Don't Tear My Heart: Sternal Wire Pericardial Injury After Aortic Valve Replacement

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INTRODUCTION

Complications after cardiac surgery carry a wide differential diagnosis and can pose life-threatening consequences. The differential diagnosis of causes for hemodynamic instability in post–cardiac surgery patients is similarly broad, with many diagnoses being life threatening. Diagnoses include, but are not limited to, congestive heart failure exacerbation, acute coronary syndrome, cardiac tamponade, pulmonary embolism, sepsis, and pneumothorax. Great advances in the field of noninvasive cardiac imaging over the past few decades have improved diagnostic yield of these complications. The various cardiac imaging modalities, each with its own set of strengths and weaknesses, can aid in the evaluation of hemodynamically unstable patients after cardiac surgery.

Our case highlights a 66-year-old man who presented with dyspnea after surgical aortic valve replacement and emphasizes the importance of prompt, appropriate cardiac imaging in the evaluation of postoperative, and more specifically, post-sternotomy, complications.

CASE PRESENTATION

A 66-year-old man presented to the emergency department with progressive dyspnea and chest pain. Initial vital signs revealed a body temperature of 38.6°C, heart rate of 140 beats/min, blood pressure of 75/36 mm Hg, respiratory rate of 26 breaths/min, and oxygen saturation of 92% on room air. Physical examination revealed respiratory distress with accessory muscle use; skin examination revealed erythema over the sternum along with pitting edema in both lower extremities, with feet that were cool to touch. Cardiac auscultation revealed a rapid rate, a regular rhythm, and a soft systolic murmur heard in the right sternal border, second intercostal space. Significant jugular venous distension was noted, along with pulsus paradoxus. Lung examination revealed tachypnea, clear to auscultation.

The patient's medical history was notable for aortic stenosis status post surgical mechanical aortic valve replacement 3 weeks prior, chronic obstructive pulmonary disease, cirrhosis secondary to alcohol use, hypertension, and hyperlipidemia.

The primary differential diagnosis included septic shock from sternal wound infection and/or endocarditis, and cardiogenic shock from postoperative complications (tamponade due to post-pericardiotomy syndrome or postsurgical bleed in a patient on warfarin anticoagulation for a mechanical valve). Additional possibilities included bacterial or viral pneumonia, acute coronary syndrome, pneumothorax, pulmonary embolism, acute heart failure exacerbation, and chronic obstructive pulmonary disease exacerbation.

Emergency bedside echocardiography revealed a moderate to large pericardial effusion with tamponade physiology (Video 1). Emergent echocardiography-guided pericardiocentesis was performed. Access to the pericardial fluid was successful with the first needle pass, and intrapericardial position was confirmed with agitated saline injection. Bright red blood was removed from the pericardial space, with appearance suggestive of hemopericardium with initial hemodynamic improvement. Transthoracic echocardiography (TTE) showed a significant decrease in the size of the pericardial effusion (Video 2).

However, the effusion could not be fully drained despite aspirating an amount of fluid larger than expected from the initial visual appearance. After removal of 1.7 L of fluid, the procedure was stopped; pericardial fluid progressively reaccumulated during 10 min of active echocardiographic monitoring (Figure 1, Video 3).

The pericardial drain was left in place. Cardiac surgery was consulted for suspected ongoing bleeding into the pericardial space. In the setting of suspected active bleeding into the pericardial space, complicated by cirrhosis and an elevated international normalized ratio, the patient received fresh frozen plasma and vitamin K in an attempt to correct the coagulopathy. The patient was admitted to the cardiac intensive care unit for further evaluation and management, and vasopressor support was initiated. Given the sternal erythema on admission in the setting of recent sternotomy, along with fever on admission, blood and pericardial cultures were drawn, and broad-spectrum antibiotics were started. On hospital day 2, before cardiac surgery, chest computed tomography (CT) without intravenous contrast was performed and revealed mid to lower sternotomy wound dehiscence with several broken wires. One of the fractured wires penetrated the pericardium and pointed directly at the right ventricular (RV) free wall (Figure 2).

