fortunately, the patient was in the CVICU for respiratory concerns allowing for immediate attention and resuscitation. This raises the question of whether the diagnosis of sternal dehiscence with a fractured wire should be an indication for urgent reintervention to prevent such complications. Further investigation and innovation is required to improve sternal closure techniques and materials in addition for the development of protocols to recognize and manage sternal wire fractures with sternal dehiscence.

Disclosures

None.

Data Availability

All of the relevant data is available within the manuscript and its supplements.

International Review Board Approval

N/A

Clinical Trial Registration

N/A

Author Contributions

Devin O'Brien, Abdullah Baghaffar: Conception, design, writing—original, approval of article.

Ryaan EL-Andari, Claudio DiQuinzio, Idris M. Ali: Conception, design, writing—revisions, approval of article.

References

1. Bagge L, Lilienberg G, Nyström SO et al. Coagulation, fibrinolysis and bleeding after open-heart surgery. *Scand J Thorac Cardiovasc Surg*. 1986;20(2):151-60.
2. Salas C, Tabe CE, Tufaro R, et al. The surgeon's role in cerclage wire failure after sternal fracture repair: a biomechanical evaluation. *J Orthopaed Res*. 2017;35.
3. Song DH, Lohman RF, Renucci JD, et al. Primary sternal plating in high-risk patients prevents mediastinitis. *Eur J Cardio-Thorac Surg*. 2004;26(2):367–372
4. Cicek, S. Sternal closure: Wires are still the king! *J Thorac Cardiovasc Surg* 2018. 156(4).
5. Dacey LJ, Munoz JJ, Baribeau YR, et al. Reexploration for Hemorrhage Following Coronary Artery Bypass Grafting: Incidence and Risk Factors. *Archive Surg* 1998;133(4):442–447.
6. Harker LA, Malpass TW, Branson HE, et al. Mechanism of abnormal bleeding in patients undergoing cardiopulmonary bypass: acquired transient platelet dysfunction associated with selective alfa-granule release. *Blood* 1980;56:824-834.
7. Lehmann S, Wong MS, Zehr K, DeGuzman BJ, et al. Wire fixation versus rigid titanium plate after sternotomy – Results of a randomized, prospective, multi-center trial. *Thorac Cardiovasc Surgeon*. 2012;60:V78
8. Nezafati P, Shomali A, Kahrom M, et al. ZipFix Versus Conventional Sternal Closure: One-Year Follow-Up. *Hear Lung Circ*. 2019;28(3):443-449.
9. Ranucci M, Bozzetti G, Ditta A, et al. Surgical Reexploration After Cardiac Operations: Why a Worse Outcome? *Ann Thorac Surg*. 2008;86(5):1557-1562.
10. Sellman M, Intonti M, Ivert T. (1997) Reoperations for bleeding after coronary artery bypass procedures during 25 years. *Eur J Cardio-Thorac Surg*. 1997;11(3):521–527
11. Tam DY, Nedadur R, Yu M, et al. Rigid Plate Fixation Versus Wire Cerclage for Sternotomy After Cardiac Surgery: A Meta-Analysis. *Ann Thorac Surg*. 2018;106(1):298–304.
12. Unsworth-White M, Herriot A, Valencia O, et al. Resternotomy for Bleeding After Cardiac Operation: A Marker for Increased Morbidity and Mortality. *Ann Thorac Surg*. 1995;59:664-7.

Figure Legends

Figure 1: Inferior sternal wire fracture seen on chest x-ray following COPD exacerbation

Figure 2: Left pleural and pericardial effusions seen on chest x-ray

