Editorial

Traumatic heart and great vessels injuries

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Submitted May 29, 2018. Accepted for publication Oct 22, 2018.
doi: 10.21037/jtd.2018.10.73
View this article at: http://dx.doi.org/10.21037/jtd.2018.10.73

Introduction

Noteworthy steps forward in diagnosis and management of cardiac and great vessels injuries have been made since Hippocrates stated that all wounds of the heart were deadly (1).

During the last century, major trauma approach had shifted from simple clinical observation to surgical intervention, and pioneers such as Francis Stewart, John Bingham Roberts, and Rehn Ludwig have led surgeons to believe that cardiac and great vessels injuries can be surgically addressed (2-4).

Experience and advances gained—the optimization in pre-hospital care and diagnosis, the use of the emergency department thoracotomy or sub xyphoid pericardial window, the availability of cardiopulmonary bypass and bioprosthetic materials for the management of complex cardiac, coronary and great vessels injuries and the development of endovascular devices—have allowed clinicians to improve diagnosis process and management. However, survival rate in this field is still poor and it is primarily limited by prehospital exsanguination and cardiac tamponade. Moreover, the proper management of these patients is still debated in the literature; a recent review of the Major Trauma Care in England concluded that 60% of patients with major thoracic trauma receive levels of care that are 'less than good practice' (5).

Epidemiology

More than 90% of the overall cardiovascular injuries are due to penetrating trauma, while blunt injury is the most common mechanism seen in civilian practice (6,7).

Cardiac trauma

In the case of penetrating cardiac trauma, the right ventricle alone is involved in the 35% of the patients reaching the hospital, the left ventricle alone in the 25% of the cases, while the right atrium alone is infrequently involved; in nearly 30% of the cases more than one chamber is injured (8,9). A meta-analysis by Rhee *et al.* regarding penetrating trauma showed that survival rate was higher for isolated cardiac injuries versus non-cardiac thoracic injuries or abdominal injuries (respectively 19% versus 11% and 4%) (10). In the case of isolated cardiac trauma, it is well-known that gunshot wounds (GSW) have worst prognoses than stab injuries due to the higher kinetic energy (11).

In the case of blunt cardiac injury, myocardial contusion is the most commonly reported; this condition is frequently undiagnosed but can cause cardiac arrhythmias, ventricular thrombi, and septal and free wall ruptures (12). Right ventricle and/or right atrium are usually involved, while left sided lesions are less frequent, and septal, coronary artery, and valve injuries occur even more rarely. Blunt cardiac injury is involved in up to 20% of all motor vehicle crashes, and in patients with severe thoracic injury or multiple injuries, its incidence may be as high as 76% (13). Other causes of blunt cardiac injury are falls, compression between two objects, sudden deceleration of the chest, straight chest blows, and severe abdominal compressions that cause massive increase in blood flow to the right atrium. Blunt cardiac injury rate in clinical studies are significantly lower than in autopsy series. This suggests that mild cases of cardiac trauma with minor symptoms may be under detected, but also that a consistent rate of patients with significant blunt cardiac injury die in the field.

Great vessels injuries

Discrepancies between clinical and autopsy studies can be detected also in the case of blunt aortic injuries. The rate of blunt aortic injuries in motor vehicle crashes ranges between 1.5% and 1.9%, and they are second only to brain injuries as the leading cause of death (6,14). Autopsy series show that the most frequent anatomic setting involved is the aortic isthmus (from 36% to 54%), followed by the ascending aorta (from 8% to 27%), the aortic arch (from 8% to 18%), and the descending thoracic aorta (from 11% to 21%) (15,16). On the other hand, surgical series demonstrate that most of the aortic ruptures occur at the isthmus (from 84% to 97%), and only few cases occur in the ascending aorta, arch, or distal descending aorta (8,17). The higher rate of isthmus injuries may exist because the mobility of the aorta at this point is limited by fixed anatomic structures such as the ligamentum arteriosum, the left main bronchus, and the intercostal arteries, therefore compression and deceleration forces are able to cause traction tears. Conversely, the periadventitial tissues around the isthmus provide some protection against free rupture that allows for short-term survival and transfer to hospital (7).

Diagnosis

Primary cause of death in patients with cardiac and great vessels injuries is exsanguination, which occurs in up to 20% of patients who arrived to the hospital alive; therefore, time to diagnosis is of paramount importance (17). The absence of clear, pathognomonic sign and symptoms, make the diagnosis of cardiac and great vessels injury difficult. The signs and symptoms most frequently reported in the literature are hypotension, elevated central venous pressure, tachycardia, upper body cyanosis, unresponsiveness, and increased heart shadow on chest X-ray films (18). A careful patient and injury dynamic evaluation is crucial to get early diagnosis. Cardiac and/or great vessels injuries should be highly suspected when there is involvement of the cardiac diamond, region bounded by the sternal notch superiorly, the nipples laterally and the umbilicus inferiorly. Cardiac and/or great vessels injuries are often part of multi-organ trauma and are most commonly associated with other thoracic injuries, such as ribs and sternal fractures, pneumothorax, hemothorax, and lung contusion.

