Ascending Aortic Injuries

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Injury Demographics

- Aortic injury from blunt or penetrating mechanisms is highly lethal, with most victims dying at the scene.
- Shock on admission and associated injuries contribute to mortality.
- There are few clinical and autopsy reports which specifically address ascending aortic trauma.
- Blunt AAI is rare, severe associated injuries are frequent and management is surgical.
- It is difficult to determine the exact incidence.
    - Autopsy studies report the ascending aorta is involved in 20 to 30% of all blunt aortic trauma, reinforcing the lethality of this injury.
    - In clinical studies the reported incidence is 2 to 20% of aortic injuries.
    - Motor vehicle collisions, motorcycle collisions, pedestrian struck, and falls from heights account for almost all ascending aortic injuries.
    - Over 80% have associated injuries, and approximately 25% have aortic regurgitation from aortic valvular trauma.
- Penetrating thoracic great vessel injury is rare and specific ascending aortic injury rarer still. Unless the injury is small and contained or transport to definitive care is rapid, exsanguination will occur rapidly. These patients are typically in their mid-twenties, associated intra-thoracic injuries may be present and shock on admission is common.
- Both blunt and penetrating injuries can involve the aortic valve resulting in acute aortic insufficiency which is poorly tolerated. This leads rapidly to pulmonary edema and shock. Another potential complication from AAI is cardiac tamponade with resultant hypotension. Independent of mechanism, well over half of the patients present in shock.

Clinical Presentation and Evaluation

- Patients in shock require immediate operation; advanced imaging or additional diagnostic studies may yield useful information, which may change the management, but should only be performed in hemodynamically stable patients.
- A widened mediastinum on chest x-ray should heighten suspicion for an aortic injury.
- Helical chest computed tomography angiography (CTA) has replaced aortography as the imaging modality of choice to diagnose aortic injuries. CTA will also provide a detailed evaluation of associated injuries.
- Chest CTA finding will classify aortic injures, which has important implications for management. The Society for Vascular Surgery classification is:
    - Grade I intimal tear
    - Grade II intramural hematoma
    - Grade III pseudoaneurysm

    - Grade IV transection or rupture.
- Additional grading system:
    - I intimal flap or intramural hematoma
    - II pseudoaneurysm involving < 50% aortic circumference,
    - III pseudoaneurysm > 50% aortic circumference,
    - IV rupture or transection.
- Secondary signs of injury, including large mediastinal hematoma and pseudocoarctation, are important findings independent of the grade of injury.

Management

- Ascending aortic injuries almost always require operative intervention. Patients with penetrating AAI typically present in profound shock and require an emergent operation. Since the precise injury location is unknown, wide mediastinal exposure is mandatory and accomplished by sternotomy or clamshell thoracotomy.
- Although an endovascular approach for blunt injury to the descending aorta (TEVAR) is nearly universally practiced, it has no role in blunt AAI.

Role for non-operative management

- There is almost no role for non-operative management in penetrating AAI even in the small subset of patients who are hemodynamically stable. There are no studies on the natural history of contained AAI, however, the body of vascular surgery literature describing other arterial injuries suggests surveillance is essential and rupture may occur. The percentage of trauma patients who return for routine follow-up is quite low, making surveillance extremely difficult, and AAI rupture has catastrophic consequences. There a few case reports of ascending aorta stenting in highly selective patients, not in shock, with penetrating trauma. The injuries were small, contained, not involving the aortic root and successfully managed with an endovascular approach. There are no studies on the long-term consequences and durability of these grafts. Despite these rare case reports, open repair of AAI is the preferred approach.
- Blunt AAI are graded using the same criteria as for descending aortic injures.
- The initial medical management of AAI is similar to that employed for descending injuries;
    - β-blockers to decrease the aortic wall shear (dp/dt) and antihypertensives to control blood pressure.
    - While no studies define the optimal end-points, a heart rate < 70/minute and systolic blood pressure < 100 mmHg with adequate end-organ perfusion are generally accepted targets.
- There are some important considerations, particularly in the multiply injured patient:

