Penetrating Pediatric Trauma
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Learning Objectives

- Please add learning objectives
- Discuss two different mechanism of injury that can cause penetrating pediatric trauma.
- Identify two advances in treating penetrating pediatric trauma that have happened within the past 10 years.
- Describe one injury prevention that can decrease pediatric penetrating trauma.
Disclosure Statement

- Speakers/Reviewers/Planners disclose no conflict of interest relative to this educational activity.
**Successful Completion**

- To successfully complete this course, participants must attend the entire event and complete/submit the evaluation at the end of the session.
- Society of Trauma Nurses is accredited as a provider of continuing nursing education by the American Nurses Credentialing Center's Commission on Accreditation.
Pediatric Trauma

• “The death of any child is a tragedy. It affects everyone involved. It even affects those who just hear about it. “
  - Andrew Baluffi, MSW, LSW
  Medical College of Pennsylvania Hospital Trauma Social Worker

• “Pediatric trauma is preventable and an adult is almost always at fault.”
  - Judith Levy, MSW, LSW
  Medical College of Pennsylvania Hospital Pediatric Social Worker
Pediatric Deaths

- It is not the normal cycle of life.
- The potential that existed for that life is lost not only to the child and the family but to society. Without the benefits of what that child may have offered, society as a whole is less.
  - Senator Robert F. Kennedy – War on Hunger and Poverty
The Pediatric Trauma Patient

- Takes more resources (the younger the more resources)
- They are always dependent on an adult for their care.
- Takes more time (prep pt, family, special equip, etc)
- They cannot communicate as effectively as adults.
- Require specialized equipment (expensive, training, etc)
- Their illness, injury and death is harder on staff.
- Dealing with parents/caregivers is sometimes harder than dealing with the child (always at least two people to communicate with – patient and care giver/s).
- Due to their smaller size and closer proximity of vital organs, one moving bullet can cause a lot of injury.
Do We Really Need Pediatric Trauma Surgeons?


• Dramatic rise in non-op manage of blunt and some penetrating injuries in the past 4 decades
• Across all age groups, Orthopedic Surgical procedures account for greatest percent of inpatient procedures. Peaks in toddler and school-aged children and then the elderly.
• Neurosurgical procedures are fairly consistent across the life span.
Do We Really Need Pediatric Trauma Surgeons?


- Trauma surgery intervention was highest among infants and adults.
- 80% of trauma surgical procedures were infants and adults over 51 yrs. and they had a hospital LOS of more than 7 days.
Do We Really Need Pediatric Trauma Surgeons?


J Trauma Acute Care Surg 77:2 pp. 210-225

• Procedures:
  • 41.2% were laparotomy or laparoscopy
  • 33.5% thoracotomy, thoracoscopy or median sternotomy
  • 13.7% vascular
  • 4.5% chest tube placement
  • 2.8% G tube placement
Do We Really Need Pediatric Trauma Surgeons?


- Most surgery performed by OS and not severely injured.
- Those with severe injuries (LOS greater than 7 days) had procedures done by TS and NS.
- TS attending in-house reduces resuscitation time, time to incision for emergent surgery and decreased hospital cost.
- There is an increased rate of missed injuries when the trauma team leader is from non-surgical background.
Case Study # 1

• 13 yr. male selling drugs on street corner to help pay heating bill for his home (has 4 younger siblings at home who are cold). Drive by shooting - sustains 3 GSW. Arrives in ED, goes emergently to OR for exploratory lap.

• Has liver, spleen, pancreas, diaphragm, and renal inj. Fx R hum, thru and thru R thigh.

• Mother gets into fight with ED RN over his jacket and cell phone.
Case Study # 1

- Mother yells at patient to “keep his mouth shut” as security is removing her.
- 13 yr. tearful and worried about who will watch younger siblings; get them up for school in AM, make breakfast, dinner and do homework.
- In SICU – cuffed to bed. Drains for pancreatic injury and developed pancreatitis. Spends 1 month in the hospital for drain, pancreatitis, TPN, etc.
- D/c to juvenile detention after discharge.
Penetrating Pancreatic Injuries


- 8 pedi tr. centers (MO, GA, FL, AL, OH, WI, TX – Houston and Dallas).
- Years 1995 – 2012 reviewed
- 310 pts had pancreatic inj: 93% blunt & 7% penetrating trauma. (n=20)
- N=20 but only 16 used due to incomplete medical records available.
- N=16; 11-male, 5=female; mean age – 11.7 yrs.
  - GSW – 14, SW – 1, boating injury - 1;
  - ISS 18 +/- 3.
Penetrating Pancreatic Injuries


- 100% had associated injuries
  - small intestine (n=9)
  - hollow viscus injury (n=12)
  - solid organ (n=9)
  - IVC (n=2)
  - splenic vein (n=1)
  - L renal vein (n=1)
  - Fem art lac from multi GSW (n=1).

