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**Cardiothoracic Surgery**

# Knife to Meet you Twice: A Two-Center Case Series of Survivable Penetrating Cardiac Trauma Managed with Emergency Sternotomy

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**Abstract** **Case Report**

Penetrating cardiac injuries remain among the most lethal forms of trauma, with mortality rates reaching 70–80% before patients even reach the hospital. Survivors often depend on rapid diagnosis, coordinated resuscitation, and immediate surgical intervention. Right-sided cardiac chambers are more frequently injured due to their anterior position, yet successful repair requires swift operative judgment and a multidisciplinary trauma response. This case series highlights two survivors of penetrating cardiac trauma presenting to two Malaysian tertiary cardiothoracic centers, demonstrating the critical importance of rapid recognition and surgical expertise. ***Case Presentation:*** Case 1 involved a young male who sustained a stab wound to the chest, presenting in extremis with hypotension and muffled heart sounds. Extended Focused Assessment with Sonography for Trauma [E-FAST] revealed pericardial effusion consistent with tamponade physiology. CT showed a focal contrast leak along the right cardiac border, raising suspicion of a right atrial injury. Emergency sternotomy revealed a 1-cm full-thickness laceration at the right atrial free wall, actively bleeding. The defect was primarily repaired using pledgeted polypropylene sutures, achieving complete hemostasis. The patient made an uneventful recovery. Case 2 presented as a penetrating precordial trauma with hemodynamic instability and worsening echocardiographic features of tamponade. CT demonstrated a defect along the right ventricle free wall with adjacent hematoma, consistent with penetrating cardiac injury. Emergency median sternotomy revealed a right ventricular laceration, which was repaired using interrupted polypropylene sutures buttressed with pledgets. The patient was successfully weaned from inotropes and extubated on postoperative day two, with no postoperative arrhythmias or cardiac dysfunction. ***Discussion:*** Both cases underscore the principle that time is myocardium in penetrating cardiac trauma. Early recognition through FAST and CT angiography, combined with prompt surgical access, remains the cornerstone of survival. This series demonstrates that even significant right-sided chamber injuries are survivable when managed with coordinated trauma protocols, rapid operative intervention, and meticulous cardiac repair techniques. ***Conclusion:*** Penetrating cardiac injuries, though rare, demand immediate action. These two cases illustrate that survival hinges on rapid diagnosis, aggressive resuscitation, and timely surgical repair. In resource-variable settings, establishing streamlined trauma pathways and ensuring early cardiothoracic involvement can dramatically improve outcomes. When seconds matter, a decisive surgical team can transform a near-fatal injury into a story of survival.

**Keywords:** Innovation, Strategy, Collaboration, Growth, Efficiency, Vision.



## INTRODUCTION

Penetrating cardiac injuries remain one of the most catastrophic forms of trauma, often described as a race against time in which survival is determined within minutes. Despite advances in pre-hospital care and trauma systems, mortality before reaching the hospital still exceeds 70–90%, emphasizing the lethal nature of cardiac violation within the confines of the pericardial sac. Even small myocardial lacerations can precipitate rapid accumulation of blood in the pericardium, leading to obstructive shock, cardiac tamponade, and cardiovascular collapse. For the minority of patients who survive long enough to present to a trauma centre, their outcome depends almost entirely on the speed of

recognition, adequacy of resuscitation, and immediate surgical intervention.

The anatomical vulnerability of the heart further shapes injury patterns. The right ventricle, forming the most anterior surface of the heart, is the most commonly affected chamber, followed by the right atrium. Stab wounds, which constitute the majority of survivable penetrating cardiac injuries, often produce linear, localized lacerations that can be sutured effectively when identified early. In contrast, gunshot wounds generate extensive, destructive energy transfer, resulting in high in-hospital mortality. Nevertheless, regardless of mechanism, early diagnosis remains the cornerstone of survival. E-FAST has emerged as an indispensable rapid bedside tool for detecting pericardial fluid, enabling near-instant recognition of tamponade. In hemodynamically responsive or transiently stabilized patients, contrast-enhanced CT can delineate the injury tract, identify associated thoracic injuries, and assist in operative planning without delaying definitive care.