The patient was intubated and underwent surgical exploration. A laceration of the RV free wall was seen and subsequently repaired. We hypothesize that the pericardial effusion was initially caused by bleeding from the RV injury caused by the fractured wire. As fluid accumulated, the free RV wall was pushed away from the wire and the bleeding stopped. At pericardiocentesis, by removing the fluid, the right ventricle re-expanded and was again impaled on the broken sternal wire, with resumption of bleeding. Despite pericardiocentesis, the patient continued to demonstrate hypotension and signs of shock requiring vasopressor support. On hospital day 2, blood and pericardial cultures were positive for *Staphylococcus aureus*. Sternal bone

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VIDEO HIGHLIGHTS

Video 1: Two-dimensional TTE, emergency point-of-care ultrasound, apical long-axis display, demonstrating a large circumferential pericardial effusion with visualized diastolic right atrial collapse, small underfilled right ventricle, and ventricular septal shifting suggestive of cardiac tamponade.

Video 2: Two-dimensional TTE, parasternal long-axis view performed during pericardiocentesis, demonstrating significantly reduced pericardial effusion, larger RV cavity, and slower heart rate.

Video 3: Two-dimensional TTE, parasternal long-axis display performed approximately 10 min after pericardiocentesis, demonstrating reaccumulation of the large circumferential pericardial effusion, which is now less echolucent and more echogenic, and a smaller RV chamber.

Video 4: Two-dimensional TEE, midesophageal two-chamber view (59°) performed on hospital day 14, demonstrating a small, mobile vegetation on the mitral valve suggestive of infective endocarditis.

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cultures grew *S aureus*, indicative of sternal osteomyelitis. Infectious disease specialty expertise was consulted and helped guide appropriate antibiotic therapy.

The patient's hospital course was complicated by ongoing shock with progressive acute kidney and liver injury despite multiple vasopressor support. Given signs of ongoing active infection with purulent exudate from the sternal wound, the patient ultimately returned to the operating room five additional times for repeat sternal wound debridement (Figure 3). Despite these efforts, the sternum never healed, and blood cultures remained positive. On hospital day 14, transesophageal echocardiography (TEE) was performed in search of endocarditis and demonstrated a new small vegetation on the mitral valve (Video 4).

Given the progressively declining clinical status, nonhealing sternal wound, and new diagnosis of endocarditis, after extensive discussions with the family, the patient was transitioned to comfort care and passed away. On autopsy, there was confirmatory evidence of RV free wall injury (Figure 4), as well as infective endocarditis of the mitral valve.

DISCUSSION

Pericardial effusion is one of the most common complications after cardiac surgery. Although common, this complication has been associated with worsened clinical outcomes.[1] Frequent causes of pericardial effusions after cardiac surgery include postcardiotomy syndrome, which is a combination of effects from cardiopulmonary bypass on inflammation, redistribution of fluid and electrolytes related to the initial surgery, and hemolysis.[2] Another contributing cause is anticoagulation or antiplatelet therapy after certain cardiac procedures, such as prosthetic valve replacement.[2] Most patients with small pericardial effusions do not develop symptoms from the effusion and do not require treatment. However, large or rapidly developing effusions can become problematic and result in cardiac tamponade. The incidence of cardiac tamponade after cardiac surgery ranges from 0.5% to 8.8%.[3] Compared with other cardiac procedures, those involving the aortic valve or the aorta tend to have a higher frequency of cardiac tamponade in the postoperative setting.[1] Although rare, cardiac tamponade in the postsurgical setting has a mortality rate of up to 30%.[4] As such, the ability to apply urgent imaging modalities that provide immediate results remains critical. Despite the many advances of other cardiac imaging modalities, TTE remains the cornerstone to rapid diagnosis of cardiac tamponade. Overall, the importance of diagnostic accuracy of cardiac imaging in postsurgical patients is paramount, as reexploration after cardiac surgery is associated with acute kidney injury, atrial fibrillation, sternal wound infection, and prolonged length of intensive care unit stay.[4]

Although complications from median sternotomy are infrequent, they confer significant morbidity and mortality. Dehiscence of the sternum, defined as separation of the bones previously divided during sternotomy, is a serious complication that can result in chest pain, respiratory dysfunction, and both superficial and mediastinal infections.[5] This can result from disruption of the sternal wires secondary to sternal motion from respiration, along with primary nonunion, poor wound healing, and premature overextension.[6] Sternal dehiscence is a common cause of sternal wound infection, and thus it warrants immediate intervention. Dehiscence differs from sternal fracture, in which the sternum breaks, potentially damaging underlying tissues such as the lungs or the heart.

