Conservative management of aortic arch injury following penetrating trauma

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ABSTRACT

Aortic arch injuries following penetrating trauma are typically lethal events with high mortality rates. Traditionally, the standard of care for patients presenting with penetrating injury and aortic involvement has included surgical intervention. We report the case of a 31-year-old man who was managed non-operatively after sustaining multiple stab wounds to the left chest and presenting with mid aortic arch injury.

KEYWORDS

Endovascular – Trauma – Thoracic aorta

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Historically, penetrating injury to the thoracic aorta has been associated with mortality rates greater than 90% and it has one of the poorest prognoses of all penetrating injuries.¹ The majority of patients die at the scene and those who do arrive at hospital are usually in critical condition.

Despite advances in trauma management and the development of dedicated trauma centres, morbidity and mortality rates have remained relatively unchanged in patients with penetrating aortic injury (PAI).¹ The incidence of penetrating trauma to the aortic arch is not well documented as most patients exsanguinate before receiving treatment.² In an autopsy study from Athens, the authors found that traumatic aortic injury was responsible for 12.7% of all injury related fatalities and penetrating trauma was responsible for 13.6% of those deaths.² Also reported was the finding that the aortic arch along with the ascending aorta were the most common site of thoracic aortic injury following stab wounds.

In patients who present with PAI, operative management is the norm and currently, there are no recommendations for conservative management. This is opposed to blunt aortic injury (BAI), where non-operative management has been explored and guidelines have been proposed by the Society for Vascular Surgery.³ We present the case of a patient who was managed conservatively following an aortic arch injury secondary to penetrating trauma with strict blood pressure control and outpatient surveillance.

Case History

A 31-year-old man received via the emergency medical services presented to our emergency department (ED) shortly after sustaining multiple stab wounds to the left anterior chest, left axilla and left upper extremity. En route, the

patient's blood pressure was 112/70mmHg and he had a pulse rate of 80bpm. He was diaphoretic at the scene, which improved on arrival to the ED. A standard *Advanced Trauma Life Support*® approach was initiated immediately in the trauma bay.

The patient was sent for computed tomography (CT) of the chest with contrast in a stable condition. The CT revealed a left upper lobe laceration, a large left haemothorax, a small left pneumothorax and extensive haemorrhages in the mediastinum surrounding the aortic arch with a hint of tiny extrusion at the aortic arch but no obvious source of bleeding. A chest tube placed into the left haemothorax put out 1,800ml serosanguinous drainage in the first 24 hours. The subsequent CT angiography (CTA) revealed a nodule of contrast at the mid aortic arch. A mid aortic arch injury could not be distinguished on the CTA from a laceration of the arterial/venous branch vessel in the mediastinum.

The patient was then transferred to the surgical intensive care unit for monitoring. His blood pressure on transfer was 113/67mmHg and his heart rate was 74bpm. The cardiothoracic surgery service was consulted and the patient was started on an esmolol drip that was titrated to maintain his systolic blood pressure between 90mmHg and 110mmHg.

Formal aortography performed on day 2 ruled out active arterial laceration but was consistent with a pseudoaneurysm at the mid aortic arch. The repeat aortography performed on day 6 revealed a slight increase in the size of the pseudoaneurysm. The follow-up CTA on days 3 and 9 demonstrated a contrast protrusion of 2.6mm x 3.0mm and 2.2mm x 2.0mm respectively at the mid aortic arch. These findings were consistent in location with the CTA from the day of admission.

Cardiothoracic surgery showed the aortic injury was stable. After lengthy discussion with the patient and his family,

it was decided to proceed with non-operative management. The patient's hospital course was uncomplicated. On day 10, he was discharged with instructions to take metoprolol 50mg twice daily for blood pressure control, to refrain from all strenuous activity and to attend regular follow-up appointments as an outpatient with surveillance imaging. CTA at four days after discharge revealed enlargement of the focus of enhancement adjacent to the aortic arch measuring 4.5mm x 3.5mm.

Discussion

Penetrating trauma involving the thoracic aorta is often fatal with a low survival rate. A review of the literature highlights the following recommendations for managing this type of injury.

