Penetrating Cardiac Injuries

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Injury Demographics

- Penetrating cardiac injuries are rare with an incidence of approximately 1% for all trauma patients.
- They are present in 5-10% of patients sustaining penetrating thoracic trauma.
- The right ventricle, the most anterior chamber of the heart, is the most frequently injured chamber.
- Although quite rare, the coronary arteries travel on the surface of the heart, making them susceptible to penetrating injuries.
- They are the most lethal of all organ injuries.
- The vast majority of these patients succumb at the scene of the traumatic incident.
- Those that survive transport often arrive in impending or cardiopulmonary arrest.
- Cardiopulmonary arrest occurs when there is a 50% loss of intravascular volume.

Clinical Presentation

- Those reaching the hospital alive are usually in severe shock. Occasionally, patients with fairly minor cardiac injuries, who experience short prehospital times, may be normotensive on admission.
- Any patient presenting in profound shock or cardiopulmonary arrest with a penetrating precordial injury is considered to have sustained a cardiac injury.
- FAST has for the most part, replaced the use of a subxyphoid pericardial window given its accuracy and reliability in detecting pericardial fluid. There are however some limitations to FAST. For instance, FAST may not be as reliable in patients presenting with an associated hemothorax, pneumothorax or both.
- A subxyphoid pericardial window maybe utilized for patients presenting with equivocal findings in the FAST exam and also for patients with combined thoracic and abdominal injuries.
- The neck veins may be distended in the presence of cardiac tamponade but it's important to remember that; the neck veins may not be distended secondary to large intravascular volume losses.
- Patients may be tachycardic with a thready peripheral pulse. The classical pulsus paradoxus described in tamponade is rarely identified.
- The classically described Beck's triad of cardiac tamponade (hypotension, muffled cardiac sounds, distended neck veins) is found in the minority of cases (less than 10%).
- Every precordial stab wound or gunshot wound to the chest, especially with hypotension, is a cardiac injury until proven otherwise!
- Clinical examination may not be reliable in diagnosing a cardiac injury in patients with:
    - absence of hypotension on admission (usually in patients with small cardiac wounds and short prehospital times).
    - multiple penetrating injuries in several body areas (i.e. chest, abdomen, extremities).

Preoperative Considerations

- In the Operating Room, the patient's entire torso from the neck to mid-thighs must be prepared and draped.
- Consider using a Cell Saver device when high-volume hemorrhage is expected.
- Open the appropriate cardiac instrument set.
- Hemostatic agents should be available.

Operative Technique

Exposure

- The left anterolateral thoracotomy:
    - is the incision of choice for patients presenting in cardiopulmonary arrest.
    - allows the quickest access to the heart.
    - may be performed in the Emergency Department to release tamponade or to control hemorrhage.
    - provides access for placement of a cross-clamp on the descending aorta.
    - may be extended to access the right hemithorax by transecting the sternum.
- A median sternotomy is the preferred approach in hemodynamically stable patients or in patients with preoperatively identified cardiac injuries.
- Total inflow occlusion (Shumacker's maneuver) of the heart may be useful for the management of right atrial or atriocaval injuries. These areas are difficult to expose and often bleed profusely. Cross-clamping of the intrapericardial superior and inferior vena cava results in immediate emptying of the heart, allowing identification and repair of the injury. The safe period for cross-clamping is estimated to be 1-3 minutes; however, this maneuver frequently leads to cardiopulmonary arrest, particularly in the injured, acidotic, and ischemic heart. If cardiopulmonary arrest occurs, internal defibrillation is performed to restore sinus rhythm.

Repair of Cardiac Injuries

- Atrial injuries:
    - Atrial injuries, particularly those of the atrial appendage, may be controlled with a Satinsky clamp. Wounds are repaired within 2–0 or 3–0 polypropylene monofilament suture on an MH needle in a running or interrupted fashion with or without pledgets.
    - The MH needle is large enough to obtain adequate tissue purchase and to pass under the finger maintaining digital pressure.
    - If used, interrupted sutures can be placed as horizontal mattress or simple interrupted sutures.
    - Use of bioprosthetic material is not recommended for these injuries.
- Ventricular injuries:
    - Ventricular wounds may be repaired by digitally occluding the laceration while placing either simple or horizontal mattress sutures.
    - Polypropylene monofilament 2-0 or 3-0 sutures on an MH needle is recommended.
- Coronary artery injuries:

