27th International & 4th National Webinar

Pediatrics Cardiac Trauma

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Traumatic injury

• Energy is transferred to the heart
• At Rates that exceed the tissue’s threshold to withstand it
• Cause Structural damage and/or functional abnormalities
Transfer of energy that can cause injury

- most commonly associated with Blunt trauma
- Penetrating trauma
- Electrical current
- Combination of forces
Trauma

- Number one cause of death among Americans who are between the ages of 1 and 46 years
- 25% of deaths secondary to trauma are related to cardiothoracic injury
- 92% of cardiothoracic trauma is Blunt
- Most common cause of important blunt chest trauma is the motor vehicle accident
- Most common cause of penetrating chest trauma is the gunshot or stab wound
- Cardiac trauma is generally associated with a High mortality rate
Airway
- Cephalad larynx (C1)
- Floppy epiglottis
- Straight blade
- Large tongue
- Airway positioning
- Short trachea
- Easily dislodged tube
- Narrow cricoid
- Uncuffed tube

Chest
- Increased chest wall compliance
  - Rib fractures
  - Force transmission

Abdomen
- Larger relative organ size
- Closer organ proximity
  - Multi-organ injuries

Head and Neck
- Proportionately larger head
  - Heat loss; injury prone
  - Higher fulcrum on spine
  - Prominent occiput
  - Cervical spine immobilization
  - Horizontal facets
  - Wedging of vertebral bodies
  - Ligamentous laxity
  - Increased risk SCI/IMORA
  - Weak musculature

Cardiopulmonary
- Increased metabolic rate
  - Wider range of normal vital signs
  - Increased risk hypoglycemia
  - Decreased pulmonary reserve
  - Risk of hypoxia with hypoventilation
  - Different BP response to shock
  - Hypotension is late finding

General
- Increased body surface area
  - Increased risk hypothermia
  - Rapidly changing growth and development
  - Weight-based drug dosing
Very important that the diagnosis be made in a timely fashion

• Complications of trauma are difficult to detect initially
• Very high index of suspicion is critical
• Complications of Blunt trauma present later
• Life threatening
• External injury results in wounds
• Bruises over the precordium/thorax
• Pediatric thorax is more compliant
• Less muscle mass
• Thinner body wall
• Penetrating injury is more likely to impact vital structures
• Mediastinum is more mobile in pediatric patients
• Allowing a pneumothorax to develop into a tension pneumothorax
• Develop hypoxia along with higher oxygen consumption
• Lower lung functional residual capacity.
BLUNT CARDIAC INJURY

• Accounts for the vast majority of injuries to children
• Chief cause of cardiac trauma in the pediatric age group
• Incidence of cardiac injury in blunt trauma among children has been reported to be from 0% to 43%
• 53% of pediatric blunt cardiac trauma is a result of motor vehicle accidents
Clinical manifestations of cardiac trauma

• Depending on the location of the injury
• Shock
• Cardiovascular instability
• Dysrhythmias
• Chest pain
• Changes in mentation
Blunt chest trauma generally results in five major injuries:

- Myocardial contusion
- Traumatic aortic dissection or tear
- Flail chest
- Tracheobronchial disruption
- Sternal fracture
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**Airway obstruction**
Loss of oropharyngeal tone is the most common cause of airway obstruction

**Tension pneumothorax**
Formation of a flap-valve causes air to enter the pleural space without a means of escape

**Open pneumothorax**
Air follows the path of least resistance into the pleural cavity through large chest defects which remain open
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**Massive haemothorax**
Defined as >1.5 L initial chest drain output or >200 mLs/hr for 2–4 hours. Significant bleeding into the pleural space can compromise ventilation.

**Flail chest**
Fracture of >2 ribs each in >2 places results in a flail segment and paradoxical movement of the affected chest wall segment with breathing.

**Cardiac tamponade**
Rapid accumulation of blood in the pericardial space via a ventricular defect prevents diastolic filling of the heart.
Blunt cardiac injuries from direct chest impact among children

- Most are the result of motor vehicle crashes
- Blunt blows with weapons
- Fists
- Animal kicks
- Blunt collisions during sports
- Falls from heights
# Mechanisms of Blunt Cardiac Trauma

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• Heart is suspended from the great vessels
• Acceleration–deceleration injuries occur as the heart moves like a pendulum in the thorax
• Traction on the great vessels can cause tears at their points of fixation
• Compression of the chest can also crush the heart or cause damage through increased intrathoracic and intracardiac pressures
• Cardiac rupture is more likely if compression occurs during maximum filling of the chambers
• Abdominal and lower extremity compression also can force blood back to the heart, causing damage through a hydraulic ram effect
Types of anatomic injuries