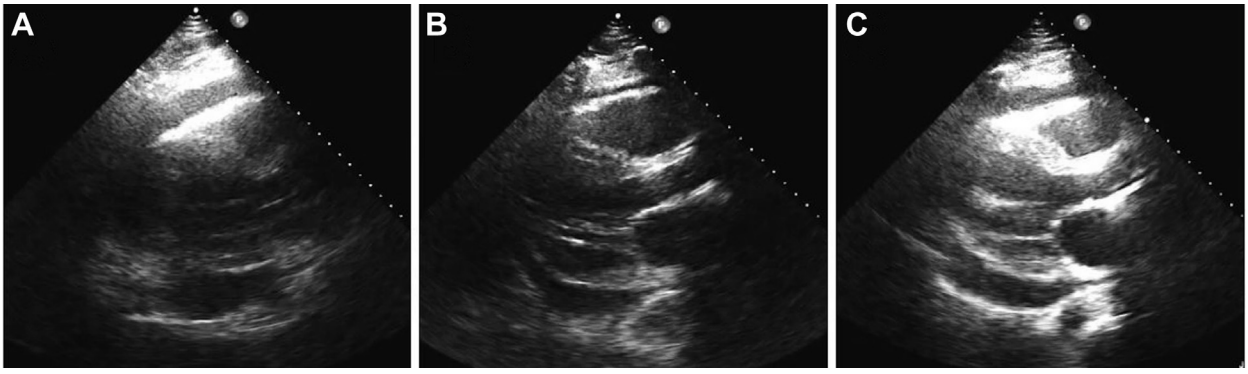

Figure 1 Two-dimensional TTE, parasternal long-axis view, early diastolic phase performed at the time of presentation, demonstrating the initial circumferential pericardial effusion **(A)**, a smaller residual pericardial effusion soon after pericardiocentesis **(B)**, and then rapid reaccumulation of the large pericardial effusion within minutes **(C)**.

