Traumatic Aortic Transection

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Abstract

Blunt traumatic aortic transection (TAT) is an uncommon injury in clinical practice and is associated with high rates of morbidity and mortality. The approach to patients with such an injury is controversial, with specific regard to the most effective diagnostic tools, timing of surgical intervention, and mechanisms of spinal cord protection. Chest X-ray with the widening of the mediastinum is unreliable as a diagnostic tool. Contrast-enhanced helical CT scan has replaced the traditional angiography as the screening diagnostic tool of choice. Active augmentation of the distal perfusion pressure during cross-clamping offers the best protection against the development of paraplegia during open surgical repair. Endovascular stenting offers a minimally invasive method of treatment, but the long-term durability of the endovascular stent is still unknown ***(Iranian Heart Journal 2008; 9 (3):62 -68).***

Key words: aortic rupture ■ blunt trauma ■ diagnosis ■ great vessel injury

Traumatic aortic transaction (TAT) is a potentially lethal injury that is second only to head injury as the most common cause of death following blunt trauma.[4]

Due to the rarity of TAT, a high volume trauma centre may only handle 2–3 cases per year.[1,2]

In the whole of the Great Britain for the year 2003, only 21 cases of TAT came to surgery.[3]

Subsequently, very few surgeons are able to accrue the personal experience required to develop evidence-based practice.

The analysis of 275 cases of TAT demonstrated an out-of- hospital mortality rate of 86.2%. Despite significant advances in pre-hospital management, very little improvement has been made in the past four decades.[4-6]

Road traffic accidents account for over 75% of cases of TAT in most series.[1,5-7] Subsequent aortic injury is generally thought to result from rapid deceleration and the application of shearing forces.[8] Other causes include fall from heights, compression by heavy objects, and direct blows.[6,7] In blunt thoracic trauma patients, the commonest site of aortic tear is distal to the left subclavian artery and proximal to the third intercostal artery; this area is commonly referred to as the isthmus[8] and accounts for the site of injury in approximately 54–65% of cases in autopsy series[5,6] and in over 85% of cases arriving at hospital alive.[9-12] Multiple organ injuries are frequent in both survivors and non-survivors of TAT. Almost every organ in the body can be involved in the initial injury. Fabian et al. observed closed head injury in 51% of cases with intracranial hemorrhage in 24%, multiple rib fractures 46%, pulmonary contusion 38%, upper limb fracture 20%, pelvic injury 31%, liver injury 22%, spine fracture 4%, spinal cord injury 4%, maxillo-facial injury 13%, diaphragmatic rupture 7%, and cardiac contusion 4%, amongst other injuries.[1]

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The vulnerability of the isthmus as the particular part of the aorta does not suggest direct trauma as the principle mechanism of injury. The ligamentum arteriosum (Botallo's ligament) fixes the aortic isthmus to the left pulmonary artery. The area of attachment may act like a hinge on which the aortic arch may move, hence it is subject to shearing forces during violent injury. There is some evidence that the aortic isthmus is inherently weaker than the other parts of the thoracic aorta. Sudden increase in the intravascular hydrostatic pressure at the time of impact can cause a tear in the aorta at its weakest point.[15]

Case report

A 22-year-old male motorcycle driver was transferred to our resuscitation room after a motor accident. On arrival in the emergency department, he was in clinical shock with a pulse of 120 bpm, oxygen saturation of 92% on room air, and a left brachial systolic blood pressure of 60 mmHg. His Glasgow coma scale (GCS) score was approximately 8-9. The patient was assessed and treated following advanced trauma life support guidelines, and a primary survey did not demonstrate any immediate life-threatening condition. Oxygen administration and fluid resuscitation were commenced, and a trauma radiological series was performed. This demonstrated no evidence of pelvic or cervical spine injury; however, an anteroposterior radiograph of the chest showed a widened mediastinum and multiple rib fractures (Fig. 1). Further examinations demonstrated an impalpable left radial pulse and a significant discrepancy between right and left brachial blood pressures (right 102/68, left 74/54 mmHg). The cervical spine was then cleared clinically. A diagnosis of great vessel injury was made, and the patient underwent computed tomography (CT) imaging of his thorax and abdomen, which confirmed a diagnosis of traumatic transection of the thoracic aorta immediately distal to the left subclavian artery. An associated mediastinal hematoma was noted, with no evidence of any other intraperitoneal injury (Fig. 2).

Fig. 1. Primary survey chest radiograph.

