Penetrating Trauma: Ballistics and Caveats of Care

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Disclaimer

• Not sponsored by Glock, Smith & Wesson or any other gun manufacturer

• No financial interests or stockholdings in the illegal drug, firearm or body-armor industry
Trauma Catalysts

• Standing on the corner (especially dangerous if you are “minding your own business”).
• Being approached by “some dude”, or yet, “two dudes”
• Having “2 beers” (1, 3, or more appear safe”)
• Eating in a Chinese take-out restaurant in West Philadelphia
• Having been previously shot or stabbed.
Ballistics

- The medical study of the wounding the human body from projectiles
- Key wounding concepts:
  - Permanent cavity (compression and crush)
  - Temporary cavity (blast effect)
Ballistics

• Concepts:
  – Muzzle velocity
    • Velocity of the round as it leaves the barrel end
  – Kinetic energy \( (J) = \frac{1}{2} \text{mass} \times \text{velocity}^2 \)
  – High velocity (rifle) vs. Low velocity (pistol)
Ballistics

• Since energy is \( k = \frac{1}{2} mv^2 \) , weight is not as destructive a factor as bullet velocity.

  – .22 170J  \((m = 40, v = 350 \, \text{m/sec})\)
  – .223 1550J \((m = 50, v = 950 \, \text{m/sec})\)
  – .38 325J  \((m = 120, v = 300 \, \text{m/sec})\)
  – 9mm 600J  \((m = 115, v = 700 \, \text{m/sec})\)
Ballistics

- Maximal temporary cavity diameters:
  - .22 (170J) 4.0 - 5.0 cm
  - .38 (325J) 4.0 - 8.3 cm
  - 9mm (600J) 8.2 - 10.6 cm
  - .223 (1550J) 13.0 - 14.0 cm
  - 7.62mm (3500J) 17.0 - 23.0 cm
Ballistics

• Flight characteristics
  – Spiral flight - well thrown football
  – Yaw - tumbling end over end
Shotgun Injuries

• The smaller the gauge, the larger the bore
  – 12 gauge > 16 gauge > 20 gauge
• Multiple pellets
• High velocity-like energy, but it quickly dissipates in tissue
• The closer you are, the “tighter” the pellet pattern
Stab Wounds
(Hand Driven Objects)

- Types
  - Slash
  - Stab
  - Impalement

- Reported 4% mortality
  - Heart
  - Great vessels
Golden Rules of Patient Care in Penetrating Trauma
#1 Assure Safety

• EMS should **never** enter an unsecured scene of violence
  – Staging a safe distance (out of gun range)
  – Radio communication with police

• Body Substance Isolation
  – Penetrating trauma is a bloody business
  – Eye and face protection often forgotten
  – Hats, eye protection, masks, gowns, gloves in the trauma bay
  – All personnel must comply
Assure Safety

• The violence and anger that caused the initial penetrating trauma may follow the patient into the back of the ambulance or into the ER.
• Be alert for weapons during exposure of the patient
• Beware of by-standers or visitors with ulterior motives
#2 ABC’s, ABC’s, ABC’s

• Immediate intubation for:
  – Airway compromise
  – Decreased mental status
  – Apnea or near apnea
  – Respiratory distress
    • Air hunger
    • Cyanosis
    • Low oxygen or high CO₂
ABC’s, ABC’s, ABC’s

• Urgent consideration of intubation:
  – Penetrating neck or facial wounds
    • Rapid airway compromise
    • Expanding hematomas
  – Persistent hypotension or hypoperfusion
  – Prominent altered mental status
    • Combative or mildly obtunded
    • Consider hypoglycemia or “reversible” drugs
ABC’s, ABC’s, ABC’s

• Circulation
  – Check distal and central pulses for level of general perfusion
  – Check and document distal pulses in all wounded extremities
    • Ankle-Brachial Index in lower extremity wounds
  – Support hypoperfusion with IV fluids, blood and an operative plan
ABC’s, ABC’s, ABC’s

• Stop external bleeding
• Direct pressure
• Elevation
• Pressure points
• All bleeding eventually stops!
ABC’s, ABC’s, ABC’s

• Never forget the “D” = Disability
• Never forget the “E” = Exposure
  – Exposure is crucial in penetrating trauma
  – Trauma patients have 4 sides
  – Mark wounds as you find them with paperclips
  – Always look low (you’re dealing with bad shots in most penetrating trauma)
  – Consideration of trajectory based on wounds
#3 Always Presume the Worst

- Always assume the most catastrophic potential of any wound
  - Proximal to knee or elbow gets full response

- Manage the patient accordingly:
  - EMS should not down-triage to BLS
  - EMS should up-grade destinations
  - Transfer boarder line patients to trauma centers
  - Intubate if there is any question about airway integrity or respiratory failure
#4 Never Assume.....
(or you’ll get burned)