Various methods have been developed to classify the type and severity of cardiac and great vessels injuries with the aim to grade them and to guide clinicians toward a standardized decision-making process. Worldwide, the best-known and most widely accepted is the injury-severity score (ISS) (19). This system is also used in clinical practice to figure mortality, morbidity, and length of hospital stay in patients with major trauma (20).

Management

Treatment of cardiovascular injuries is tailored to the type and severity of the damage and ranges from electrocardiogram follow-up to urgent standard sternotomy or thoracotomy with complex surgical repair.

In hemodynamically stable patients, delayed cardiovascular surgical management may be appropriate in the case of severe associated intracranial or abdominal injuries that require emergent craniotomy or laparotomy. Conversely, in hemodynamically unstable patients with ongoing aortic or cardiac bleeding or signs of impending rupture, immediate cardiovascular surgical intervention is required.

The efficacy of the emergency department thoracotomy is one of the most debated issues in this field. The American College of Surgeons states that it should be performed rarely in patients sustaining cardiopulmonary arrest secondary to blunt trauma because of its very low survival rate and poor neurologic outcomes. It should be limited to those that arrive with vital signs at the trauma center and experience a witnessed cardiopulmonary arrest (level of evidence II). Emergency department thoracotomy is best applied to patients sustaining penetrating injuries who arrive at trauma centers after a short scene and transport time with witnessed or objectively measured physiologic parameters (signs of life): pupillary response, spontaneous ventilation, presence of carotid pulse, measurable or palpable blood pressure, extremity movement, and cardiac electrical activity (level of evidence II) (21).

Cardiac trauma

Surgical indication in the case of cardiac injuries is dependent on the presence of anatomical damage and/or hemodynamic instability. According to the heart ISS, management of cardiac injuries may require close monitoring without immediate surgical intervention, percutaneous coronary intervention, pericardial decompression, immediate or delayed surgical repair in the case of penetrating trauma or anatomical disruptions, and ECMO support in the case of myocardial contusion without anatomical lesions but hemodynamic instability.

Particularly, in the case of deteriorating vital signs with refractory hypotension and high suspicious of cardiac bleeding, emergency median sternotomy should be performed to open the pericardium, relieve the tamponade, and control sources of hemorrhage (12).

Great vessels injuries

In the case of traumatic aortic lesions, conventional open repair with interposition grafting is the standard of care. After this type of procedure, paraplegia is the main complication; none of the pre- or intra-operative variables have been identified as the, most important risk factor of this feared event, and the cause is likely multifactorial (cross-clamp time, length of the thoracic aorta involved, systemic hypotension, low distal perfusion pressure, number of intercostal arteries excluded, body temperature, and cerebrospinal fluid pressure) (22,23). Different strategies and perfusion techniques have been described and are taken into consideration according to the injury's severity. The simplest and most used in the past is the aortic cross-clamping technique or "cut and sew technique". Case series performed with this technique have recorded a high rate of paraplegia; particularly, cross-clamp time greater than 30 minutes has been associated with paraplegia rates of 15% to 30% (17). To avoid this complication, many centers have tried to adopt strategies of lower body perfusion with various modes of extracorporeal circulation, such as the Gott shunt technique, partial left-heart cardio-pulmonary by-pass, full cardio-pulmonary by-pass, and full cardio-pulmonary by-pass with deep hypothermic circulatory arrest.

Endovascular repair of the thoracic aorta after traumatic rupture is an alternative to open repair and its use is becoming increasingly widespread. The perceived benefits of thoracic endovascular aortic repair (TEVAR) in elective patients and the good short-and mid-term outcomes have led to address also acute aortic injuries with this technology. To date, many reports show the efficacy and safety of TEVAR also in the case of acute traumatic aortic injuries (24,25).

Conclusions

Cardiac and great vessels injuries are usually observed in the setting of high impact trauma, and may lead to massive bleeding, pericardial tamponade, and death. To date, dramatic advances have been made in the diagnostic work-up and surgical management of these patients, with consequently improvement in terms of natural history and prognosis.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Cite this article as: Barbero C, Ricci D, Boffini M, Rinaldi M. Traumatic heart and great vessels injuries. J Thorac Dis 2019;11(Suppl 2):S192-S195. doi: 10.21037/jtd.2018.10.73