AAST Acute Care Surgery Didactic Curriculum

Cardiac Injuries

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Penetrating Cardiac Injury

Highlights:

- Initial diagnostic work up should include point of care ultrasonography (POCUS) to evaluate for the presence of pericardial fluid; if the patient's hemodynamic status permits, a chest radiograph should be done to evaluate for hemopneumothorax and other non-cardiac thoracic injuries.
- Hemodynamically stable patients: Occult penetrating cardiac injury must be ruled out. A POCUS performed to evaluate for pericardial fluid must be cautiously interpreted in the presence of a left-sided hemothorax as bleeding from the heart may be decompressing into the left chest through the traumatic opening in the pericardium. If there is no pericardial fluid but a left-sided hemothorax is present, a confirmatory test must be performed to evaluate for an occult cardiac wound. Options include subxiphoid pericardial window, computed tomography imaging, echocardiography, and video-assisted thoracoscopic surgery. The choice of confirmatory test depends on the resources available and the trajectory of the penetrating wound. If a pericardial window is utilized and hemopericardium is observed, the trauma surgeon must decide whether to perform pericardial drainage alone or sternotomy for further evaluation and potential repair of the cardiac injury. To help delineate this choice, the pericardium is gently irrigated with warm saline; if significant bleeding persists, a sternotomy should be performed. However, if after irrigation the bleeding essentially stops, one may consider pericardial drainage alone as it is unlikely a full-thickness cardiac injury exists.
- Hypotensive patients with pericardial tamponade physiology: The patient should be transported to the OR after rapid evaluation and ideally prior to intubation (to prevent arrest).
- Patients who have cardiac arrest upon presentation or while in the Emergency Department: A left anterolateral resuscitative thoracotomy should be performed with wide opening of the pericardium and control of bleeding. Options to control bleeding include digital occlusion, closure with skin staples (if the edges of the left ventricular cardiac wound come together during diastole), or rapid whip-stitch with a 2-0 or 3-0 prolene with an MH needle. Using balloon occlusion with a Foley catheter inflated after placement through the cardiac injury can be helpful, but care must be taken not to enlarge the injury with the balloon, particularly in the thin-walled right ventricle or atria. Vascular clamps may be used to control atrial injuries, particularly the floppy atrial

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appendage, but care must be taken not to worsen the injury, especially during transportation to the OR.

- Incisions: A median sternotomy is useful for patients with anterior stab wounds who have some degree of hemodynamic stability. A left anterolateral thoracotomy should be performed for patients in extremis. If needed, the thoracotomy incision may be extended across the sternum with a Lebsche knife or may be fully extended into a bilateral transsternal anterolateral (clamshell) thoracotomy for better exposure.
- Operative technique:
    - Myocardial injuries: Nonabsorbable monofilament 3-0 suture (eg polypropylene) should be used to suture cardiac lacerations. Figure-of-eight, running, or horizontal mattress sutures may be used depending on the size and location of the laceration. If the laceration is located adjacent to a coronary artery, horizontal mattress sutures that pass under and run along an axis parallel to the artery should be used. The use of pledgets may be cumbersome; while advocated for use in cases where the myocardium is thinner and hence will not easily hold sutures without tearing, pledgets are variably used in the thicker section of the myocardium.
    - Coronary artery injuries: Proximal coronary artery injuries will require repair, especially if there is evidence of ventricular dysfunction. Repair of these injuries often requires placing the patient of cardiopulmonary bypass. Distal coronary artery injuries (particularly those in the distal one-third of the vessel) can be ligated and any resultant functional impairment managed medically.
    - After cardiac repair, the pericardium is typically left open. The pericardiotomy may be extended laterally in both directions at the inferior aspect, taking care not to injure the phrenic nerves, to prevent compression and restricted filling of the right heart.
- Formal transesophageal echocardiography may be performed intraoperatively or postoperatively to evaluate for other injuries such as valve injuries or intracardiac fistulas. ECHO should be performed in patients with new murmurs on exam or cardiac dysfunction requiring significant vasopressor support.