- Still need to have a drain, amylase not really good indicator of progress, complicated care.
Case Study # 2

- 6 yo is playing by himself on a farm where his parents are migrant workers. His toy plane flies into a pen where bulls are kept.
- Gets the plane and no knows what happens next. (a) flew plane which lands farther in the pen or (b) got the plane and was walking around the pen or (3) went to pet the bull?
- The bull charged the boy hitting him with his horns. He was charged at least twice, hit with thorns and held against fence. Thrown in air, stomped. Had abdominal puncture wound, arm wound and facial injuries.
Case Study # 2

• Due to heavy electrical storm advancing, no helicopter would fly. Was being taken by ground to closest pediatric trauma center.

• Diverted to adult center due to falling BP. In extremis, BP 20 palp, unable to tell extent of injury. Intubated and in OR – 10 min after arrival.

• Lacerated spleen, liver, diaphragm, mesenteric artery.

• Phone intra-op consult with pedi center, pedi ground team waiting in PACU for him

• Died 24 hours later
Thoraco-abdominal impalement injury: a case report


- Only case report of pediatric thoraco-abdominal impalement.
- 5 yr old impaled on a bamboo stake.
- Rapidly stabilize and transport to a trauma center.
- Rapidly assess and resuscitate in the ED. Avoid unnecessary tests that delay treatment.
- OR is where the definitive care needs to be given.
- Early administration of antibiotics and tetanus.
Pre-Hospital Use of Blood and Plasma in Pediatric Trauma Pts.


- 9 yr. retrospective study of those < 18 years who received blood during helicopter transport to their facility.

- Blood trans for pedi trauma is rare; estimated < 1% to 2.5% require it.

- Routine lab values i.e. type & screen not indicated and not cost-effective in the majority of ped tr. patients
Pre-Hospital Use of Blood and Plasma in Ped Trauma Pts.


- N=16 (all female)
  - mean age 13.
  - Mean transport time 30 min
  - 75% were from a referring facility.
- 9 blunt (including a bull incident) and 2 were penetrating (GSW)
Pre-Hospital Use of Blood and Plasma in Ped Trauma Pts.


- Follow standard crystalloid boluses.

- Indications for PRBC in pediatric trauma include
  - appropriate tachycardia or hypotension despite 2 to 20 mL/kg crystalloid fl bolus
  - already receiving blood or blood prod from outside institution
  - known use of anticoagulant
Pre-Hospital Use of Blood and Plasma in Ped Trauma Pts.


• Base deficit at admission to pedi tr center predicts mortality and long-term outcomes in injured children.

• BIG Score - Base deficit, INR and GCS combine into BIG score which accurately predicts mortality in ped tr pts.
Tranexamic acid administration to pediatric trauma patients in a combat setting: The pediatric trauma and tranexamic acid study (PED_TRAX).

- 766 pts under 18 yrs.
  - 88% male - 73% penetrating injury
  - Mean ISS 10 - Mean GCS 12
  - 35% needed transfusion in first 24 hours; 9% got TXA
  - 10% needed massive transfusion
  - 76% required surgery
Tranexamic acid administration to pediatric trauma patients in a combat setting: The pediatric trauma and tranexamic acid study (PED_TRAX). Eckert M. (2014) J trauma acute care surg 77:6, pp. 852-858.

- To get TXA needed severe abdominal or extremity injury and base deficit greater than 5.
- Recommended with first 3 hours of injury but unable to document timing of all first dose or secondary dosing.
- There was decreased mortality.
- There were no adverse safety or medication related complications identified.
Case Study # 3

- 7 yo playing with his 10 yo brother and 8 yo neighbor. Dad is a police officer who worked the night shift. Mom is at work. They come in the house to get juice because it is hot outside.

- Dad left gun and holster out and went to bed. The 8 yo neighbor finds gun and picks it up. The 10 yo tells him to put it down. It accidently discharges while being placed down on the kitchen table. The 7 yo is stuck in the abdomen.

- Brought to closest Level 1 trauma center. Paralyzed from the waist down – bullet lodged in spine. It traveled thru small bowel and stomach.
Case Study # 3

- Father blames the 10 yo brother for the event. ED in chaos.
- Children told not to talk because “Daddy could lose his job”.
- Pt transferred to the pediatric Level I trauma center.
- Visits 3 months later in a w/c with his brother and an aunt to thank staff.
- NS chief resident breaks down after visit.
Penetrating Spine Injuries

- Very rare in pediatric pop.
- Concussive forces of bullets can cause damage as well as the bullet.
- Vascular supply disruption to cord can cause ischemia.
- Damage is almost always permanent.
- High dose steroids not done.
- Stabilization and aggressive early rehab to prevent complications.
Case Study # 4

• 2 yo being held by his father on a street corner. Shots fired. Child reportedly used as shield to protect father and sustains GSW to R arm and R neck.