The management of penetrating cardiac injuries has evolved, yet the principles remain grounded in urgency and precision. Median sternotomy continues to be the preferred approach for most anterior cardiac wounds, offering rapid access, wide exposure, and optimal control. Techniques such as pledgeted polypropylene suturing, adjunctive hemostatic materials, and careful visualization of adjacent structures are vital to achieving durable repair. Timely pericardial decompression, restoration of cardiac output, and coordinated multidisciplinary involvement from emergency physicians to trauma surgeons, cardiothoracic surgeons, and anesthesiologists form the backbone of successful outcomes.

In Malaysia, penetrating cardiac trauma is relatively uncommon, and published local experience remains scarce. As such, sharing institutional cases contributes meaningful insight into real-world challenges and reinforces best practices. This case series presents two survivors of penetrating right-sided cardiac injuries one involving the right atrium and the other the right ventricle managed at two major tertiary cardiothoracic centres. By examining their clinical presentation, imaging findings, operative strategies, and recovery trajectories, this report highlights the pivotal elements that transform a typically fatal injury into a survivable event. More importantly, it underscores a consistent message echoed across international literature: in cardiac trauma, survival is won by seconds, secured by skill, and sustained through teamwork.

## CASE PRESENTATION

**Case 1: Penetrating Right Atrial Injury [Hospital Sultanah Aminah Johor Bahru]**

A 42-year-old previously healthy male was brought to the Emergency Department after sustaining an anterior chest stab wound during an altercation. The knife remained embedded at the inferior aspect of the sternum upon arrival. He was pale, diaphoretic, and tachycardic, with an initial blood pressure of 90/60 mmHg and heart rate of 120 beats per minute. Peripheral perfusion was poor, and the patient reported worsening dyspnea and presyncope.

A focused E-FAST examination demonstrated a significant pericardial effusion with tamponade physiology. After transient stabilization with fluid resuscitation, the trauma team proceeded with contrast-enhanced CT of the thorax, which revealed a mediastinal hematoma extending inferiorly, hemopericardium with compression of the right cardiac chambers, and the knife tip abutting the anterior right atrium. No major aortic or pulmonary arterial injury was identified.

The patient was transferred emergently to the cardiothoracic theatre. A median sternotomy was performed, and upon opening the pericardium, approximately 300 mL of clotted and fresh blood was evacuated, relieving tamponade. The knife was still partially embedded through the pericardial reflection. Controlled extraction under direct vision revealed a 2 cm longitudinal laceration along the free wall of the right atrium near the atrioventricular groove.

The bleeding was brisk but contained using digital pressure and gauze packing. The defect was repaired using interrupted 4-0 polypropylene sutures buttressed with pledgets to prevent tearing of the thin atrial tissue. Hemostasis was confirmed, and the repair remained stable with no arrhythmias noted intraoperatively. The patient was extubated on postoperative day two and had an uneventful recovery. He was discharged well on day seven with preserved cardiac function and no pericardial effusion on follow-up echocardiography.

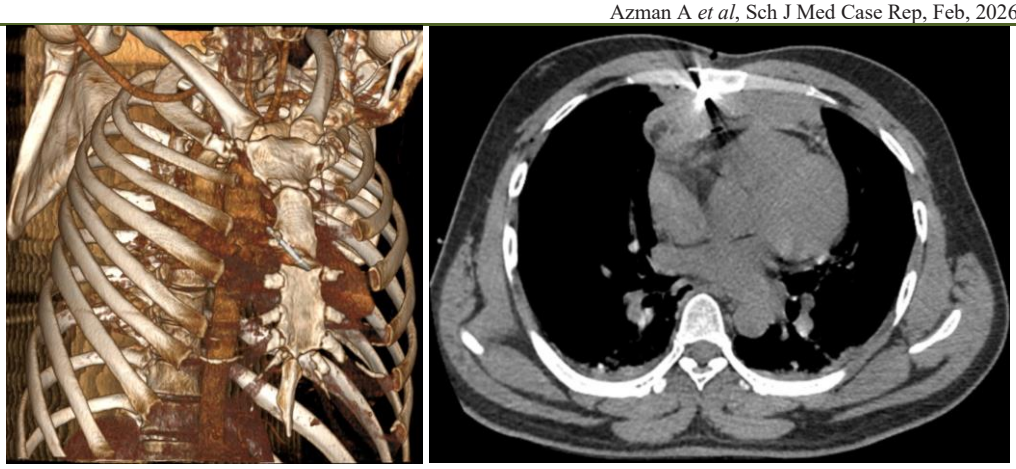

**Figure 1 & 2 : Contrast-enhanced computed tomography of the chest demonstrates a penetrating anterior chest wall injury with a retained knife traversing the lower sternum and projecting into the anterior mediastinum. Axial images reveal a hyperdense hemopericardium with associated mediastinal hematoma, consistent with acute cardiac penetration. The knife trajectory is directed posteriorly toward the cardiac silhouette, with its tip in close proximity to the right atrial/right ventricular region. No major thoracic vascular injury is identified. Three-dimensional volume-rendered reconstruction illustrates the transsternal entry point and retained foreign body, aiding visualization of the injury trajectory and surgical planning.**