- Pericardial injury
- Myocardial contusion
- Cardiac rupture
- Septal disruption
- Ventricular aneurysm
- Injury to the heart valves and supporting structures
- Injury to the great vessels, brachiocephalic arteries, venae cavae, and coronary arteries
ACUTE PERICARDIAL TAMPOONADE

- Sudden fluid accumulation
- Pericardium cannot adjust

→ Dramatic increase in pressure inside pericardial sac

CAUSES

CHEST TRAUMA

RUPTURED AORTA

RUPTURED of VENTRICLE AFTER a HEART ATTACK
Pericardial Injury

• Range from contusion to rupture
• Usually associated with myocardial injury
• Echocardiographic imaging in the early evaluation of chest injury is an important diagnostic tool
• Isolated pericardial injuries are rare
• Pericardial lacerations and pericardial rupture are rarely significant injuries unless cardiac herniation occurs through a pericardial tear
PERICARDIUM

BUILD UP OF FLUID, BLOOD, or AIR

CONSIDERED a MEDICAL EMERGENCY
CAN PROGRESS to CIRCULATORY SHOCK and CARDIAC ARREST
• Traumatic cardiac tamponade rarely presents with all the classic features

• Triad s of Beck
  Hypotension
  Muffle heart sounds
  Elevated central venous pressure with neck vein distension

• echocardiogram is the most sensitive diagnostic test for cardiac tamponade
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Low Blood Pressure

Beck's Triad

Distension of Jugular Veins

Muffled Heart Sounds
Myocardial Contusion

- Most often a result of direct blunt force
- During motor vehicle crashes
- Industrial injuries
- Farm injuries
- Sports injuries
- The usual initial presentation
- Chest discomfort
- Bruising
- One-third of children with cardiac contusion may have no external evidence of chest injury
• Most cases of myocardial contusion are mild and asymptomatic
• But complications can be serious
• Complications of myocardial contusion include:
  - Dysrhythmias
  - Conduction disturbances
  - Cardiac failure
  - Aneurysms
  - Pseudoaneurysms
  - Myocardial wall thinning
  - Cardiac rupture
  - Cardiac arrest
• Pathologic findings of myocardial contusion include
• Myocardial hemorrhage
• Edema
• Myocardial fiber necrosis similar to a myocardial infarction
• Scar formation
• ECG demonstrates
• Dysrhythmia
• Changes compatible with ischemia or contusion
• Historically CPK-MB fraction of >5% of the total CPK
• Troponin I and T have been shown to be accurate indicators of myocardial injury
Echocardiogram may be more useful than serial ECGs or cardiac isoenzyme measurements in evaluating blunt cardiac injuries.

Can detect:
- Pericardial effusion
- Valvular dysfunction
- Septal defects
- Enlarging chambers
- Wall motion abnormalities
- Determine ejection fraction
• Following blunt chest trauma
• Patients with abnormal ECGs require admission
• Continuous cardiac monitoring
• Evaluation of cardiac isoenzymes
• Cardiac monitoring should continue until abnormal ECGs have reverted to normal for at least 24 hours
• Cardiac isoenzymes have normalized
• Stabilization of other major injuries has been achieved
• The main treatment goal is avoidance of death caused by dysrhythmias or hemodynamic compromise
Cardiac Rupture

• Ventricular rupture is more common than atrial rupture
• Thin-walled anteriorly positioned right ventricle is more commonly ruptured than the left ventricle
• Ventricular rupture can result
• Direct cardiac compression
• Indirect hydraulic ram effect that occurs during abdominal or extremity compression
• During late diastole, compressing a distended noncompliant ventricle can tear AV valves, chambers, septa, and other cardiac structures
Septal Disruption

- Interventricular septum ruptures
- Most commonly in the muscular portion
- Near the apex
- The thinnest area of the septum
- Echocardiography
- 2- to 3-day delayed presentation is not uncommon
- Due to the inflammatory response that can occur after the injury
- VSDs with significant left-to-right shunts require surgical closure.
Ventricular Aneurysm

- Post Traumatic ventricular aneurysms
- Usually occur as a complication of coronary artery injury
- Most commonly to the left anterior descending coronary artery
- Most common presenting symptoms
  - Congestive heart failure
  - Palpitations or dysrhythmias
  - Arterial embolus
- Time of diagnosis ranged from 5 days to 18 years (median time 3 months) post injury
- Ventricular aneurysmectomy is recommended to avoid lethal complications
Injury to Heart Valves and Supporting Structures

• Rapid increase in intracardiac pressure against a closed valve
• During late diastole to early systole
• Filled chambers experience their highest normal intraluminal pressures
• Additional external pressure from forceful compression of the chest, abnormally high pressure is exerted on a closed heart valve
• timing of chest trauma in the cardiac cycle appears to determine which valve is injured
• greater left heart pressure gradients may contribute to the higher frequency of injury to the aortic and mitral valves
• Helpful diagnostic tests are the chest radiograph and ECG
• The most useful test is Doppler echocardiography
Great Vessel Injury