Blunt Cardiac Injury

Highlights:

- Blunt cardiac injury (BCI) is a spectrum of injuries ranging from clinically insignificant myocardial contusions to cardiac failure or frank rupture. BCI occurs with direct chest trauma, primarily with motor vehicle crashes, auto vs pedestrian crashes, motorcycle crashes, and falls. In clinical studies to date, sternal fractures are not independently associated with BCI; sternal fractures may, in fact, be protective from BCI by decreasing the force transmitted to the heart. Significant BCIs are often apparent at the time of initial evaluation, however, some patients may not develop signs or symptoms until 6-24 hours post injury.
- Evaluation for BCI:

- EKG: EKG should be performed at the time of initial evaluation on all patients who have suffered chest trauma. ST segment and T wave abnormalities, new bundle branch block (BBB), and premature ventricular contractions (PVCs) are significant findings. Sinus tachycardia or non-specific changes are commonly identified on EKG, but do not correlate with significant BCI and pump failure. Of note, a normal EKG alone does not rule out BCI.
- Cardiac enzymes: Troponins do not reliably correlate with significant BCI and are better for ruling out BCI. Troponins should be checked 8 hours post-injury for patients with suspected BCI but no other reason for admission to determine if they may be discharged. Patients with a negative EKG and normal troponin do not have a significant BCI. There is no need for serial troponins in asymptomatic patients. Troponins should be drawn for patients with concern for acute coronary syndrome including a possible traumatic coronary dissection.
- Echocardiography: This is performed to evaluate cardiac function, wall motion abnormalities, pericardial effusion/tamponade, and structural abnormalities (eg valve, chordae, or septal injuries). Echocardiography should be performed in patients with markedly symptomatic BCI (eg hypoperfusion, shock, significant EKG changes). Echocardiography should not be part of routine screening and should not be performed in asymptomatic patients with benign or nonspecific EKG changes or with isolated cardiac enzyme elevation.
- Cardiac CT/MRI: This may be helpful for differentiating BCI from acute myocardial infarction in patients with ambiguous etiology (eg patients with a history of coronary artery disease who have experienced chest trauma). The decision to pursue this imaging should be made in conjunction with Cardiology/Cardiothoracic Surgery.

- Significant BCIs include: injuries requiring specific interventions
  - Electrical disturbances: The most common EKG findings are sinus tachycardia followed by atrial fibrillation. Atrial fibrillation is equally common after thoracic trauma and after abdominal or head trauma; it is not specific for BCI. Right BBB is the most common conduction abnormality in BCI patients.
  - Cardiac hypokinesis/failure: A hypokinetic segment seen on echocardiography is a key finding for BCI. Due to the anterior anatomic location of the right ventricle, this is the chamber most often affected.
  - Pericardial laceration: These are almost always associated with other cardiac injuries. Large pericardial lacerations may allow for cardiac herniation leading to compromised cardiac function.
  - Septal rupture with intracardiac fistula
  - Valve rupture: Valve injury results in valvular incompetence with regurgitation; resultant symptoms may range from syncope and angina to cardiac failure with pulmonary edema. Tricuspid injuries may be associated with heart block. The

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highest to lowest incidence of valve injury is: aortic, mitral, tricuspid, and pulmonary.

- Coronary artery injury: These injuries include dissection, occlusion, laceration, and/or aneurysm. ST segment elevations are seen on EKG, consistent with the associated coronary ischemia. Revascularization procedures should be performed.
- Cardiac wall rupture: Echocardiography may reveal a pericardial effusion, but often there is an associated pericardial laceration resulting in hemothorax. The most common sites of rupture from highest to lowest are: right atrium, right ventricle, left ventricle, and then left atrium. Small full-thickness cardiac wall injuries, particularly in the atria, may result in a slow accumulation of pericardial blood. For patients who are initially hemodynamically stable but then decompensate 5-60 minutes after injury, cardiac tamponade with repeat FAST should be excluded as a cause of shock.
- Commotio cordis: This occurs primarily in young healthy people while playing sports. The most common dysrhythmia is ventricular fibrillation.

