Ballistic Trauma

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September 22, 2016
Case Presentation

• Most cases at Kings County Hospital
Case Presentation

• HPI: 22yo male presented as Level I Trauma Activation s/p GSW to the abdomen.

• Primary Survey: intact
• Vital Signs:
  – T 97.2  BP 142/79  HR 102  RR 29  O2 sat 100% on 4L NR
• Secondary Survey
  – Distended, peritoneal
  – GSW to right flank
  – GSW to RLQ
  – FAST+
Case Presentation

• Labs:
  – CBC 8.57>15.2/44.5<296
  – BMP 140/3.5/103/16/17/1.21<143
  – Ca/M/P 9.8/2/4.3
  – Coags 9.8/19.9/0.9
  – EtOH negative
  – Lactate 6.5
Case Presentation
Case Presentation

- Exploratory laparotomy
- >50% small bowel injury → resection and primary staple anastomosis
- Cecal injury x 2 <50% circumference → staple resection
- EBL 250cc, 2U pRBC, 1U platelets, 1900IVF
Case Presentation

• POD#0 – remained intubated in SICU
• POD#1 – extubated
• POD#3
  – +flatus → CLD
  – delayed primary closure of abdominal wound
• POD#4 – regular diet
• POD#5 – discharged home with wound care

• POD#10 – clinic – well-healing wound, no complaints
Case Presentation
Ballistic Trauma

- Epidemiology
- Firearms
- External Ballistics
- Terminal Ballistics
- Damaging factors
- Management of GSW
Epidemiology

- 33,636 mortalities in US → 85 deaths/day → 3 deaths/hour
- 73,000 treated for non-fatal gunshot wounds in 2010
- 3rd leading cause of injury-related deaths (after MVA and poisoning)
Epidemiology

(1970-2013)

Firearms Murder Vic. Rate per 100 thousand pop.

Mass Public Shooting Murder Vic. Rate per 10 mil. pop.

- Firearms Murder Rate per 100 thousand/population
- Mass Public Shooting Murder Rate per 10 million/population
BROOKLYN
GUN
BUY BACK

TURN IN YOUR OPERABLE HANDGUNS
AND ASSAULT RIFLES AND RECEIVE A
$200 BANK CARD

$25 BANK CARD FOR OPERABLE RIFLES AND SHOTGUNS

NO QUESTIONS ASKED
NO ID REQUIRED
NO CURRENT OR FORMER LAW ENFORCEMENT HANDGUNS

SATURDAY, AUGUST 27, 2016

Clarendon Road Church
3304 Clarendon Rd, Brooklyn, NY 11203
between New York Avenue and East 34th Street
10:00 a.m. - 4:00 p.m.

For more information: 718-250-3888
www.brooklynda.org
History of Firearms

• 9th Century China - discovery of gunpowder
  – Potassium nitrate, charcoal, sulfur
  – Expands to 6 times with heat
  – Bamboo shoot filled with shrapnel

• 10th Century China - fire lance
  – Bamboo → metal
  – Shrapnel → occlusive projectile to maximize combustion
Basic Anatomy...of a gun

- Gunpowder $\rightarrow$ combustion
- Barrel – length vs velocity
- Projectile – bullets
Types of Firearms

- Handguns
- Long guns - requires 2 hands
- Semiautomatic - automatic reload
- Fully automatic - hold down the trigger
Types of Firearms

- **Handguns/pistols**
  - low velocity, short barrel

- **Rifle**
  - high-velocity long gun
  - Rifling – inner grooves of the barrel for bullet stability/spin

- **Shotgun**
  - low-velocity
  - multiple projectiles
Shotguns

• **Type I**  <5m
  – pellets enter as single high impact mass
  – 85-90% mortality

• **Type II**  5-12m
  – dispersal of pellets at lower velocity, may penetrate fascia but deeper injury is rare
  – 15-20% mortality

• **Type III**  >12m
  – may penetrate skin
  – 0-5% mortality
Ballistic Trauma

- Ballistics – science of projectile motion
Ballistic Trauma

- Ballistics – science of projectile motion
- Internal ballistics
Ballistic Trauma

- Ballistics – science of projectile motion
- Internal ballistics
- External ballistics
Ballistic Trauma

• Ballistics – science of projectile motion

• Internal ballistics

• External ballistics

• Terminal ballistics
External Ballistics

- Impeding forces
  - Gravity
  - Air Resistance
External Ballistics

- Center of gravity - lies behind center of resistance
  - Yaw
  - Precession
Terminal Ballistics
Terminal Ballistics

Entry wounds

.45  10mm  .40  .357mm  .38  9mm  .380  .22
Terminal Ballistics

- **Permanent cavity**
  - Constant tract
- **Temporary cavity**
  - Depends on velocity of bullet
  - Up to 10-30 times the size of the permanent cavity
  - Expands and collapses repeatedly with decreasing amplitude
Terminal Ballistics

• Zones of GSW
  – Primary zone
  – Contusion zone
    • inflammation
  – Concussion zone
    • Stretching and shearing
Terminal Ballistics

**Entry wounds**

- .45
- 10mm
- .40
- .357mm
- .38
- 9mm
- .380
- .22

**Exit wounds**

- .22
- .380
- 9mm
- .38
- .357
- .40
- 10mm
- .45
Terminal Ballistics

• Short distance
  – larger with ragged edges
  – yaw upon exit

• Long distance
  – Smaller
  – yaw internally
Damaging Factors

- Projectile velocity
- Yaw
- Projectile features
- Fragmentation
- Tissue elasticity
- Secondary wounding
Projectile Velocity

