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CASE REPORT
Cardiac imaging

A case report of an aorto-pulmonary-venacaval fistula after penetrating cardiac injury

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Background Penetrating cardiac injury (PCI) is an accepted burden in high violent crime areas. Traumatic intracardiac fistulae are however not that commonly detected on initial presentation, with most of these injuries being detected post-operatively or at routine follow-up. The literature is devoid of general principles around the pre-operative planning and intra-operative management in these cases, and thus warrant documented case reports by clinical units experienced in the management of these challenging clinical scenarios.

Case summary We describe a case report of a 29-year-old male patient presenting to our Cardiothoracic Unit with an aorto-pulmonary-venacaval fistula after a traumatic PCI. We describe the clinical presentation, diagnostic challenges, and institutional experience in the operative management of this case.

Discussion The patient was treated successfully with repair via sternotomy and femoral cardiopulmonary bypass with no neurological, pulmonary, or cardiac sequelae at early follow-up. The importance of selective pre-operative imaging in PCI, appropriate pre-operative surgical planning, and surgical experience in the management of these injuries is highlighted in this case presentation.

Keywords Echocardiography • Cardiac injury • Penetrating injury • Case report

Learning points

- Pre-operative cardiac ultrasound, where available, is warranted in unstable penetrating cardiac injuries with qualitative imaging techniques reserved for haemodynamically stable or select transiently stable patients, most notably in those in whom an intracardiac injury is suspected.
- Intra-operative transoesophageal ECHO may be beneficial in identifying intracardiac fistulae, especially in haemodynamically unstable patients with no formal pre-operative transthoracic cardiac ECHO and where an intracardiac injury is suspected clinically.
- Penetrating ascending aortic injuries, regardless of their size should undergo repair with an appropriate pre-operative heart team assessment.
- Small cardiac defects should undergo repair using pledgeted and non-pledgeted prolene sutures. Synthetic or biological patch repairs are reserved for larger defects.

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Introduction

Penetrating cardiac injury (PCI) is an accepted burden in high violent crime areas, especially in developing countries like South Africa and Brazil.[1,2] Diagnosing intracardiac fistula in the acute setting is a challenge and can most likely be attributed to the initial haemodynamic instability and urgent need for operative intervention outweighing the waiting period for formal transthoracic cardiac ECHO (TTE), associated with the absence of transoesophageal ECHO (TOE) in non-cardiac operating theatres.

Case presentation

A 29-year-old male presented to the Emergency Department with a penetrating stab wound to the anterior left second intercostal space, 2 cm medial to the mid-clavicular line. Previous medical history consisted of a right tibia-fibula fracture with intra-medullary nailing 7 years prior.

The patient presented haemodynamically unstable, in grade 3 haemorrhagic shock[3] and after resuscitation, improved as a transient fluid responder. A left-sided intercostal drain was inserted for a large haemothorax. Vital signs after resuscitation: heart rate 100; respiratory rate 14; saturating at 95% on room air; blood pressure 101/64.

Timeline

Admission Day	Assessment	Findings	Management
Day 1	**A 29 year-old male.** **Presents with Acute Penetrating Cardiac Injury**	Precordial stab at 2nd intercostal space, midclavicular line • Haemodynamically unstable • Grade 3 shock • Left Haemothorax • Previous medical history consisted of a right tibia-fibula fracture with Intra-medullary nailing	❖ Guided Fluid Resuscitation ❖ Left sided Intercostal Drain Inserted ❖ FAST scan demonstrates 1cm pericardial effusion
Day 1	**Re-assessment after Resuscitation**	• HR 100 • RR 14 • Saturating at 95% on Room air • BP 101/64	CT ordered for Proximity of injury to great vessels
Day 1	**Contrast CT**	❖ Right ventricular outflow tract injury (RVOT) ❖ Suspected thrombus. ❖ Aortic root injury ❖ Suspected IVC injury	❖ Cardiothoracic Surgery Referral ❖ Formal Transthoracic ECHO ordered
Day 1	**Transthoracic ECHO**	❖ Suspected clot beneath pulmonary valve ❖ No features for SBE ❖ Tamponade ❖ No valvulopathies or RWMA's ❖ Preserved LVEF (%) ❖ No intracardiac shunt	
Day 1	**Surgery**	❖ Large clot with defect in the medial wall of the RVOT, abutting the ascending aorta ❖ A 0.5cm laceration in the aortic wall, about 1mm left of the right coronary ostium ❖ Defect in contralateral side of the ascending aorta ❖ small point injury to the base of the superior vena cava	❖ RVOT defect was closed with a single pledgeted suture ❖ Left aorta defect was repaired primarily using 5/0 Prolene sutures ❖ Right Aortic defect repaired with incorporation into aortic closure ❖ The SVC was repaired with a single 4/0 Prolene suture
Day 7	**Discharge**	Uncomplicated Admission	
Day 30	**Follow Up**	Clinical: No Respiratory, Cardiac or Neurological sequelae TTE: No residual thrombus or intra-cardiac shunt	