Since the majority of patients with PAI die of haemorrhage secondary to their injuries, it is crucial to minimise the period between the accident and presentation at the nearest hospital. The 'scoop and run' approach is preferred as any delays reduce the survival rates. This has been documented by studies demonstrating higher incidence of complications or death in the paramedic transported group than in the non-paramedic group.⁴ Additionally, intravenous fluid resuscitation before surgical control compared with delayed resuscitation has been associated with poorer survival outcomes. This association may be secondary to the protective effect of hypotension in reducing bleeding or through reducing the time between injury and presentation.^{4,5}

Since the majority of patients with PAI present in critical condition, many require an immediate ED thoracotomy. In these cases, the diagnosis is confirmed operatively.⁴ The opening incision is made on the same side as the suspected side of injury.^{4,5} The left anterolateral thoracotomy in the supine position is often the most appropriate with excellent exposure to the heart and aorta.^{4,6} If necessary, a transsternal extension is made to the opposite haemothorax (clam-shell incision) for access to the right lung hilum, ascending aorta and right subclavian vessels. Bleeding is controlled through direct pressure or vascular clamping. For injuries to subclavian vessels, balloon tamponade can be used to gain control of the bleeding behind the clavicle until definitive control can be achieved in the operating room. With the descending aorta cross-clamped, cardiac massage can be performed to attempt resuscitation. The overall survival rates in cases requiring emergency thoracotomy is poor, ranging from 9% to 12%.^{4,5}

The diagnosis of PAI can be reached from a focused history and physical examination when patients are more stable on presentation although a vascular injury may be masked by concomitant injuries to other vital structures in the thorax in haemodynamically normal patients.⁶ With penetrating thoracic trauma, patients can present with haemorrhage, pericardial tamponade or systemic air embolism.⁵ The most important screening tool is anteroposterior chest radiography with suggestive findings for PAI listed in Table 1.^{6,7}

Patients who are haemodynamically normal with abnormal findings suggestive of a vascular injury should receive

Table 1 Suggestive findings for penetrating aortic injuries on chest radiography

1. Superior mediastinal widening >8cm and/or 25% of the width of the thorax (*most common finding*)
2. Depression of the left mainstem bronchus of >140°
3. Loss of the aortic knob
4. Deviation of the nasogastric, endotracheal or oesophageal tubes to the right
5. Fracture of the first or second rib, scapula or sternum
6. Left apical pleural cap
7. Obliteration of the aortopulmonary window on lateral chest radiography (*sensitive finding*)
8. Anterior displacement of trachea on lateral chest radiography
9. Fracture dislocation of thoracic spine
10. Calcium layering in aortic knob area
11. Obvious double contour of aorta/abnormalities of the transverse aortic arch (*sensitive finding*)
12. Multiple left rib fractures
13. Massive haemothorax

aortography, the gold standard test, to confirm the diagnosis and facilitate operative planning. Alternatively, transoesophageal echocardiography (TOE) can be used to assess patients who must be transported immediately to the operating room although this technique is not as sensitive or specific (85.7% and 92.0% respectively) as aortography (89.0% and 100% respectively) in evaluating aortic injury and it is heavily operator dependent.⁶ Another limitation of TOE is poor evaluation of the distal ascending aorta and proximal aortic arch, which may be obscured by tracheal and bronchial air artefacts.⁸

In patients with a high index of suspicion for aortic injury but presenting with a benign physical examination and normal chest radiography, delayed chest radiography or contrast enhanced CT of the chest should be performed to rule out aortic injury.^{7,8} CT of the chest has become the standard screening tool to rule out aortic disruptions as sensitivity and negative predictive value of the test approach 100%.⁸ Signs of traumatic aortic injury on CT are listed in Table 2.⁷

Traditionally, immediate aortic repair is recommended for all patients with aortic injury and without associated injuries requiring emergency laparotomy, craniotomy or pelvic stabilisation.⁸ If surgical management is delayed for a contained aortic injury, patients should be managed aggressively with short acting beta-blockers to reduce the

Table 2 Computed tomography findings consistent with penetrating aortic injuries

1. Presence of an intimal flap
2. Traumatic pseudoaneurysm
3. Contained rupture
4. Intraluminal mural thrombus
5. Abnormal aortic contour
6. Sudden change in aortic calibre (pseudocoarctation)

Table 3 Indications for urgent surgical intervention in penetrating aortic injuries

1. Initial loss of 1,500ml of blood from a tube thoracotomy
2. Continuing haemorrhage of >200ml/hr from tube thoracotomy
3. Post-traumatic haemopericardium
4. Pericardial tamponade
5. Exsanguinating haemorrhage presenting from supraclavicular penetrating wound
6. Imaging evidence of acute thoracic great vessel injury
7. Radiographic or other imaging evidence of chronic thoracic great vessel injury complications

ongoing wall stress sustained by the aorta and in-hospital aortic rupture rates.⁸ Indications for urgent surgical intervention associated with PAI are listed in Table 3.⁶