    - β blockers must be used with care, if at all, in a patient requiring ongoing volume resuscitation, since relative bradycardia and depressed myocardial function may be detrimental.
    - Similarly, relative hypotension may result in end-organ dysfunction, exacerbate existing shock and worsen neurologic outcome in patients with a traumatic brain injury.
    - Antihypertensives and β blockers with short half-lives, administered by continuous IV infusion, which are easy to titrate, should be used.
- While there is no role for the endovascular management of blunt AAI, there are a rare case reports of medical management as definite therapy for selective grade I injuries. If this strategy is chosen, patients need close out patient follow-up for heart rate and blood pressure control, and surveillance CT imaging. This is problematic since trauma patients are frequently lost to follow up.

Indications for Surgery

- Blunt and penetrating AAI are managed operatively except in rare, highly selected cases.
- Patients in shock require immediate operation. Additional imaging or diagnostic studies should only be performed in hemodynamically stable patients.
- Multiply injured patients especially those with severe potentially life-threatening associated injuries present a particular challenge. After characterizing all the injuries several important decisions need to be made; is immediate medical management with β blockade and antihypertensives indicated for AAI, is an emergent operation indicated for AAI, if not, is the patient a candidate for endovascular or medical therapy as definitive management. If there are significant associated injuries further decisions are necessary; prioritizing competing injuries, timing of multi-cavitary procedures, and the need for simultaneous operating teams.
- Patients with severe traumatic brain injuries are a particularly challenging subset. If emergent surgery for AAI is indicated, then optimal management of the traumatic brain injury is imperative. Avoiding hypotension and hypoxia are essential, as either will worsen neurologic outcome in these patients. If the AAI is amenable to an endovascular repair the neurologic outcome may be improved by delaying catheter based therapy.
- Immediate surgical repair is the preferred management. In selected cases delayed repair may be beneficial, especially with a concomitant severe traumatic brain injury. It must be emphasized this approach is infrequent and applicable only in highly selected patients.

Operative Management

- Median sternotomy and bilateral anterolateral (clamshell) thoracotomy provide excellent exposure to the mediastinum.
- The choice of incision will depend on several factors; the presence of shock, the speed in achieving vascular control and the surgeon's familiarly with the various approaches.
- Penetrating injuries to the anterior ascending aorta are initially controlled with digital pressure or with the application of a side-biting vascular clamp. Typically, the aorta is repaired with interrupted, double armed 3-0 or 4-0 polypropylene sutures, with Teflon pledgets as indicated. A patch may be needed to repair larger aortic injuries; bovine pericardium is preferred as it is durable, easy to use and more resistant to infection than non-biologic material. Running or interrupted polypropylene suture, with or without pledgets, should be used to secure the patch.
- Penetrating injuries involving the aortic root, lateral or posterior aortic surfaces can be particularly challenging. Injury to the aortic root may involve the aortic valve, coronary cusp or coronary ostia, and is typically repaired on cardiopulmonary bypass. The right lateral aortic wall can be exposed by applying gentle traction to the aorta, rotating it medially.
- Exposure of the left and a portion of posterior aortic surfaces require careful sharp dissection between the aorta and pulmonary artery, and may be easier using an intra-pericardial approach. Once the aorta is mobilized the injury can be repaired as described above.
- Exposure and repair of the posterior aorta is challenging and cardiopulmonary bypass may be needed.
- There are additional considerations when managing penetrating AAI:
    - Hemopericardium, if present, is relieved and the source located, which may be the intra-pericardial ascending aorta, another great vessel or the heart itself.
    - Maintaining hypotension while suturing the aorta allows better visualization and precise suture placement.
    - Intermittent occlusion of the superior and inferior vena cavae will result in hypotension but extreme care must be exercised when using this technique.
    - Lastly, some injuries need to be repaired on cardiopulmonary bypass utilizing a combination of cardioplegia, hypothermia and rarely circulatory arrest.
- The technical operative details are beyond the scope of this discussion but a few salient points are to be noted. Operative management includes sternotomy, cardiopulmonary bypass, ascending aortic replacement and TEE. Assessment of the aortic valve is performed using TEE. If aortic insufficiency is present a determination regarding valve repair or replacement is made. Cardiopulmonary bypass is established with cannulation of the femoral, or more commonly, the axillary artery. The degree of hypothermia is determined by the extent of the aortic replacement ranging from mild to profound