• Taken to closest Level I trauma center. Has ulnar and carotid art inj. To OR, arm repaired with smallest graft, carotid ligated. DYFS contacted.

• Pt d/c to home. DYFS tells mother not to let the father take child out of house alone.
Pediatric vascular injury: Experience of a level 1 trauma center.  

• Children tolerate complete vascular occlusion to the extremities to a greater extent than adults. There vessels have a more elastic nature.

• Pedi peripheral vascular injuries requiring a resection are repaired with autologous tissue whenever possible.

• Use of endovascular stents in children is successful for the short term but there have not been any long-term use studies.

• In adults mortality with penetrating carotid inj nears 50% and 80% incidence of persistent neurologic deficit. No major tx modifications since 1990’s.

• Vessel repair by any means yields a better neurological outcome and survival than if the vessel is ligated.

• Pedi penetrating carotid injury is an unusual and formidable problem due to threats of rapid exsanguinating hem due to smaller total blood volume and devastating neurologic inj.
Successful endovascular repair of exsanguinating penetrating carotid artery injury in two pediatric patients.

• Surgical issues:
  • difficult to gain proximal and distal control
  • compact anatomy
  • short neck in children
  • increased risk of injury to nerves
  • Difficult to perform neck exploration and concurrently maintain pressure at bullet entrance site
  • Primary repair likely difficult as vessels can be very small

• Questions with endovascular stenting of the carotid artery in pent neck inj
  • long-term patency (use small caliber stents)
  • stent occlusion may cause neurologic injury
  • growing child with a stent that does not grow in diameter or length
  • need for antiplatelet or anticoagulation therapy
Case Study # 5

• 12 yo at home watching 4 younger siblings. Mother has gone out for the evening. Father comes home from work at 10:15 PM and upset that last beer is gone. 12 yo says mother drank it earlier. Father is angry and tells 12 yo to get money and go get more beer.

• Child has no money, father gets shot gun out to intimidate son to get money from his room or mom’s hiding spot. Accidentally shoots him in the chest close range x2.

• Neighbors call 911 when they hear a GSW and the children screaming.

• Taken to closest Level I trauma center. Loses vitals enroute in police car. Has a large hole in chest and sucking chest wound.

• ED thoracotomy on arrival. Holes in R & L ventricle – attempting to suture in ED, Level I infuser going, blood, able to restore rhythm but holes too major to repair. Dies in hallway while running to OR for bypass machine.
Case Study # 6

- 14 yo moves to Phila due to mother getting a new job. On first day of school, he asks a girl for directions to get to a classroom. He sees her again in the afternoon and asks her another question.
- Within 5 minutes of the 2\textsuperscript{nd} question, he is shot x3 in the chest by someone who likes the girl. “No one talks to her without my permission.”
- Brought by police to ED, losing VS, ED thoracotomy done. Hole in aorta, vena cava, pulm artery, R lung and knick in pericardial sac. ED thor extended to clamshell. “A team” - chief res and attending on.
- Aorta and R pulm hilum cross-clamped. All holes repaired in ED (within 30 minutes of arrival). Taken to OR, wakes up in SICU 6 hours later – paralyzed due to ischemic cord damage from aortic clamp. Aorta clamp on for 35 min. Sent to rehab and remains in w/c.
- Tr site survey team when hospital inspected hailed this case. Tr attending and chief res have never forgiven themselves for not being fast enough. They still think of him and what his life is like now.
Resuscitative Thoracotomy in Pediatric Trauma

- Resus thoracotomy gained acceptance in pedi tr centers in 1980s and 1990s. Outcomes poor, esp with blunt tr.
- Increased exposure for healthcare workers, waste of resources; cost more than $100,000 for each blunt tr pt.
- Two recent adult studies show possible improvement in mortality
- Lit review - 30 pedi tr pt case studies who had resus thoracotomy (bl & pen). No survivors.
Resuscitative Thoracotomy in Pediatric Trauma

- IL State Trauma Reg had 60,000 pedi pts. Queried from 1999-2009 for those aged 15 and younger.
- One of largest studies - Data from over 60 hospitals collected over 11 yrs.
- There were no survivors of blunt trauma with ED thoracotomy.
- Infrequently done with peds except for older adolescents pts (n=57) aged 16-18 had ED thor.
Resuscitative Thoracotomy in Pediatric Trauma

- Under 15 yr., n=25. Used most for pen tr (n=19, 76% as compared to bl tr (n=6, 24%).
- Males more than females (19 vs 6).
- Pts were in extremis, n=20/24 (83%) had no SBP. 1 pt had no BP noted or recorded at all.
- 6 pts (24%) survived ED
- Only 2 (8%) survived to d/c. (1 GSW & 1 SW)
Resuscitative Thoracotomy in Pediatric Trauma