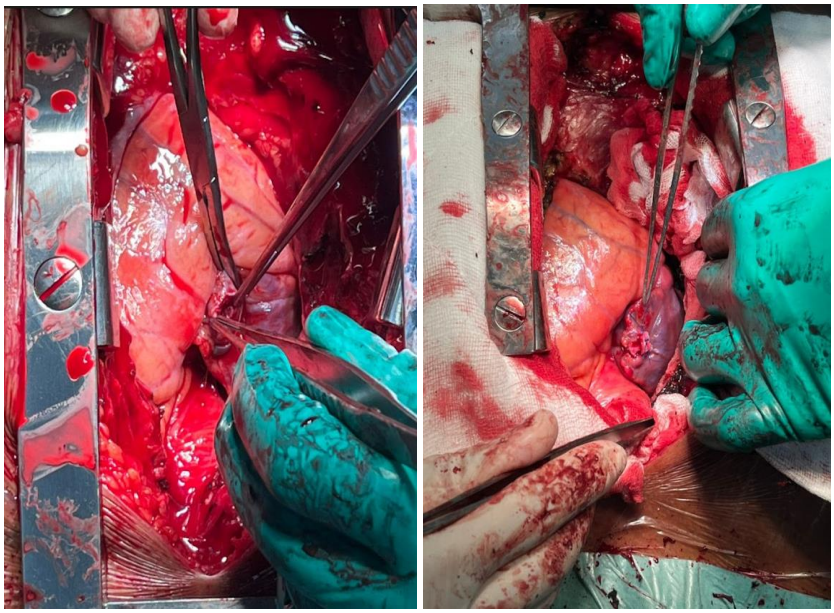

**Figure 3 & 4: Intraoperative photographs illustrating the penetrating cardiac injury involving the right atrial appendage. [Left] Initial exposure reveals a linear laceration at the right atrial appendage with active bleeding. [Right] post-repair view showing successful closure of the defect with prolene sutures.**

**Case 2: Penetrating Right Ventricular Injury [Hospital Canselor Tuanku Muhriz]**

A 47-year-old male with no known medical history presented following an assault in which he sustained a single stab wound to the left anterior chest. On arrival, he was confused, tachypneic [RR 32 breaths/min], and hypotensive with a blood pressure of 85/50 mmHg. His jugular venous pressure was elevated, and heart sounds were muffled, consistent with obstructive shock.

Rapid bedside E-FAST revealed a large circumferential pericardial effusion with features of tamponade. The patient responded minimally to fluid boluses. A CT scan was performed due to transient hemodynamic improvement; this demonstrated global hemopericardium with right ventricular contour flattening and a clear tract extending toward the anterior right ventricular free wall. No injury to the great vessels or lungs was observed.

Given the tamponade and suspected ventricular injury, the patient was taken immediately to the operating theatre. Median sternotomy was performed, and the pericardium was opened, releasing a large volume of blood and clot. A 1 cm puncture wound was identified on the right ventricular free wall, consistent with the trajectory observed on CT.

The injury site exhibited active oozing that was temporarily controlled with finger pressure. The ventricular defect was repaired with interrupted 4-0 polypropylene sutures reinforced with pledgets to support the friable myocardial edges, enhancing hemostasis. Hemostatic adjuncts were used to secure the repair, and ventricular contractility remained preserved throughout.

The patient demonstrated rapid postoperative improvement. He was extubated the following day and transferred out of the ICU on postoperative day two. He was discharged home on day three in stable condition, with no signs of pericardial collection or cardiac dysfunction on subsequent follow-up imaging.