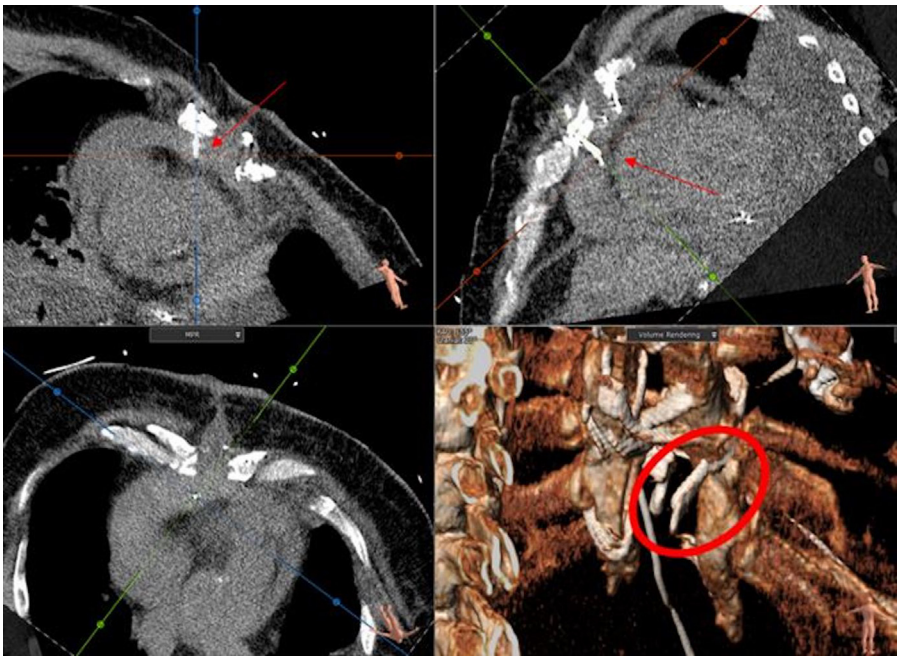

Figure 2 Chest CT, without contrast, multiplanar reconstructions focusing on the sternal wires, demonstrating a fractured sternal wire puncturing the anterior pericardium in oblique frontal *(top left)*, oblique sagittal *(top right)*, and oblique axial *(bottom left)* displays. The volume-rendered three-dimensional display *(bottom right)* carefully highlights the sternal fracture with sharp wires *(red circle)*.

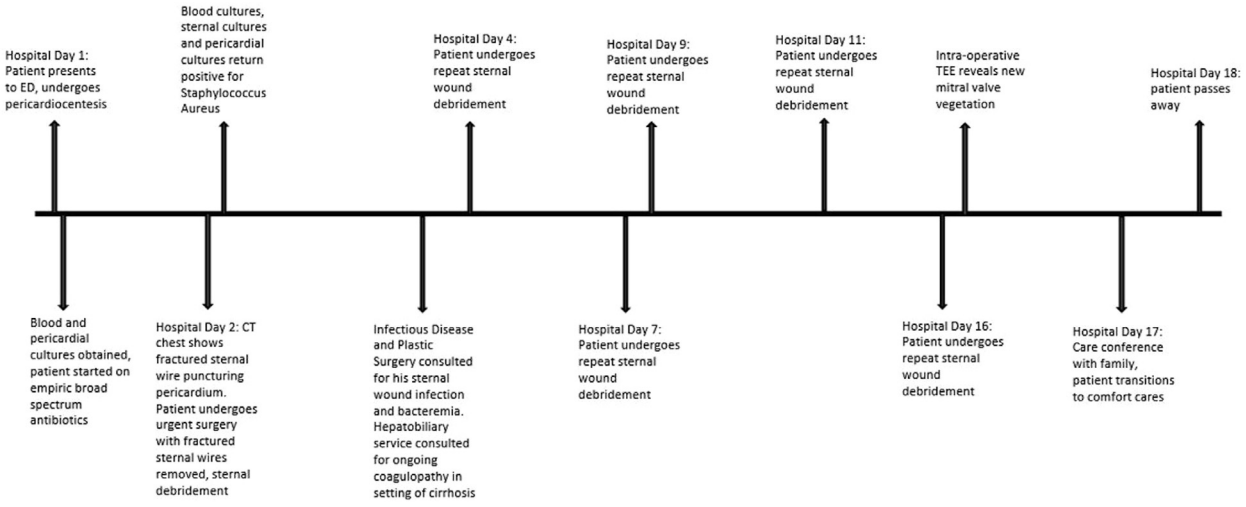

Figure 3 Timeline of patient events.

Sternal wound infections can vary from mild to life threatening dependent on the depth of infection. Risk factors for sternotomy site infections include cardiopulmonary bypass, atherosclerosis, obesity, chronic obstructive pulmonary disease, and New York Heart Association functional class IV heart failure.[7] Most sternal wound infections are superficial and can be treated with local wound care and antibiotic therapy.[8] Deep sternal wound infections, most frequently caused by coagulase-negative *Staphylococcus* species, can lead to more serious complications such as endocarditis.[8] Major complications such as this can often lead to mortality, as in our patient, representing a major adverse outcome.[9]

Endocarditis in the post–cardiac surgery setting is a life-threatening complication with mortality rates as high as 30%.[10] This diagnosis, as mentioned, can often result from deep sternal wound infections