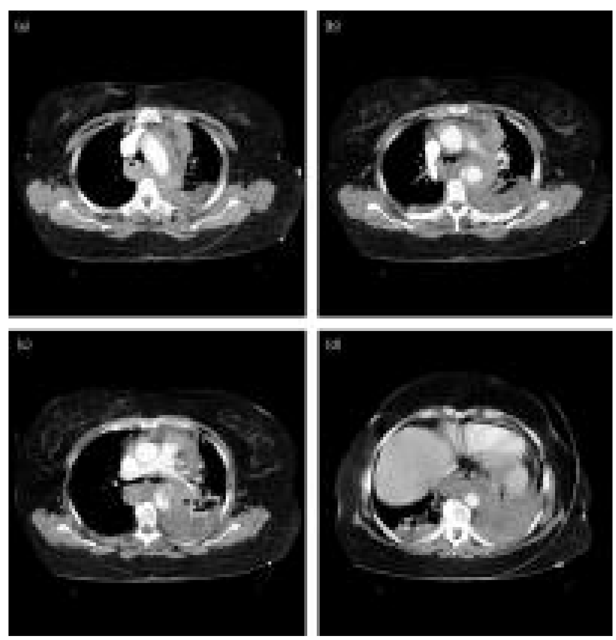

Fig. 2. Initial contrast computed tomography imaging of thorax. (a) Above the level of transection; (b) and (c) at the level of aortic injury; (d) below the level of aortic injury

The patient was transferred to the regional cardiothoracic unit and underwent aortic angiography, which confirmed a diagnosis of TAT of the aorta immediately after the left subclavian artery. The patient was taken to the operating room, and surgical repair was performed with cardiopulmonary bypass (CPB) after the cannulation of the right femoral artery and vein and right subclavian artery. After starting CPB and with a left posterolateral thoracotomy incision and control of the TAT site, the patient suddenly developed ventricular fibrillation. The right subclavian artery cannula was immediately opened, and the ascending aorta and its branches were completely perfused. Finally, repair of the aortic transection with a woven dacron graft was performed. The procedure was successful and the patient was stabilized in the intensive care unit. He subsequently made a good recovery and his GCS gradually returned to normal. He was discharged to continue rehabilitation at home.

Discussion

The possibility of TAT should be considered in all patients involved in a major road traffic accident. Plain chest X-ray remains the first line screening tool. Widening of the mediastinum is the most frequently cited chest X-ray finding that triggers additional investigative workup for TAT.[1,19,20] A widened mediastinum is defined as a width greater than 8 cm at the level of the aortic knob or a mediastinal/chest width ratio greater than 0.38.[21-23] The positive predictive value of a widened mediastinum for traumatic aortic laceration at the isthmus is about 15%.[20] Other chest X-ray abnormalities of the mediastinum that might point to the diagnosis of traumatic aortic injury are obscuring of the aortic knob, depression of the left main stem bronchus, deviation of a placed nasogastric tube, opacification of the aorto-pulmonary window, widened paratracheal and para-spinous stripes, and apical capping.[18-20, 23-27] A negative chest X-ray does not exclude blunt aortic injury; and when suspicion is high based on the mechanism of the injury, additional screening tests should be carried out. Fabian et al. in a prospective study documented negative chest X-ray findings in 7% of cases, while Gammie et al. observed this in 12% of their series.[11,32] CT scanning is recommended as a screening tool for all patients with blunt thoracic trauma.[33-35] Newer generation helical or spiral CT scanners have increased the accuracy of diagnosis. A sensitivity of 100% has been reported with the helical CT scanner in the diagnosis of TAT in patients investigated for blunt thoracic trauma.[31,32] The helical CT scan will replace angiography as the screening diagnostic tool of choice for TAT. Transesophageal echocardiography (TEE) is another useful diagnostic tool. TEE diagnosis is based on the identification of mediastinal hematoma. The major drawbacks with TEE are that it requires specific training and expertise to interpret the results and it may not be readily available. Furthermore, it lacks the sensitivity and specificity of either the CT scan or angiography.[31,39] Minard et al. reported a sensitivity and specificity of 57 and 91%, respectively, compared with aortography, for which sensitivity was 89% and specificity was 100%.[39] Visualization of the ascending aorta and arch can be difficult with TEE, and injuries in these areas can be missed.[40] Angiography used to be regarded as the gold standard diagnostic confirmatory test for TAT. It remained the most widely used confirmatory investigation prior to surgical management until recently.[1,9,43] Aortic angiography is a very sensitive and accurate diagnostic tool. In a retrospective analysis of 314 patients with blunt thoracic trauma investigated by angiography, Sturm et al. observed a diagnostic accuracy of 99.3%.[44] Fabian et al. documented a specificity of 99% and a positive predictive value of 97%.[32] It is, however, an invasive procedure requiring a complex set-up. In addition, the process is not without risk: cases of free rupture leading to death during or immediately after angiography have been reported.[4] There is also a small incidence of false-positive reports, which may lead to negative thoracotomy.[44] Conventional angiography uses a retrograde femoral approach and a considerable bolus of contrast is required, which may cause renal impairment in critically ill patients.