• The 2 survivors:
  • 1 had VS and GCS of 15 on arrival. Spent 6 days in ICU and 14 days on floor. D/c to rehab with independent function for ADLS.
  • 1 SW pt came to ED with no signs of life. Transport from scene was 3 min. Spent 4 days in ICU and then transferred to another hosp. Was independent function for ADLs when transferred.
Resuscitative Thoracotomy in Pediatric Trauma


- Results were no different than adults. Survival is very few – almost none.
- More selective use of ED thoracotomy is being done now than 20-30 yrs. ago.
- Medical cost-saving, futile applications of heroic measures are becoming under closer scrutiny.
Case Study # 7

- 15 yo high school sophomore - talented baseball pitcher and hoping for scholarship to college.
- A college scout is coming to see him play on Wednesday. On Tuesday goes to corner store to get milk for younger siblings. Walks into a robbery.
- Sustains close range GSW to chest from sawed off shot-gun. Arrives via police – carried in by two officers.
- He arrives at the closest level I trauma center. He has pupillary function but no pulse and not breathing. Thoracotomy done. Multiple holes from buckshot. Take to OR for debridement of shot, pellets in pericardial sac, repair of mammary artery.
- Tried to get all buck shot. Spend 1 week in ICU and 3 days on floor. On day # 3, thought pt had PE and worked up.
An unusual case of foreign body pulmonary embolus: case report and review of penetrating trauma at a pediatric trauma center.

- Penetrating cardiac trauma in children is very rare but increasing.
- 4500 firearm related deaths/year are children
- With cardiac trauma, only 16.8% of inj from pen tr.
- FB emboli - needles, bullets or other projectile objects. Risk of a bullet lodging in the vasc system is 0.3%
- Approx. 80% of FB or bullet emboli are arterial (systemic or pulm).
An unusual case of foreign body pulmonary embolus: case report and review of penetrating trauma at a pediatric trauma center.

- A few cases of retained cardiac FB identified years after injury have been reported and usually require surgical removal.
  - Most are veterans with retained shrapnel.
  - Many others are from civilian bullets.

- Can you track embolized foreign bodies with radiology prior to intervention? Should you think about it?
- Should you only track things because you can not be find it in the OR?
- From cardiac injury the foreign body can go to:
  - R pulm art to main pulm art and then into L pulm art or
  - Superior vena cava or cavoatrial junction to the R ventricle and then into L pulm art.
An unusual case of foreign body pulmonary embolus: case report and review of penetrating trauma at a pediatric trauma center.


• Risk of erosion of a retained FB can include erosion of the vessel or erosion into other surrounding tissue.

• Case reports of spontaneous expectoration of retained intrathoracic bullets.
Case Study # 8

• 8 yo at school is taking attendance sheet and milk money to the office and then meeting her class in the library to watch a movie. It has rained outside and the hallways are wet and slippery.

• She leaves the office carrying her freshly sharpened pencil in R hand along with her notebook in her L hand. She is almost running in the hallway to not miss the beginning of the movie. She slips on the wet floor and falls backwards. Her R hand goes up and impales the pencil in her R eye.

• Taken to closest hospital which is a Level I trauma center. Has penetration of the globe and object still in her eye on arrival. There is moderate amount of blood. Pencil stabilized and transferred to pedi trauma center.
Case Study # 8

- No one likes eye injuries and the pt knew it. She heard people refusing to care for her.
- She cried due to being scared and looking “disgusting, horrific, etc”.
- The principal took ED staff to task for making the child “the main attraction in a freak show”.
- Sitting and talking to her, holding her hand made her feel better. Trauma attending taking her picture, made her smile because “she was going to be a cover girl”.
Prevention

- Teach children not to run with objects in their hands (scissors, knives, pencils, etc.) or mouth (lollipops, popsicles).
- Gun safety (NRA Eddie Eagle program). If you don’t teach them – someone else will (and who will that be?)
- Stop the Bleed – learn it, be prepared and teach it.
Smart Guns

• We have the technology
• Limit sales: How many guns in a day do you need to buy?
• Background checks: Why would you be in a rush to buy a gun?
• Straw purchases: Buy a gun for a criminal-enforce the jail policy.

• Education: Take a course (it can be 4 hours long) on how to use it, store it, fire it, etc.
• Gun Insurance: Just like a car insurance, homeowners insurance.
Questions

• Thank you for coming.
• Enjoy the conference.
• Safe travels home.
• See you in 2020 in Atlanta!
• Get out and see some of this beautiful city. Mary Todd Lincoln home is open:
  • 10 AM – 3 PM. Tours are 1 hour and last one starts at 3 PM.
  • 10 minute walk from the hotel