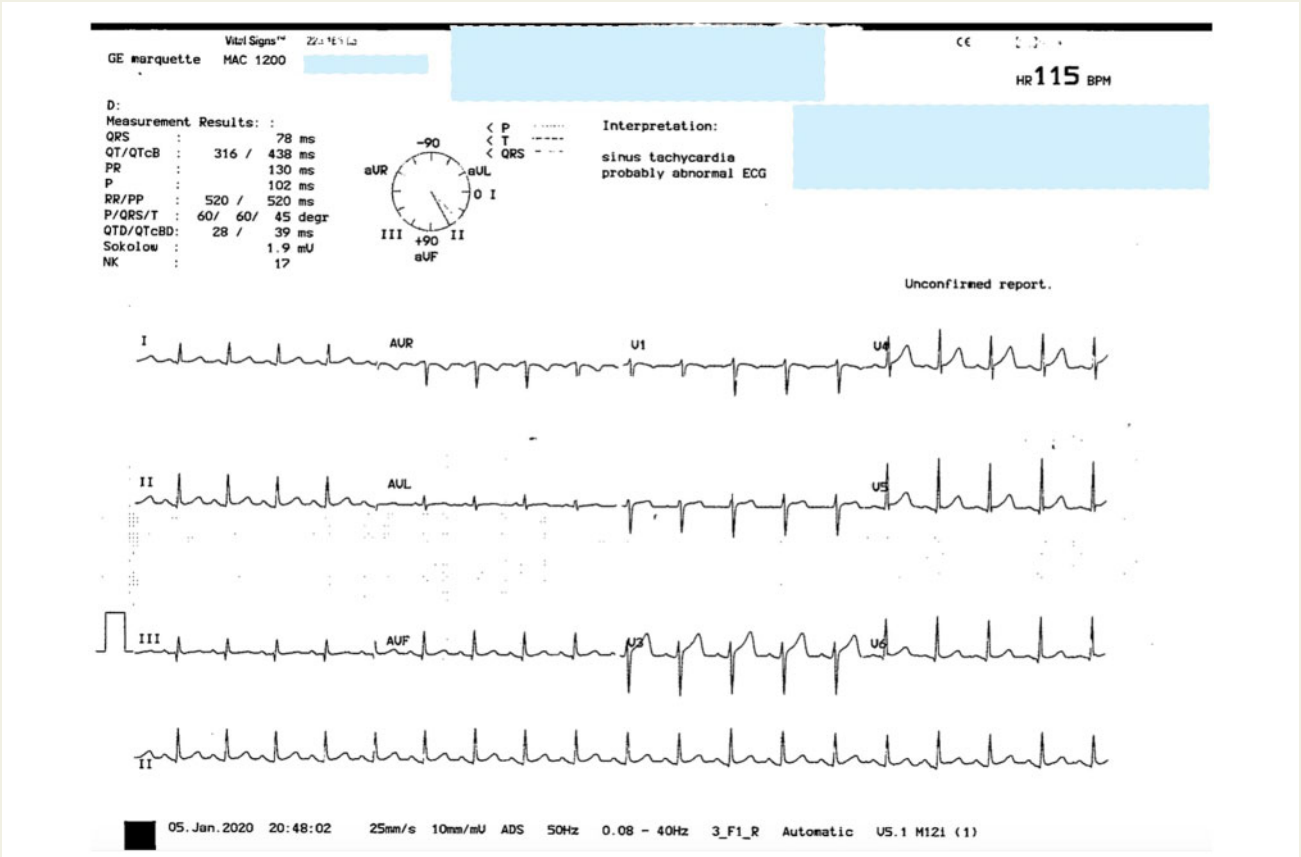


Figure 1 Electrocardiogram post-resuscitation.

Post-resuscitation, no angina was reported. On examination: no features of cardiac failure, central cyanosis, bruits, or murmurs were elicited. No ST or other rhythm abnormalities were noted on electrocardiogram (*Figure 1*). Pertinent findings were that of chronic septic hardware of the right lower limb which on further enquiry, had not been formally assessed by an orthopaedic service. Microbiological workup of the local septic limb was deferred until after haemodynamic stabilization.

A preliminary diagnosis of local septic hardware led to screening for methicillin-resistant *Staphylococcus aureus*, and antibiotic prophylaxis with broad-spectrum coverage.