• Medium velocity bullets
  – Direct insult

• High velocity bullets
  – Kinetic energy transferred to surrounding tissue
  – Negative pressure sucks in air/debris
Yaw

- **External Ballistics** → resistance/drag
- **Terminal Ballistics** → tissue damage
Projectile Features

• Mass/weight
• Jacket
• Expanding bullets
• Caliber/diameter
• Tip
Projectile Features

- Mass/weight
- Jacket
- Expanding bullets
- Caliber/diameter
- Tip

$E = \frac{1}{2} MV^2$

Larger bullet $\rightarrow$ more resistance $\rightarrow$ more tissue damage
Projectile Features

- Mass/weight
- Jacket
- Expanding bullets
- Caliber/diameter
- Tip

Flight dynamics
Tissue penetration
Projectile Features

- Mass/weight
- Jacket
- Expanding bullets
- Caliber/diameter
- Tip
Projectile Features

• Mass/weight
• Jacket
• Expanding bullets
• Caliber/diameter
• Tip
Projectile Features

- Mass/weight
- Jacket
- Expanding bullets
- Caliber/diameter
- Tip – pointed, flat, round, hollow
Damaging Factors

- Projectile velocity
- Yaw
- Projectile features
- Fragmentation
- Tissue elasticity
- Secondary wounding

Bullet particles, bone, clothing, debris
Tissue Elasticity

• Higher elasticity – less injury
  – Skin
  – Lung tissue
• Low elasticity – more injury
  – Muscle
  – Bone/tendon
• Fluid-filled organs – not compressible → burst!
  – Blood vessels and heart
  – Bladder
Secondary Wounding

• Myth: Bullets are sterile from combustion and heat

• Foreign bodies
• Clothing, debris
• Contamination

• Wolf et al shot S Aureus coated bullet into sterile gel and grew + cultures
Management of GSW

• Assessment
• Specific Considerations
• Control of infection
• Nutrition
• Reconstruction
• Bulletectomy
Assessment

• Primary survey - ABC’s
  – Secure airway
  – Control hemorrhage
• Secondary survey
  – Thorough examination
    - axilla and groin
  – Imaging
• Tertiary survey
Specific Considerations

- Head
- Neck
- Chest
- Abdomen
- Extremities
Specific Considerations – Head

- Contained space - shock waves compress brain matter and may cause skull to explode
- Medium velocity bullets may follow the curvature of the interior skull → more damage
Specific Considerations – Neck

- Hard signs
  - Airway compromise
  - Significant subcutaneous emphysema
  - Bubbling through wound
  - Expanding/pulsatile hematoma
  - Active bleeding
  - Shock
  - Neurologic deficit
  - Hematemesis

- Hemodynamic instability
Specific Considerations – Neck

- Zones of the neck
- CTA neck
- EGD/swallow study
- Bronchoscopy
Specific Considerations – Chest

- Lung tissue
  - Less dense thus less damage
  - Contusion
  - Pneumothorax
  - Hemothorax
- Major blood vessels and heart
  - more vulnerable to shock waves
- Esophagus
- Rib fractures
Specific Considerations – Abdomen

• Bone
  – fragmentation → secondary missiles!

• Solid organs, muscles, peripheral nerves, and blood vessels
  – more vulnerable to shock
Specific Considerations – Abdomen

• Small bowel and colon
  – Simple lacerations <50% → debridement and repair
  – >50% defect → resection and primary anastomosis
    • no difference between staple or hand-sewn
– Colostomy - high risk patients
  • damage control, unstable patient, transfusion requirements, high injury severity score, extraperitoneal rectal injury
Specific Considerations – Extremities

- Hard signs → OR
  - Pulse deficit, pulsatile bleeding, bruit, thrill, expanding hematoma
- Soft signs, ABI < 0.9, and/or abnormal exam → CTA extremity
  - Non-expanding hematoma, resolved bleeding, proximity to artery, neurologic deficit
- Normal exam + ABI > 0.9 → discharge home
Management of GSW

- Assessment
- Specific Considerations
- Control of infection
- Nutrition
- Reconstruction
- Bulletectomy

- Tetanus vaccine
- Wound irrigation
- Consider 24h antibiotics
Management of GSW

- Assessment
- Specific Considerations
- Control of infection
- Nutrition
- Reconstruction
- Bulletectomy
Management of GSW

• Assessment
• Specific Considerations
• Control of infection
• Nutrition
• Reconstruction
• Bulletectomy
Management of GSW

• Assessment
• Specific Considerations
• Control of infection
• Nutrition
• Reconstruction

• Indications
  – Pain
  – Infection
  – Functional impairment
  – Deformity
  – Potential neurotoxicity
  – Proximity to large artery or nerve - copper, brass
  – Patient preference
• Ballistics – science of projectile motion
• Tissue damage dependent upon multiple factors – firearm, bullet, victim
• Tissue damage zones – permanent, contusion, concussion
• Tissue elasticity can determine damage

“Whatever you do, do NOT pull that out!”
Questions?

I Mustache You A Question!
During laparotomy for a GSW to the abdomen, patient is found to have a 4cm laceration to the anterior surface of the sigmoid colon approximately 5cm above the peritoneal reflection. Patient is hemodynamically stable without gross spillage. What is the best management?

A debridement and primary repair

B primary repair with proximal diversion

C resection, end colostomy, mucus fistula

D resection, end colostomy, hartmann’s pouch