- That the single low B/P that EMS got, on a now normotensive patient, was an error.
- That the patient has only one wound.
- That the diaphragm was maximally contracted at the moment the patient was shot or stabbed (ie. the abdomen begins at the nipple line).
#4 Never Assume…..
(or you’ll get burned)

- That it was just your fingers (or the intern’s fingers), when you initially could feel no pulse in a wounded extremity…..but now have a strong distal pulse.
History

- Type of weapon
  - Caliber of gun
  - Length of knife
- Other associated trauma
  - i.e. was he shot and then fell off the roof
- “How many shots did you hear?”
Generic Care

• ABCDE
• Oxygen
• Monitoring (B/P, Pulse ox, EKG)
• At least one large bore IV
• Labs with type and cross or screen
• IV Normal Saline or LR initially, but PRBCs for persistent signs of shock
Generic Care

• Early radiographs especially as indicated
  – “Radiographic assisted exposure”
• Mark all wounds prior to x-ray
• Contemplate wound trajectories
• Assess an operative plan!
Fluid Resuscitation

• Warmed LR or Saline initially
  – Remember that too much crystalloid does not appear to improve, and may worsen, outcome of hypovolemic patients.
  – Hypertonic saline (HTS)?

• PRBCs for persistent signs of hypoperfusion (Type O)

• Keep in mind that definitive care is in the OR for most hypovolemic penetrating trauma patients
Trauma Arrest

• Patients in traumatic cardiac arrest upon EMS scene arrival are going to stay that way!

• In our institution, only narrow complex PEA, and witnessed trauma arrest patients are considered for resuscitation.
Traumatic Arrest

- Penetrating trauma arrests in the presence of EMS have a very narrow window of potential survival (4 minutes BLS and perhaps up to 9 minutes with ALS and intubation) with emergency thoracotomy.
ER Trauma Triage

• Based on an individual institutions’ resources:
  – Should be based on ACS guidelines
  – “Trauma alert” vs. “Trauma response” vs. “Trauma consult”

• Two-Tiered system effective in academic centers:
  – Surgery and emergency medicine working jointly
    • Speeds through-put time (to OR, ICU or home)
    • Optimizes application of resources
ER Trauma Triage

• Community hospital model is less clear
  – General surgeon must be notified immediately
    • Key to decision making process
    • Best knows OR and anesthesia resources
  – Blood products may be scarce
  – Abilities and training of ER physician crucial
  – Timing of evacuation to a trauma center
Multiple GSW Victims

• Hard core military triage
  – After ABC’s, most viable patient comes first
  – Low viability patients
    • Head shots with exposed brain matter
    • Arrests, other than narrow complex PEA

• Careful handling of bloods, X-rays, etc.
  – Assure right patient = right test
  – Assure right patient = right procedure
Injury Prevention

- Penetrating trauma is a chronic disease in certain urban populations
- Estimated that there is up to a 20% recidivism rate
- Key Factors:
  - Access to weapons
  - Domestic violence
  - Youth violence and gangs
  - Street drugs
Weapons on the Streets

- 08:30 in front of a school drop-off zone
- 94 rounds fired from 6 different guns
- 10 year old boy fatally shot in the head
Case Studies
Blast Injury

- Essential to maintain safe blast zone radius
- Take all threats seriously
- Secure the scene and get the expertise you need
- Caution for secondary devices

QuickTime™ and a YUV420 codec decompressor are needed to see this picture.
Israeli Experience

• Open space suicide bombings with a 15% mortality rate
• Confined space suicide bombings (night clubs, buses, etc.) with a 40% mortality rate
Blast Injuries

• Primary blast injury
  – Blast wave effects
  – Sudden change in atmospheric pressure

• Secondary blast injury
  – Classic shrapnel injuries
Blast Injuries

- Tertiary blast injury
  - Injuries that result from secondary impacts after the blast wave has propelled patient

- Miscellaneous blast injury
  - Smoke
  - Burns
  - Inhalation injuries
Primary Blast Injury

- Most severe closest to epicenter of the blast
- Sudden change in pressure devastates air and fluid filled organs and cavities
- Direct brain injury
Secondary Blast Injury

- Injury from flying debris
- Classic shrapnel injuries of various velocities
- Manage as standard penetrating trauma
- #1 Military killer in the 20th Century
Tertiary Blast Injury

- Axial load injuries
- Wide-range of blunt trauma injuries:
  - Spine
  - Orthopedic
  - Head
  - Solid and hollow organ injuries
Miscellaneous Blast Injury

- Inhalation injuries from dust and gasses
- Burns
  - Thermal
  - Radiation
Golden Rules of Penetrating Trauma Care

- Assure personnel safety
- ABCDE, ABCDE, ABCDE
- Always presume the worst
- Never assume.................