Focused Assessment with Sonography for Trauma scan demonstrated a 1 cm pericardial effusion. A contrasted computed tomographical scan of the chest and cardiac TTE was ordered.[4]

Computed tomographical findings (*Figure 2* and *Video 1*) demonstrated a right ventricular outflow tract (RVOT) injury at the level of the pulmonary valve and an associated suspected thrombus. A small aortic root injury with a small pseudo-aneurysm and intimal flap was also observed. The injury tract extended to the medial superior vena cava (SVC) and a high index of suspicion for an SVC injury was entertained.

Transthoracic cardiac ECHO (*Figure 3* and *Video 2*) findings did not demonstrate valvulopathies, clear flow reversal or shunting, regional wall motion abnormalities, tamponade, or features of infective endocarditis. The patient had a preserved left ventricular ejection fraction.

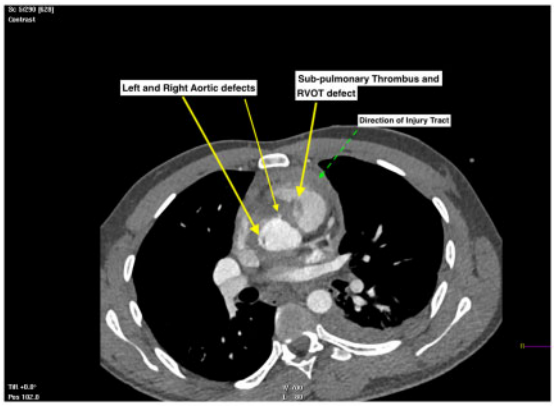
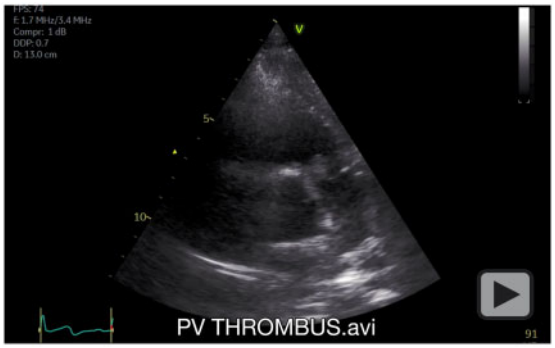


Figure 2 Non-gated contrast computed tomography of the chest. RVOT, right ventricular outflow tract.

A large dense lesion was noted immediately beneath the pulmonary valve which demonstrated beat to beat movement and was noted to be highly suggestive of a clot.

Pertinent laboratory findings showed that the patient had normal renal and liver function with a normocytic normochromic anaemia

Video 1 Non-gated contrast computed tomography of the chest.



Video 2 Transthoracic ECHO demonstrating a sub-pulmonary thrombus with beat-to-beat variation.

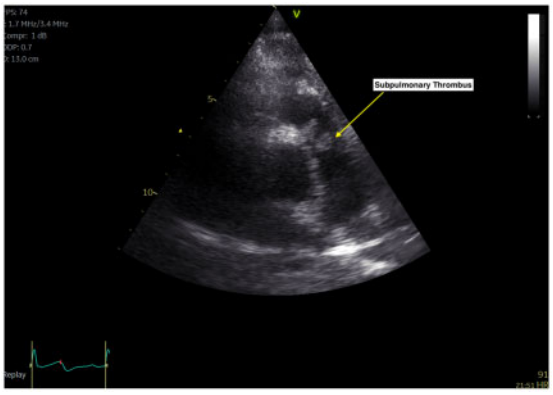


Figure 3 Pre-operative transthoracic cardiac ECHO demonstrating a sub-pulmonary thrombus and no intracardiac shunt.

Figure 4 Patient is intubated and prepared for surgery (note the left-sided intercostal drain and haemothorax).

(haemoglobin = 10.9) and no coagulation abnormalities (normal prothrombin and partial thromboplastin time).

The patient was intubated under general anaesthesia with a single lumen endotracheal tube (*Figure 4*). Femoral cardiopulmonary bypass was initiated via the left groin. A median sternotomy was performed and no active bleeding was seen.

The aorta was then clamped and the heart arrested with cold blood cardioplegia administered into the aortic root. Cardioplegia was given every 20 min throughout the procedure.

A large clot was found within a defect in the medial wall of the RVOT, abutting the ascending aorta, and was subsequently removed. The RVOT was repaired with continuous 3/0 prolene sutures.