    - The proximal 2/3rds of coronary injuries should be repaired or bypassed. These patients may benefit from the insertion of an intraaortic balloon pump and immediate cardiopulmonary bypass, although the mortality of these patients is exceedingly high.
    - Distal third coronary artery injuries can be ligated.
- Closure of the incision:
    - Two mediastinal chest tubes should be inserted to remove blood and to prevent post-operative tamponade. A straight 36 French chest tube is inserted to the left side of the xyphoid and directed posteriorly into the pericardial recess. A right sided curved 36 French chest tube is inserted on the right side of the xiphoid and directed to the pericardial recess.
    - Chest tubes should be placed if the pleura is opened.
    - Thoracotomy incisions are closed with multiple pericostal sutures of 0- or 2-0 Vicryl or Dexon around ribs above and below the incision.
    - The sternum is reapproximated with sternal wires.
    - The skin and soft tissues are closed in layers.

Postoperative Management

- Patients are admitted directly to the Surgical Intensive Care Unit. Endpoints of resuscitation must be met with ongoing resuscitation. Restoration of normothermia and correction of coagulopathy should be achieved.
- Chest tubes and mediastinal tubes should be carefully monitored for evidence of bleeding. Excessive bleeding in patients with normal coagulation studies mandates a return to the operating room
- Patients may develop dysrhythmias.
- In patients with concern for ischemia, postoperative ECGs should be and are notable for elevated ST segments which do not return to baseline or any dysrhythmia.
    - Patients with ligation of the distal third of the LAD.
    - Patients that have survived right posterior ventricular injuries.
- Echocardiographic evaluation is performed in the first 24 hours to determine if anatomic or functional cardiac abnormalities are present. In patients with a new murmur, this should be done expeditiously.

Complications

- About 30% of survivors develop late cardiac complications:
    - ventricular or atrial septal defects
    - valvular abnormalities
    - papillary muscle dysfunction
    - myocardial dyskinesia
    - pericarditis.
- Many of these complications may not be identified during the early clinical or echocardiographic examinations; small defects may enlarge and manifest at a later date.

- It is essential that a late clinical examination should be performed at about one month after the injury. EKG and echocardiography should be performed if clinically indicated.

Editors' Note

- Surgeons should be aware of a variety of management options for patients with penetrating cardiac injuries. For patients with evidence of pericardial effusion on FAST exam, marginal hemodynamics, and a transport to the OR, placement of a percutaneous pericardial drain can be performed. This may help stabilize the patient and does not appear to negatively affect patient outcomes.

Suggested Readings

- Rodrigues AJ, Lopes-Furlanetti LL, Bijos-Faidiga G, Scarpelivi S, et al. Penetrating cardiac injuries: a 13 year retrospective evaluation form a Brazilian trauma center. Interactive Cardiovascular and Thoracic Surgery. Vol 4 p212-215 2005
- Topal AE, Celik Y, Eren MN. Predictors of outcome in penetrating cardiac injuries. J Trauma. 2010;69(3):574-8
- Soto JR, Murray JS, Truitt MS, Dunn EL. Penetrating Cardiac Injuries at a Level II Trauma Center: A 15-year Review. Am Surg. 2015;81(3):324-5.
- Jones TS, Burlew CC, Stovall R, et al. Emergency department pericardial drainage for penetrating cardiac wounds is a viable option for stabilization. Am J Surg 2014;207(6):931-4.
- Buckman RF, Badellino MM, Mauro LH, Asensio JA. Penetrating cardiac wounds: prospective study of factors influencing initial resuscitation. J Trauma. 1993;34:717-727.
- Asensio JA, Murray J, Demetriades D, et al. Penetrating cardiac injuries: a prospective study of variables predicting outcomes. J Am Coll Surg. 1998;186:24-34.
- Asensio JA, Berne JD, Demetriades D, Chan L, Murray J, Falabella A, et al. One hundred five penetrating cardiac injuries: a 2-year prospective evaluation. J Trauma. 1998;44(6):1073–82.
- Asensio JA, Stewart BM, Murray J, et al. Penetrating cardiac injuries. Surg Clin North Am. 1996;76:685-724.