Guide to Ballistics

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Objectives:

• Describe the basic physics and kinetic properties of ballistic injuries
• Discuss the prehospital management of penetrating ballistic injuries
• Review the physics of blast injuries
• Summarize the prehospital and hospital management of blast injuries
Kickin’ Ballistics and Blast with Dr. Balls

Adam Balls, MD
IHC EMS Conference
5/15/15
kickin' ballistics

To reason with someone, to tell them how things really are, to philosophize about a topic.

*Me and my man Gary sat up all night listening to his older brother Charles kickin' ballistics about prison industry-complex.*

by merrakesh August 29, 2010
Dr. Rob Bryant
Member of
New Zealand “Sheep” Army
And Navy
Nathan Jones takes a firm stance as Rictus Erectus.
My Life Experience with Weaponry..... I’m not a Ballistics Expert
OBJECTIVES

• Basic Physics of Ballistics

• Management of Ballistics Injuries
OBJECTIVES

• Physics of Blast Injuries

• Prehospital Blast Trauma Management
TYPES OF PENETRATING TRAUMA

- GSW
  - Rifle
  - Pistol
  - Shotgun
- Blast

Is Mechanism Really Important?
EXTERIOR BALLISTICS

I'm out of the gun according to plan - now what?

INITIAL SPEED AND DIRECTION

BORE EROSION

PROPELLING CHARGE AND BURNING RATE

POWDER TEMPERATURE

DENSITY AND MANNER OF LOADING
TERMlNAL BALLISTICS

* PROJECTILE BEHAVIOR

* TRANSFER OF KINETIC ENERGY
\[ K = \frac{1}{2}mv^2 \]
Kinetic Energy VS Range of various projectiles

- Brenneke 114 grain
- Federal 109 grain
- Remington 87.5 grain
- 380 APC 95 grain
- 38 special 158 grain
- 375 Mag 158 grain
- 41 Rem 210 grain
GSW: Report “G” “S” and “W”

- **Gun**: Type of Weapon, Caliber of Bullet
- **Space**: Distance from Shooter to Victim
- **Way**: Way the bullet enters/trajectory
“G”
AK-47

- Developed by Kalashnikov in 1945
- 7.62X39mm Round
- Muzzle Velocity: 715 m/s (2351 m/s)
- Upgrades to M67 Cartridge
  - Earlier destabilization (Yaw) greater tissue damage
Typical Russian Caliber Wound Profiles

5.45 x 39 mm Russian
53 gr M74 FMJ
at 3066 f/s

7.62 x 39 mm Russian
120.5 gr M43 PS FMJ
at 2340 f/s

7.62 x 39 mm Yugoslavian
124 gr M67 FMJ
at 2300 f/s

7.62 x 39 mm
Commercial 123 gr JSP
at 2303 f/s

7.62 x 54 mm Russian
M1898/1908 Type L
148 gr FMJ at 2799 f/s

Steel core 7.62 x 39 mm FMJ
demonstrates deep penetration
with minimal tissue
damage prior to initial yaw.

7.62 x 39 mm
lead core FMJ of
Yugoslavian, PRC,
Czech and other origin has
early yaw & acts more like the
Russian 53 gr M74 FMJ fired by the AK74

Well engineered 7.62 x 39 mm JSP
acts somewhat like .30-30 JSP

centimeters penetration
AR-15

- Fully automatic: 800 rounds/min
- 975 m/s (3200 ft/s)
- Effective Range up to 400m-600m
HANDGUNS

- 9mm: velocity range 990 to 1350 ft/s
- .45: velocity 835 to 1150 ft/s.
- 0.38 Special: 940 ft/s
- 0.357 Magnum: 1040 ft/s
From the first shot to the last, get improved shot speed and minimum muzzle rise with little or no loss of velocity.
0.357 Club
<table>
<thead>
<tr>
<th>Caliber</th>
<th>Energy (J)</th>
<th>(m = g, v = m/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>.22</td>
<td>170</td>
<td>(36, 350)</td>
</tr>
<tr>
<td>.223</td>
<td>1550</td>
<td>(50, 900)</td>
</tr>
<tr>
<td>.38</td>
<td>325</td>
<td>(120, 300)</td>
</tr>
<tr>
<td>7.62</td>
<td>3500</td>
<td>(165, 850)</td>
</tr>
</tbody>
</table>
Projectile Motion is Complex and Varies over Range

M855 Yaw Behavior

Largest Yaw Variability is in the CQB Range

M855 Yaw History
Non-Linear Aerodynamics

Source: http://wstiac.alionscience.com/pdf/WQV8N1_ART01.pdf
PERMANENT AND TEMPORARY CAVITATION

