Repair of a penetrating aortic arch injury using deep hypothermic circulatory arrest and retrograde cerebral perfusion

George Samanidisa,*, Stergios Dimitrioua, Athanasios Sakorafasb and Mazen Khourya

a 2nd Department of Adult Cardiac Surgery, Onassis Cardiac Surgery Center, Athens, Greece
b Department of Perfusion, Onassis Cardiac Surgery Center, Athens, Greece
* Corresponding author. 2nd Department of Adult Cardiac Surgery, Onassis Cardiac Surgery Center, 356 Syggrou Av., 17674 Athens, Greece.
Tel: +30-3-2109493000; e-mail: gsamanidis@yahoo.gr (G. Samanidis).

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Abstract

The traumatic rupture of the thoracic aorta is a severe and life-threatening entity. The incidence of penetrating trauma to the aortic arch is not known, because most patients die of haemorrhage even before they receive adequate treatment. Clinical signs of such injuries include external or internal haemorrhage, bruit, distal pulse deficit, neurological deficit and shock. We present a 42-year old female with a penetrating aortic arch injury successfully repaired using deep hypothermic circulatory arrest and retrograde cerebral perfusion.

Keywords: Aortic arch • Aortic trauma • Deep hypothermic circulatory arrest • Retrograde cerebral perfusion

INTRODUCTION

Stab wounds and gunshot wounds comprise a vast majority of penetrating thoracic injuries. The overall mortality of thoracic aortic injuries is more than 90% [1].

The injury is usually diagnosed by an abnormal chest X-ray, followed by a more definitive study such as computed tomography (CT) or magnetic resonance imaging (MRI) of the chest.

Deep hypothermic circulatory arrest (DHCA) offers the optimal exposure to the aortic arch in a bloodless field and enables the surgeon to inspect the entire aortic arch from within the lumen.

We present a 42-year old female with a through-and-through penetrating aortic arch injury and successful repair using DHCA with retrograde cerebral perfusion (RCP).

CASE REPORT

A 42-year old female was brought to the emergency department after she had been shot with an airgun. A 4-mm wound was noted on the left anterior chest wall at the third intercostal space in the midclavicular line with no palpable underlying pellet. On presentation, the patient had a heart rate of 98 bpm, a blood pressure of 110/70 mmHg and a blood oxygen saturation of 100% on room air. Transthoracic echocardiography showed no pericardial effusion. The chest X-ray demonstrated a pellet within the mediastinum, with a lateral view confirming this to be in the posterior mediastinum. No haemothorax or pneumothorax was seen (Fig. 1a and b).

Within a few minutes, the patient developed an increased heart rate (130 bpm) and a lower blood pressure (80/50 mmHg). A new chest X-ray was performed and it showed a left haemothorax. A chest tube was inserted into the left hemithorax, and a multidetected CT (MDCT) was performed, which showed a widened mediastinum, left haemothorax and a haematoma near the aortic arch, with the bullet entry and exit points in the anterior and the posterior wall of the aortic arch, respectively (Fig. 1c). The pellet was identified in the stomach (Fig. 1d). These MDCT findings confirmed the suspicion that the foreign body had penetrated the anterior chest wall, left lung, anterior and posterior aortic arch wall as well as the oesophagus.

The patient was immediately taken to the operating theatre, where a median sternotomy was performed and a nasogastric tube was inserted. A penetrating injury in the left upper lobe (LUL), haematomas along the left phrenic nerve up to the left hemidiaphragm, posterior mediastinum, the anterior wall of the distal aortic arch and the posterior wall of the mid-aortic arch and blood in the left hemithorax were observed once the sternum, hemithoraces and pericardium were opened (Fig. 2a). Cardiopulmonary bypass (CPB) was established along with cannulation of the ascending aorta and the right atrium. During cooling, the entry and exit points of the bullet in the LUL were repaired. When the core temperature was ≈18°C, using α-stat, RCP was started thus resulting in circulatory arrest. Heart arrest was achieved with retrograde cold blood cardioplegia. The head was packed in ice. After circulatory arrest, a longitudinal incision ≈4 cm in front of the branches of the aortic arch was performed. The entry point in the anterior wall of the distal aortic arch and the exit point in the posterior wall of the mid-aortic arch were identified and repaired with 4-0 Prolene sutures. The longitudinal incision of the aortic arch was sutured with 4-0 Prolene with a reinforced strip of Teflon (Fig. 2b). The total duration of CA was 35 min. The patient could easily be weaned off bypass at normothermia and the surgery was completed under stable haemodynamic conditions. She was extubated two days post-operatively without exhibiting any sign of a neurologic deficit. The oesophagus injury was treated without surgical intervention.