hypothermia with circulatory arrest, if the aortic arch is involved. Typically, replacement of the ascending aorta is all that is required but in approximately 25% of patients the aortic valve is involved.

Associated Injuries

- Associated injuries are common with blunt and penetrating AAI, and have an appreciable impact on mortality. Over 80% of patients with blunt AAI have severe associated thoracic, abdominal, pelvis and head injuries. The percentage of associated injuries with penetrating AAI is similar but almost exclusively intrathoracic including, great vessels, heart, lung and aerodigestive, many of which themselves would be fatal. Any associated trauma, particularly head and spinal cord, results in higher morality.

Mortality and Morbidity

- The overall mortality for AAI, blunt or penetrating, is impressively high.
    - Autopsy studies confirm most patients with AAI die at the scene, with the remainder succumbing to their injuries prior to operative intervention.
    - Operative mortality for blunt AAI varies between 12% and 30% and often determined by concomitant injures or shock on admission.
    - Since so few patients with penetrating AAI survive to definite care, there are no reports in the literature which directly addressing this injury. However, the morality for penetrating trauma to any portion of the thoracic aorta exceeds 60%.
    - The post-operative care and morbidity following repair of AAI is similar to that after sternotomy and cardiopulmonary bypass, except neurologic complications are higher.

Special Considerations

- Blunt and penetrating injury to the innominate artery is uncommon, with similarities and important difference to AAI. Penetrating innominate artery trauma shares many similarities with AAI. They are most often young males, typically present in shock, frequently have other concomitant great vessel injuries and need an emergent operation. The preferred operative approach is sternotomy, which provides optimal mediastinal exposure; a clamshell incision also yields adequate exposure. The artery may be injured anywhere along its length. After obtaining vascular control, primary repair or graft interposition is performed. Cardiopulmonary bypass is rarely needed.

- The mechanisms for blunt innominate artery injury are identical to those for AAI. The site of injury is typically at the vessel's origin. Contrary to AAI, most patients are hemodynamically stable on admission, despite almost all having associated injures. Since these patients are stable addition imaging is obtained and generally demonstrates a contained injury. Median sternotomy is the preferred incision. For the typical injury at the origin of the innominate artery repair is accomplished by an interposition graft from the ascending aorta to the mid or distal innominate. Injuries to the mid or distal innominate require establishing flow individually to the subclavian and carotid arteries. Similar to penetrating trauma, cardiopulmonary bypass is seldom indicated. Stent grafts are not indicated.

Summary

- Whether from a blunt or penetrating mechanism, ascending aortic injuries are rare, often fatal with few victims arriving to definitive care and, associated injuries are very common. Over half the patients present in shock and emergent surgery is indicated. Hemodynamically stable patients benefit from additional imaging with CTA, and TEE to assess the aortic valve. Imaging will define the injury grade as well as characterize associated injuries. Operative management is the preferred treatment option. The exception is in highly selective patients, notably those with low grade injures and/or severe traumatic brain injuries, in whom medical management alone or an endovascular approach may be preferred. Median sternotomy or a clamshell incision provides appropriate mediastinal exposure. The vast majority of injures are amenable to primary repair or interposition graft; cardiopulmonary bypass is infrequently indicated. Refined judgment is needed when managing the multiply injured patient with an ascending aortic injury.

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