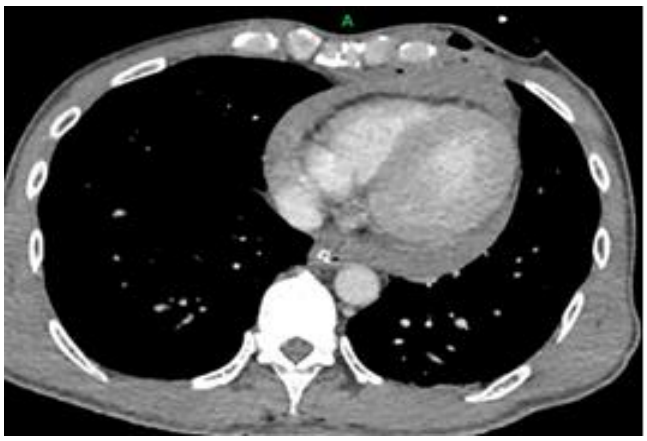

**Figure 5 & 6: Contrast-enhanced CT of the thorax demonstrates a penetrating anterior chest injury with a clear wound tract extending through the anterior chest wall toward the cardiac silhouette. There is a moderate circumferential hemopericardium, resulting in compression of the cardiac chambers, consistent with acute cardiac tamponade. Focal disruption of the anterior myocardial contour is noted, suspicious for penetrating cardiac injury, most likely involving the right-sided cardiac chambers given their anterior location. Associated anterior mediastinal hematoma is present. No contrast extravasation from the great vessels is identified, and there is no evidence of major thoracic vascular injury. Lung fields are otherwise clear, with no significant pneumothorax or hemothorax.**

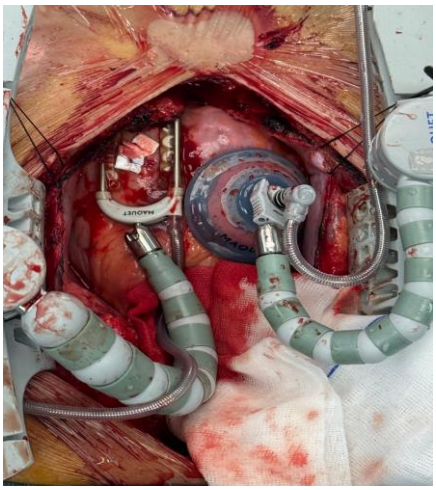

**Figure 7: Intraoperative view of right ventricular repair. The heart was stabilized using Octopus™ and Starfish™ cardiac stabilizers, as routinely employed in off-pump beating-heart surgery, to minimize cardiac motion and allow precise repair on the beating heart. The right ventricular defect was closed with interrupted polypropylene sutures reinforced with pledgets. This technique provided excellent tissue control, secure myocardial approximation, and complete hemostasis without the need for cardiopulmonary bypass.**

## DISCUSSION

Penetrating cardiac trauma remains one of the most lethal forms of thoracic injury, with pre-hospital mortality rates exceeding 80–90% according to major series [1]. Survival hinges on a critical interplay of rapid recognition, efficient resuscitation, and immediate operative control [2]. Our two cases one right atrial laceration and one right ventricular puncture exemplify how coordinated trauma workflows and timely sternotomy can convert near-fatal injuries into survivable events.

### Mechanism and Anatomical Vulnerability

The mechanism of injury significantly influences prognosis. Stab wounds generally produce localized myocardial lacerations, with more predictable

injury paths, and therefore offer better survival potential compared with ballistic trauma, which causes cavitation, fragmentation, and uncontrollable bleeding [3]. Among cardiac chambers, the right ventricle [RV] is most frequently injured due to its anterior position, accounting for up to 50% of cases [4], followed by the right atrium [RA]. These anatomical realities were reflected in our series, with one RV and one RA injury both classic patterns of anterior penetrating trauma.

Case 1 involved a retained blade embedded at the lower sternum with the tip abutting the right atrium. Literature strongly advises against field removal because uncontrolled extraction may precipitate massive hemorrhage [5]. Controlled removal under direct vision, as performed in our case, is the recommended approach.

Case 2 demonstrated the classical physiological consequence of penetrating myocardial injury rapid accumulation of pericardial blood resulting in tamponade. Even a small puncture in the RV can be fatal due to rapid pericardial filling and impaired diastolic filling [6]. This reinforces the principle that injury size does not correlate with physiological severity.

**Diagnostic Priorities: E-FAST and CT as Complementary Tools**

Early detection of hemopericardium is essential for survival. E-FAST provides rapid bedside assessment with high sensitivity [85–95%] for detecting pericardial fluid [7]. In both cases, E-FAST provided immediate confirmation of tamponade physiology and guided urgent surgical decision-making.