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abdominal CT performed three days post-operatively showed the foreign body in the descending colon, and the nasogastric tube was removed on the 4th post-operative day after the gastrografin test, which was negative for any leak from the oesophagus. The pellet was defecated 5 days after the operation. The patient was discharged home without any complications on the 10th post-operative day. At 2-month follow-up, she was asymptomatic and the repeat echo showed a normal cardiac function without a pericardial effusion.

DISCUSSION

Thoracic trauma comprises 10–15% of all traumas and represents 25% of all fatalities due to trauma [2]. Penetrating aortic arch injury victims commonly do not survive for hospital treatment. Patients with a traumatic aortic injury typically present with multisystem trauma. Aortic injuries lead to greater intra-operative bleeding and are more difficult to control than injuries to the aortic arch branches.

With modern imaging techniques such as CT, MRI or transoesophageal echocardiography, most of the great vessel and aortic injuries can be diagnosed with a high degree of accuracy. Nowadays, the MDCT is the most widely used technique in the diagnosis of cardiovascular pathology.

The management of penetrating injuries to major arteries within the thoracic inlet and the aortic arch remains a surgical challenge. Through-and-through stab or bullet wounds frequently require proximal and distal cross-clamping of the aorta, but the use of DHCA enables rapid exposure and accurate repair of the aortic arch injury. Systemic hypothermia is advantageous when it is anticipated that the aortic defect will be difficult to control, e.g. injuries to the anterior or the posterior wall of the aortic arch [3]. Another advantage of DHCA is the protection of the brain when damage to great vessels or uncertainty of the extent of damage to the aortic arch coexists. Uncontrollable intra-operative haemorrhage from penetrating aortic arch injuries has been prevented, permitting successful normothermic repair, by the induction of ventricular fibrillation or by the clamping of the vena cava, with or without simultaneous ascending aortic cross-clamping; such techniques demand a rapid aortic repair [4]. An emergent thoracic endovascular aortic repair has become the treatment of choice for acute surgical emergencies involving the descending thoracic aorta [5].

In conclusion, traumatic aortic arch injuries remain highly lethal, and a traditional surgical repair is associated with significant morbidity and mortality. A significant prognostic factor is a pre-existing neurological deficit on admission. Adjuncts such as

Figure 1: Photographs of chest radiography and MDCT: (a) chest radiography (face view) demonstrates a pellet in the mediastinum (arrow), (b) chest radiography (lateral view) demonstrates the pellet in the posterior mediastinum (arrow), (c) MDCT: the entry and the exit points of the pellet in the anterior and the posterior wall of the aortic arch (yellow arrow) and (d) MDCT: the pellet in the stomach (white arrow).

Figure 2: Intra-operative views: (a) the haematoma along the left phrenic nerve up to the left hemidiaphragm and the haematoma in the posterior mediastinum (white arrow) and (b) the incision of the aortic arch sutured with 4-0 Prolene with a reinforced strip of Teflon (black arrow).
partial or total CPB and DHCA may be required to achieve haemodynamic stability and allow the surgical repair.

**AUTHOR’S CONTRIBUTIONS**

George Samanidis, Stergios Dimitriou and Athanasios Sakorafas took part in patient care and contributed to the search of medical literature. Mazen Khoury had the supervision report. All authors approved the final manuscript.

**Conflict of interest:** none declared.

**REFERENCES**