Of note, chronic pseudoaneurysms of the aorta can occur following undiagnosed traumatic aortic injury.⁹ These patients present with symptoms of mass effect secondary to aneurysmal expansion and should be operated on unless contraindications are present.¹⁰

The choice of opening incision is based on the location of injury. For access to the aortic arch as well as the ascending thoracic aorta, a median sternotomy can be performed.^{4,11} Further exposure of the transverse arch can be obtained if necessary by extending the median sternotomy incision to the neck and dividing the innominate vein. Small anterior or lateral lacerations can be repaired primarily with running 4/0 polypropylene sutures following proximal and distal control of the aorta. Larger, complex injuries may require reconstruction with the use of interposition grafts and cardiopulmonary bypass for repair.^{6,11}

Although spinal cord protections with adjuvant perfusion techniques are not commonly used for acute management of penetrating injury, ischaemic damage is uncommon in survivors of PAI.⁴ Alternatively, in studies investigating paraplegia following repair of the descending thoracic aorta following BAI, the overall incidence of postoperative paraplegia averages 8%.⁶ PAI to the aortic arch is associated with the highest mortality compared with other locations, with intraoperative exsanguination being the leading cause of death.¹² The use of deep hypothermic circulatory arrest with cardiopulmonary bypass has been postulated in the management of PAI whenever possible as it can prevent uncontrollable intraoperative haemorrhages.¹³

During the early postoperative period, pulmonary complications such as atelectasis, pneumonia and acute respiratory distress syndrome are most common.⁶ Aggressive pulmonary toileting and adequate pain control are therefore crucial to postoperative care. Survivors of PAI are usually a self-selected group with small, contained penetrations or fistulous communications between the thoracic aorta and adjacent veins.^{4,14} Rarely, an aorto-oesophageal fistula may develop and present later with massive haemoptysis.

In addition to the traditional open approach to surgical repair of aortic injury, the endovascular approach has been evaluated as an alternative in recent years. Compared with

the open procedure requiring thoracotomy, aortic cross-clamping and/or cardiopulmonary bypass with an overall mortality rate of 28% and a paraplegia rate of 16%,¹⁵ the endovascular approach is less invasive and better tolerated by patients with severe illness, older age, other co-morbidities or associated injuries such as open/closed head injuries, bleeding abdominal visceral injury, retroperitoneal bleeding and pulmonary contusions.⁸

The optimal patients for consideration are those who can maintain stable mediastinal supporting connective tissue as well as a relatively low and stable blood pressure.¹⁴ Consequently, injuries to the descending thoracic aorta are more amenable to endovascular options owing to their location and stability while injuries proximal such as the aortic arch are rarely candidates as these patients typically require more immediate surgical intervention.¹⁴ Special considerations for the endovascular approach are the requirement of an adequate 'seal or landing zone' for the stent graft as well as an adequate size vessel to deliver the device through 18–24Fr sheaths.¹⁴

Although there are no guidelines supporting conservative management of PAI, there has been growing interest in the literature investigating non-operative approaches to BAI given the development of higher resolution CT being able to detect aortic injuries of lesser severity, the morbidity and mortality associated with an open repair operation, and the unknown durability of endovascular repair.¹⁶ The goal of medical management in BAI is to reduce aortic shear forces with the use of antihypertensive medications and negative inotropes along with surveillance for disease progression through regular clinical and radiographic follow-ups. According to guidelines from the Society for Vascular Surgery, type I aortic injuries defined as an isolated intimal tear can be managed expectantly with serial imaging.⁵ The rationale is that type I injuries are likely to heal spontaneously.^{5,16} More severe injuries (type II [intramural haematoma], type III [pseudoaneurysm] and type IV [rupture]) require surgical intervention.

Our patient was discharged with instructions to take metoprolol 50mg twice daily for blood pressure control, refrain from all strenuous activity and attend follow-up appointments as an outpatient with regular surveillance imaging. Although follow-up CTA of the chest demonstrated enlargement of focus/enhancement adjacent to the aortic arch, blood pressure was controlled adequately and the patient was asymptomatic. Reasonable surveillance would include repeating CTA at one week and six months after discharge. Of note, adequate blood pressure control with beta-blockade is of paramount importance.

Conclusions

Surgical intervention in patients with aortic arch injury following penetrating trauma can be delayed in certain situations. For patients who are haemodynamically stable, with minimal aortic injury, and who can be surveyed reliably in the long term, the non-operative approach afforded to BAI could be explored in PAI for the same reasons ascribed above for BAI.

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