CT, when feasible in responsive patients, adds valuable anatomical detail. It identifies injury trajectories, quantifies mediastinal hematoma, and rules out associated great vessel injuries. The CT findings in both patients mediastinal hematoma and hemopericardium in Case 1, and global hemopericardium with RV contour changes in Case 2 were consistent with the diagnostic strengths of modern multidetector CT reported in contemporary trauma studies [8].

Combining E-FAST for rapid detection and CT for anatomical precision creates a highly effective diagnostic pathway in penetrating cardiac trauma.

**Surgical Management: Sternotomy and Myocardial Repair**

Median sternotomy remains the gold-standard approach for most penetrating cardiac injuries [9]. It provides wide exposure, allows rapid control of hemorrhage, and facilitates management of multi-chamber injuries or associated vascular trauma.

Both injuries were repaired using pledgeted 4-0 polypropylene sutures a widely accepted technique that prevents suture pull-through in friable myocardial tissue and ensures durable hemostasis [10]. In the RV injury, adjunctive hemostatic materials were used, reflecting current recommendations for reinforcing thin-walled ventricular tissue [9].

Pericardial decompression and removal of clot restored cardiac output immediately a critical step since tamponade is often the primary reversible cause of intraoperative instability.

**Outcomes and Comparison with Global Evidence**

The excellent recovery in both cases mirrors published survival rates of 60–80% for stab wounds managed with early surgical intervention [1,2]. Key predictors of survival include:

- arriving with signs of life [1]
- rapid diagnosis with E-FAST [7]
- transport to specialist centres with CT capability [8]
- immediate operative access [2]
- effective pledgeted repair [10]

Both patients were extubated early and discharged without complications, consistent with outcomes reported in systematic reviews of surgically managed penetrating cardiac trauma [3,6].

**These cases highlight several essential lessons:**

1. Survival is time-dependent delays in diagnosis or operative access drastically worsen mortality [1].
2. Even small injuries can be fatal if tamponade physiology develops [6].
3. Simple, rapid techniques save lives pledgeted sutures remain the cornerstone of repair [10].
4. Team coordination is as important as surgical skill, especially in resource-limited or mixed-acuity trauma settings [2].

## CONCLUSION

Penetrating cardiac trauma remains one of the most unforgiving emergencies in cardiothoracic surgery, where survival is measured in minutes and outcomes are determined long before the patient reaches the operating theatre. Our two-case series involving right atrial and right ventricular stab injuries demonstrates that even in the face of life-threatening physiology, survival is achievable when rapid diagnosis, decisive action, and coordinated multidisciplinary teamwork converge at the right moment.

Both cases highlight several universal truths in cardiac trauma care. First, timely recognition of tamponade physiology remains the single most crucial determinant of survival. The integration of E-FAST as a frontline diagnostic tool provides invaluable speed, enabling early activation of the surgical pathway before hemodynamic collapse occurs. Second, CT imaging, when feasible, adds anatomical precision that guides

operative planning, particularly in patients who remain transiently responsive. Together, these modalities create a complementary diagnostic strategy that minimizes delay and maximizes surgical clarity.

Equally essential is the principle of immediate surgical access, with median sternotomy continuing to provide the safest and most versatile exposure for penetrating cardiac injuries. The use of pledgeted polypropylene sutures, with or without adjunctive hemostatic reinforcement, remains the gold standard for definitive myocardial repair. These techniques, though simple, are time-tested and continue to deliver excellent results across trauma centres worldwide. Our patients' rapid postoperative recovery and early discharge underscore the durability and effectiveness of these surgical fundamentals.

At a broader level, these cases reinforce the importance of system readiness from pre-hospital stabilization and emergency department triage, to imaging availability, operating room preparedness, and the seamless coordination between trauma, anesthesia, and cardiothoracic teams. When these components align, even patients with catastrophic injuries can be given a genuine chance at survival.

Ultimately, this dual-centre experience affirms a powerful central message: in penetrating cardiac trauma, speed saves, skill sustains, and teamwork heals. Time is myocardium, and collective effort is life. By embracing rapid recognition, immediate intervention, and unwavering surgical precision, we can continue transforming what should be fatal injuries into stories of survival, recovery, and restored futures.

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