- **Permanent**: tissue crush and excavation
- **Temporary**: blast effect due to tissue stretch
BALLISTIC GEL CAVITATION
BULLET TYPES

- Full metal jacket
- Lead
- Softpoint, semi jacketed
- Hollow point, ballistic tips
BULLET FRAGMENTATION

- Increased tissue destruction compared to temporary cavity
- Hague convention of 1899
- Restrictions on use of expanding/fragmenting bullets
COMMON BULLETS

• .22 caliber
  – Hand pistol
  – Cheap and readily available
  – Low energy, lead bullet
  – Tumble tissue kinetics
COMMON BULLETS

• .38 caliber
  – Pistol
  – Low velocity
COMMON BULLETS

• 30-06
  – Rifle
  – Common hunting round
    • Fragmenting bullets
  – Old military use
SHOTGUN

• “bird shot”
  – Multiple low energy spreading pellets, short range effect
• “buck shot”
  – Fewer larger pellets
• Slug
  – Single projectile, longer effective range
PREHOSPITAL PRINCIPLES

• What you can’t see may kill your patient!!

• Rapid Stabilization and Transport

• Hemorrhage Control and Permissive Hypotension?
CABCD? Say What

- **C**atastrophic Hemorrhage
- **A**irway
- **B**reathing
- **C**irculation
- **D**isability
- **E**xposure
C.A.T or no CAT?
Tourniquet Use

- Arterial Bleeding resulting in large blood loss
- Poor hemorrhage control with direct pressure
- Apply as low as possible above wound
- May result in compartment syndrome
- Nerve Injury or Paralysis
EXPLOSIVE BLAST INJURIES
head-strike against vehicle roof in unrestrained occupant

fragmentation injury from flying debris

local deformation causing axial loading to lower limb

supersonic detonation products causing rupture of floor pan

kinetic energy imparted by soil ejecta causing global vehicle acceleration

thermal burns from explosions
Fig 1: Instance of the maximum pressure loading on the human face during the impact of the planar blast wave. The pressure of the blast front is 143 kPa just before the impact.
Blast Injury

- Ocular Injury
- Aural Injury
- Pulmonary Injury
- Cardiovascular Injury
- Musculoskeletal Injuries
- Brain Injury
- Abdominal Injury
<table>
<thead>
<tr>
<th>CATEGORIES OF BLAST INJURY</th>
<th>HOW THE BODY IS AFFECTED</th>
<th>TYPES OF INJURIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRIMARY INJURY results from impact of the over pressurized, high velocity blast wave with body surfaces.</td>
<td>Gas-filled structures, the lungs, gastro-intestinal tract, and middle ear are most affected.</td>
<td>Blast lung; blast gut; ruptured eardrums or eyes; abdominal perforation or hemorrhage; concussion; amputation; air embolism.</td>
</tr>
<tr>
<td>SECONDARY INJURY results from flying debris and bomb fragments.</td>
<td>Any body part may be affected; severity of injury depends on speed of objects hitting the body.</td>
<td>Cuts; bruises; tearing; penetration by shrapnel; internal bleeding.</td>
</tr>
<tr>
<td>TERTIARY INJURY results from being thrown by the blast wind.</td>
<td>Any body part may be affected; severity of injury depends on speed of body as it flies through the air.</td>
<td>Fractured bones; amputations; brain injuries.</td>
</tr>
<tr>
<td>QUATERNARY INJURY includes all other injuries from the blast.</td>
<td>Any body part may be affected.</td>
<td>Burns from the fireball or objects that catch fire; crush injuries; brain injuries; injuries from breathing in dust, smoke and toxic fumes; angina; existing conditions like diabetes or high blood pressure may be worsened; post traumatic stress injury.</td>
</tr>
</tbody>
</table>
BLAST LUNG INJURY

• May Lead to Air Emboli
• Patient with Head/Torso Injuries, > 10% Burns higher incidence of BLI
• May take 24-48 hours to develop
• Symptoms: Cough, SOB, Hemoptysis, Hypoxia
• Management: High Flow 02, Airway Interventions
PREHOSPITAL MANAGEMENT

• **Scene Safety:**
  – Assess Scene, Secondary Blast aimed at First Responders

• **Information:**
  – Type of Blast, Location of Victim to Epicenter

• **Treatment:**
  – High Flow 02 in patients with respiratory systems
  – Control Hemorrhage
  – C-spine stabilization and Fracture Management