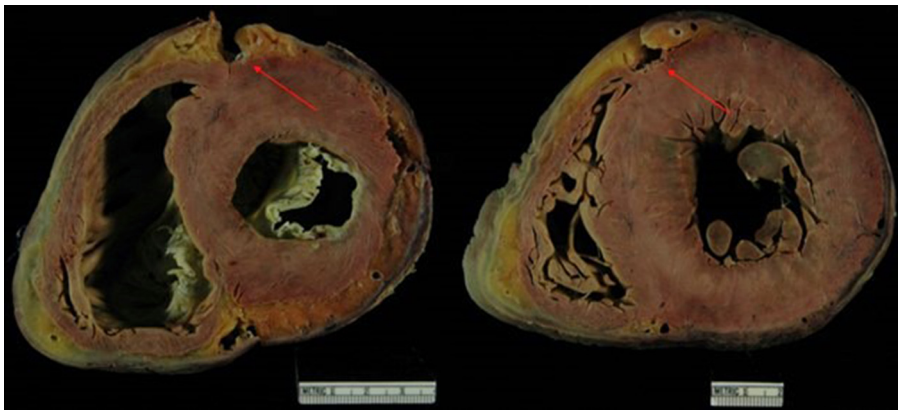

Figure 4 Photograph of the gross pathologic specimen of the entire heart, short-axis orientation from a basal slice *(left)* and midventricular slice *(right)*, demonstrating the RV free wall injury from the sternal wire penetration *(arrows)*.

resulting in bacteremia in the post–cardiac surgery setting, especially after prosthetic valve replacement. Risk factors for infective endocarditis after surgical aortic valve replacement include male sex, higher body mass index, and end-stage renal disease requiring dialysis.[11]

The various cardiac imaging modalities can aid in the evaluation of hemodynamic instability in the post–cardiac surgery setting. Echocardiography, either TTE or TEE, offers immediate imaging, but the accuracy of these modalities is more subjective, on the basis of the imager's ability to obtain images in the various windows. CT and magnetic resonance imaging both offer high-resolution imaging with less user variability, but these modalities are often more expensive, and they frequently require contrast as well as lack of portability compared with echocardiography, requiring critically ill patients to be moved for imaging. Sternal dehiscence can often be diagnosed on physical examination, but advanced imaging modalities such as CT and magnetic resonance imaging can supplement the examination with image findings that depict the dehiscence. Similarly, complications related to sternal dehiscence, such as fractured sternal wire as in our patient, can be diagnosed with these modalities.

TTE and TEE play complementary roles in the diagnosis of infective endocarditis. Classically, the first imaging test to diagnose infective endocarditis is TTE, with sensitivity of about 75% and specificity of about 100%.[12] However, TEE is more sensitive in diagnosing infective endocarditis and related complications.[13] As such, TEE is often necessary to make the diagnosis if the results on initial TTE are negative but clinical suspicion remains. Furthermore, TTE can be challenging in diagnosing prosthetic valve endocarditis, as there is often significant artifact from the prosthetic valve, making visualization of vegetations difficult.[10] Cardiac CT has been found to have a similar sensitivity to TEE but has been shown to have improved detection of paravalvular infection and abscess formation.[14] Fluorine-18 fluorodeoxyglucose positron emission tomography/CT can play an important role in the evaluation of infective endocarditis, especially in the setting of prosthetic valves.[15]

CONCLUSION

Our case highlights the importance of considering postsurgical complications in the diagnostic workup of recurrent pericardial effusions. Although sternal wire fracture is not uncommon, consequent cardiac laceration is very unusual and rarely seen. Clinicians must consider a broad differential diagnosis when evaluating patients for symptoms in the postsurgical setting. Furthermore, advanced imaging modalities are playing an increasingly important role in the workup of complex postsurgical complications.

ETHICS STATEMENT

The authors declare that the work described has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. The authors declare that the work described has been carried out in accordance with the ARRIVE guidelines and with the U.K. Animals (Scientific Procedures) Act, 1986 and associated guidelines, EU Directive 2010/63/EU for animal experiments, or the National Research Council's Guide for the Care and Use of Laboratory Animals.

CONSENT STATEMENT

The authors declare that since this was a non-interventional, retrospective, observational study utilizing de-identified data, informed consent was not required from the patient under an IRB exemption status.

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DISCLOSURE STATEMENT

The authors report no conflict of interest.

SUPPLEMENTARY DATA

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