The aorta was opened via a transverse 'J' incision (*Figure 5*). There was a 0.5 cm laceration in the aortic wall, ~1 mm left of the right coronary ostium which was repaired primarily. The plane between the main pulmonary artery (PA) and ascending aorta was dissected and opened. The right coronary artery was not injured. The contralateral side of the ascending aorta (right side) also had a defect through it

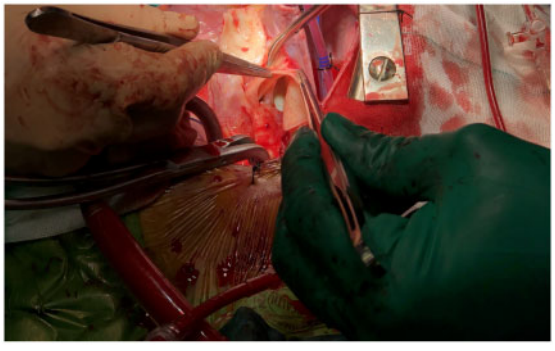


Figure 5 Aorta is opened and the aortotomy is inspected.

and there was a small point injury to the base of the SVC which were both primarily repaired.

Pre-operative radiological findings had a good correlation with the intra-operative findings and no other intra-operative injuries were noted.

The patient was weaned off of cardiopulmonary bypass and closure of the femoral cannulation site, and sternum was performed successfully. The patient remained intubated and was transported to intensive care unit.

A complete recovery was made with no residual thrombus or intracardiac shunt at early follow-up. There was no cardiac, respiratory, or neurological sequelae at 30-day follow-up.

Discussion

In this case, we were fortunate that the patient was a transient fluid responder, which made the amenability to undergo further imaging, possible. Intracardiac fistulae are rarely detected or repaired at index surgery in unstable patients and this is largely ascribed to the diagnostic limitation in the pre-operative assessment of these patients as well as the relatively unstable haemodynamic profile seen intra-operatively. Further enquiry exists as to how often intracardiac fistulae are missed at index surgery and whether formal TTE operators who can screen for, and quantify fistulae, should be made more readily available in emergency centres with a high burden of PCI.

The mechanism of injury, and the associated injury tract should be correlated with knowledge of the underlying anatomy in order to determine the pre-test probability of a cardiac, great vessel, or other organ injury.

Advanced imaging with high-resolution multi-slice techniques and gating may demonstrate injury tracts more clearly in the former and the latter may assist in removing motion artefact. Delaying surgery for the purposes of prioritized imaging is an accepted diagnostic approach, and although concern for an acute haemorrhage with resultant tamponade is a low, it is an accepted risk.

Although we excluded infective endocarditis in our patient, the ECHO features of a PCI with a sub-pulmonary mobile mass, in the setting of a local septic focus, should raise suspicion for possible concomitant infective endocarditis and should not be ignored or assumed to be solely related to the traumatic aetiology.

The prognosis and role of surgery in traumatic aorto-pulmonary fistulas are uncertain due to a lack of any population study conducted in this group with only a few documented cases reporting the beneficial role of surgery.[5] The poor prognosis associated with a pseudoaneurysm and intimal flap of the ascending thoracic aorta determined the urgency of surgery in our case, and was largely guided by the European Association for Cardiothoracic Surgery (EACTS) and the American Heart Association (AHA) Guidelines on thoracic aorta disease, which recommend urgent open surgery for ascending aortic intimal defects with, or without intramural haematoma, regardless of the size of the defect.[6,7] These guidelines are largely based on the natural history of these injuries which although variable, has a risk of dissection, or rupture with tamponade, present in 90% of some cases with only 10% of these intimal defects resolving spontaneously.

Transoesophageal ECHO where available should be employed for all penetrating cardiac injuries undergoing operative repair. The question that arises: in patients who are often too unstable for pre-operative TTE, and that present with close proximity injuries to the RVOT and pulmonary valve, or where TOE services are not readily available, is should the tissue plane between the aorta and PA be routinely explored for potential aortic injuries that are not suspected clinically?

The resultant drop in intrathoracic pressure after sternotomy may potentially lead to a higher-pressure gradient at injury sites with potential dislodgment of a temporizing thrombus and massive exsanguination. Thus, femoral cardiopulmonary bypass prior to surgical incision in patients presenting with acute traumatic great vessel fistulas is our preferred method when compared to routine open-cardiac bypass.

Primary repair of penetrating cardiac injuries using pledgeted prolene sutures is our preferred method for small cardiac defects. Repair with pericardial patch (autologous or bovine) or synthetic material is reserved for larger defects.

Conclusion

The importance of selective pre-operative imaging in PCI, appropriate pre-operative surgical planning, and surgical experience in the management of these injuries is highlighted in this case presentation.

Appropriate pre-operative imaging enabled accurate planning and surgical repair via sternotomy and femoral cardiopulmonary bypass, with no neurological, pulmonary, or cardiac sequelae at early follow-up.

Lead author biography

Johannes Gerhardus Koen is an Epidemiologist and is currently practising as a specialist registrar in Cardiothoracic Surgery at Tygerberg Hospital and the University of Stellenbosch, in Cape Town, South Africa.

Supplementary material

Supplementary material is available at *European Heart Journal - Case Reports* online.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The author/s confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patient in line with COPE guidance.

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Conflict of interest: none declared.

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