• Aorta is the most commonly injured great vessel
• Pulmonary artery is rarely reported
• Aortic rupture from blunt trauma can occur with falls, crush injuries, and blast injuries
• The aorta most commonly ruptures when acceleration–deceleration forces pull a mobile aortic segment away from a point of fixation
• Sites usually ruptured are:
  • Aortic isthmus, fixed by the brachiocephalic arteries
  • Ascending aorta, fixed to the heart at the aortic root
  • Descending aorta, fixed at the diaphragm
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• Autopsy studies showed tears in the aortic isthmus and ascending aorta occur in 45% and 20% of cases of aortic rupture
• Clinical studies show about 90% of aortic tears at the aortic isthmus
• 80% to 90% of persons with motor vehicle–related aortic rupture are dead at the scene
• Fortunately, aortic dissections are rare in pediatric patients and are most commonly associated with trauma or a pre-existing medical condition (e.g., Marfan, Louys–Dietz, or Turner syndrome)
• Management relies heavily on decision making and treatments established in the adult literature
• Stanford Type A
• Stanford Type B
• Chest radiographs may show mediastinal widening, a right-sided aortic root prominence, left hemothorax, loss of aortic arch sharpness, or rightward deviation of the trachea

• Less common radiographic findings include downward displacement of the left mainstem bronchus, rightward deviation of the esophageal nasogastric tube, left hemothorax, the apical cap sign, and first rib fracture

• However, CT angiographic imaging has quickly become the diagnostic modality of choice in suspected blunt aortic trauma
Brachiocephalic Arteries

• The second most common vascular injury with blunt trauma
• mechanism of injury includes horizontal and vertical deceleration, chest compression, crush, distraction, and hyperextension of the shoulder
• Massive bleeding or ischemia are rare complications
Vena Caval Injury

• infrequent with nonpenetrating trauma
• abdominal segment of the inferior vena cava is more frequently injured than the chest segment
• thin-walled veins do not vasoconstrict like transected arteries after injury, severe hemorrhage and high mortality are usual with vena caval injuries
• Mortality is higher in abdominal than in chest segment vena caval injury
• Blunt trauma
• can cause avulsion or tear of the inferior vena cava near the right atrium that can extend into the right atrium
Coronary Artery Injury

• The most commonly injured coronary artery is the left anterior descending coronary artery.
• Consequences of coronary artery injury are myocardial infarction, hemopericardium, cardiac tamponade, and coronary artery and ventricular aneurysms and pseudoaneurysms.
• Definitive diagnosis of coronary artery injury is accomplished by angiography.
• Injuries are underdiagnosed because chest pain associated with blunt chest injury is often attributed to concomitant chest wall contusion, pericarditis, pulmonary contusion, rib fractures, or other associated injuries that are not routinely evaluated by coronary angiography.
• Coronary angiography is indicated for all blunt cardiac trauma patients with angina or myocardial infarction to determine the status of the coronary arteries and to locate surgically correctable lesions.
Commotio cordis

- specific form of cardiac trauma that has become an increasingly recognized cause of sudden cardiac death in otherwise healthy young athletes
- nonpenetrating chest trauma insufficient to result in significant myocardial or chest wall injury
- malignant arrhythmia
- two critical components appear to be precordial impact location and the timing of the impact occurring during the upstroke of the T wave
- Vulnerable period of ventricular recovery
- This can cause ventricular fibrillation
Penetrating cardiac injury

- Penetrating trauma is increasing among young adults, teenagers, and even younger children
- The mortality risk for penetrating cardiac trauma is related to a number of factors:
  - cause of injury
  - size of the wound
  - location of the wound
  - any associated noncardiac injuries
  - length of time from injury to initiation of resuscitative
- Penetrating cardiac injury is highly lethal
  - mortality rates of 70% to 80%
• Gunshot wounds cause much more extensive tissue destruction than stab wounds
• mortality rate of gunshot wounds to the heart is approximately twice that of stab wounds
• stab wound is more likely to result in cardiac tamponade than a gunshot wound
• More than 80% of stab wounds to the heart present with cardiac tamponade
• decreasing order of frequency, penetrating cardiac injuries involve
• Right ventricle, left ventricle, right atrium, and left atrium
Two most causes of death from penetrating trauma are

- Hemorrhagic shock (77.5%)
- Cardiac tamponade (22.5%)

Children with a penetrating cardiac wound should receive emergency thoracotomy in the emergency department whenever they are too unstable to be transported to the operating room.
Thanks for Your Attention