- Management of the patient with possible BCI who is hemodynamically abnormal:
  - Initial evaluation should include EKG and echocardiography if hemodynamically unstable.
  - Pericardial tamponade/blunt cardiac rupture: Resuscitative thoracotomy is performed to decompress the pericardium and control bleeding. This should be performed in the ED if the patient is in extremis or in the OR if the patient has a perfusing blood pressure and may be safely transported. Further operative management is based on the findings after opening the pericardium.
    - Convert the left anterolateral thoracotomy to a bilateral transsternal anterolateral (clamshell) thoracotomy if more exposure is required.
    - Options to control bleeding include digital occlusion, closure with skin staples (if the edges of the left ventricular cardiac wound come together during diastole), or rapid whip-stitch with a 2-0 or 3-0 prolene on an MH needle. Using balloon occlusion with a Foley catheter inflated after placement through the cardiac injury can be helpful, but care must be taken not to enlarge the injury with the balloon, particularly in the thin-walled right ventricle or atria. Vascular clamps may be used to control atrial injuries, particularly the floppy atrial appendage, but care must be taken not to worsen the injury, especially during transportation to the OR.
    - Nonabsorbable monofilament 3-0 suture (eg polypropylene) should be used to suture cardiac lacerations. Figure-of-eight, running, or horizontal mattress sutures may be used depending on the size and location of the laceration. If the laceration is located adjacent to a coronary artery, horizontal mattress sutures that pass under and run along an axis parallel to the artery should be used. The use of pledgets may be cumbersome;

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while advocated for use in cases where the myocardium is thinner and hence will not easily hold sutures without tearing, pledgets are variably used in the thicker section of the myocardium.
        - After cardiac repair, the pericardium is left open. The pericardiotomy may be extended laterally in both directions at the inferior aspect, taking care not to injure the phrenic nerves, to prevent compression and restricted filling of the right heart.
    - Dysrhythmia: Antidysrhythmic treatment is provided per ACLS guidelines. Perform cardioversion for unstable patients or defibrillation for ventricular dysrhythmias. Beta blockers or calcium channel blocker should be used for rate control in patients with atrial fibrillation. Vagal maneuvers or treatment with adenosine should be performed for supraventricular tachycardia; consider beta-blockers for recurrent episodes. The patient should be evaluated for coronary artery disease or structural heart disease for sustained ventricular tachycardia.
    - Cardiogenic shock: Heart failure treatment including inotropic support and mechanical circulatory assistance (eg intra-aortic balloon pump, Impella, ECMO, ventricular assist device) when indicated. Cardiothoracic Surgery should evaluate the patient if there is an acute valvular, septal, or coronary artery injury.
- Management of the patient with possible BCI who is hemodynamically normal:
    - Initial evaluation includes EKG.
        - If there is suspicion for BCI but no significant EKG findings and the patient can otherwise be discharged home, obtain a troponin level at 8 hours post injury.
            - If negative EKG and normal troponin level, the patient does not have a significant BCI and does not need 24 hours of telemetry monitoring.
            - If negative EKG and abnormal troponin level, the patient should be monitored on telemetry for 24 hours.
        - If there are significant EKG changes and the patient is being admitted for another reason, the patient should be monitored on telemetry for 24 hours.
    - Echocardiography
        - Should be performed selectively in patients with evidence of hypoperfusion (eg persistent metabolic or lactic acidosis, oliguria, or orthostasis) or shock.
        - If the patient was observed for EKG changes and has remained asymptomatic on telemetry for 24 hours, echocardiography should not be performed.
    - Dysrhythmia: as above and per ACLS guidelines.

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    - Pericardial effusion in the absence of tamponade physiology: Consider subxiphoid pericardial drain or window to assess for blood. If there is a large amount of blood or ongoing bleeding, convert to thoracotomy or sternotomy. If there is a hemothorax and concern for significant BCI, consider thoracoscopy to assess for pericardial laceration and cardiac bleeding.
    - Hypokinesis or structural injury: Cautious volume resuscitation and inotropic support should be administered as indicated. Consult Cardiothoracic Surgery for structural injuries.
- Long-term outcomes: There is a paucity of information about the long-term outcomes of patients with BCI. Severe cardiac contusions or coronary artery injuries with wall motion abnormalities may lead to chronic heart failure. The available evidence demonstrates that the majority of patients with these severe injuries have no residual wall motion abnormalities at 12 months.