Surgical management of this group of patients is very challenging, with an operative mortality rate as high as 30%.[1,2] Multiple severe associated injuries are very common and are responsible for the excess mortality. This has raised the question: is it always safe to operate immediately? The natural history of TAT is dominated by fear of subsequent rupture. The timing of this event is unpredictable and ranges from a few hours to months.[1,7] This fear is real with in-hospital rupture rates ranging from 10 to 13% and in most cases occurring within a few hours of admission.[1,2,11] Fabian et al. observed 24 deaths from rupture out of 207 stable patients prior to surgical repair.[1] Furthermore, 92% of these occurred within 24 hrs of admission. They recommended titration of systolic blood pressure to 100 mmHg and pulse rate to less than 100/min using intravenous beta blockers, labetelol or esmolol, and the addition of a vasodilator, sodium nitroprusside, if satisfactory systolic blood pressure was not achieved.[32] This may reduce the risk of spontaneous rupture. In some instances where surgery has been delayed due to severe associated injuries and the aortic tear is monitored with serial helical CT scan or MRI, complete resolution of a small tear has been documented.[10,12,36]

Undoubtedly, the most controversial aspect of TAT management centers upon the prevention of spinal cord injury. The etiology of postoperative paraplegia during surgical repair of TAT is multi-factorial. Important factors are the duration of cross-clamp, the level and length of the aorta excluded by the cross-clamp, and the perfusion pressure in the aorta distal to the cross-clamp. Available strategies for cord protection during cross-clamp include: (1) augmentation of the distal circulation either by use of passive or active shunt, (2) local or systemic hypothermia, and (3) drainage of cerebrospinal fluid to reduce cord pressure. With active augmentation of distal circulation, the time constraint of cross-clamping is eliminated. Active augmentation of the distal circulation beyond the cross-clamp can also be achieved by partial or full right heart bypass using a pump oxygenator. This method has the advantages of being able to support the circulation in the event of cardiac failure, improve oxygenation in the presence of severe pulmonary damage, and improve cord protection by hypothermia. The major disadvantage of right heart bypass is the necessity for full heparinization in the presence of fresh trauma.

Different techniques for the repair of TAT include direct suture where a small tear is present, patch repair, resection and direct anastomosis or the placement of an inter-position graft. The optimal method for cord protection during operation is still a source of considerable debate in the literature. One meta-analysis showed a paraplegia rate of 19.2% for simple clamp-and-sew, 11.1% when passive distal circulatory support with a Gott shunt was employed, and a drop to 2.3% with active augmentation. However, in the patients using full CPB, the cannulation of the right subclavian artery may be of benefit, especially when cardiac rhythm disturbances such as ventricular fibrillation compromise the perfusion of the heart and brain. As a result, perhaps in emergency, unstable and critical patients, prophylactic cannulation of the right subclavian artery may have benefits for patients. Despite the overwhelming and compelling weight of evidence in support of the role of the augmentation of the distal circulation to reduce paraplegia rates, some authors, championed by Sweeney et al. still advocate the clamp-and-sew technique. [36] In surgical practice, it is not always possible to predict whether repair can be performed safely within the 20 to 30-minute limit. The risk of bleeding following full heparinization for distal mechanical support appears to be overstated. Pate et al. found that 90.9% of their patients survived without paraplegia and they had no evidence of new or increased bleeding attributable to heparin.[44] Gammie et al. used partial left heart bypass with heparin and did not find any morbidity related to the heparinization.[11] Of the 134 patients (65%) in the North American study who underwent repair with CPB, none had significant complications attributable to full heparinization.[1]

Conclusion

Blunt thoracic aortic injury is a potentially lethal condition with no current uniform approach to diagnosis and management. Road traffic accidents account for the majority of cases in the current clinical practice. The principal mechanism of injury is deceleration, when a moving vehicle suddenly comes to a stand still. The majority of the tears occur at the aortic isthmus. Chest X-ray with widening of the mediastinum is unreliable as a diagnostic tool. Contrast-enhanced helical CT scan has replaced the traditional angiography as the screening diagnostic tool of choice. Active augmentation of the distal perfusion pressure during cross-clamping offers the best protection against the development of paraplegia during open surgical repair. Endovascular stenting offers a minimally invasive method of treatment, but the long-term durability of the endovascular stent is still unknown.

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