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The History of Genitourinary Blast Trauma

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Blast Wave

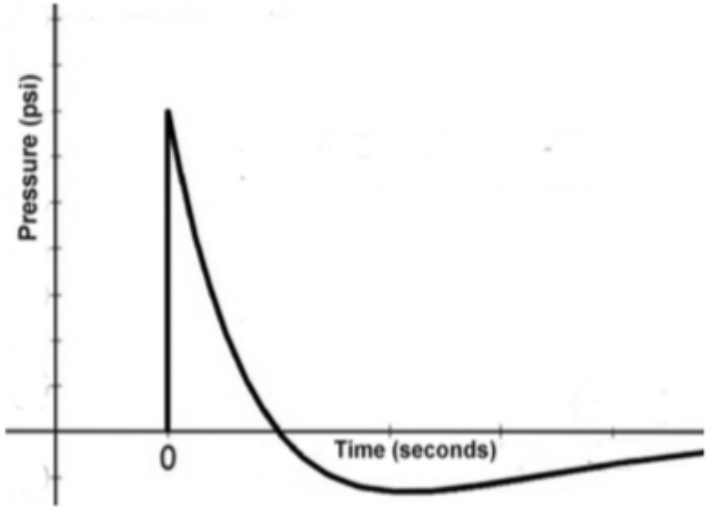
Peak Overpressure
- Overpressure
- Duration of overpressure

Fragmentation Effect
- Projectiles

Blast Wind
- Pressure differential

Incendiary Thermal Effect

Secondary Blast Pressure Effect
- Deflection



Friedlander waveform

Garner et al, Anesthesiol Clin 2007
Champion et al, J Trauma 2009

Blast Injury

Primary-

- *Peak overpressure* and *dynamic overpressure*

Secondary-

- Debris carried by the generated blast wind
- Blunt and/or penetrating trauma

Tertiary-

- Displacement of the victim from the blast wind

Quaternary-

- Burns, inhalation injury, toxin inhalation, and radiation exposure

Wolf et al, Lancet 2009
Ritenaur et al, Crit Care Med 2008

Methods

Objective: Investigate the historical relationship between blast trauma and the evolution of genitourinary (GU) trauma care.

Literature review

- Blast injury, GU trauma, and battlefield medicine

Textbooks and peer-reviewed articles

Queried for GU blast injury

- Department of Defense records
- Library of Congress archives
- Centers for Disease Control

Results

Circa 618–907 C.E.

- Tang Dynasty

1044 C.E.

- Song Dynasty Military Manual
  - "Fire arrows"

American Revolutionary (1775-1783) and American Civil War (1861-1865)

- Urotrauma <1% of injuries

Needham et al, *the gunpowder epic* 1986

American Civil War

Total of 1,497 GU injuries

- GU Injuries only 0.61% of all battle wounds
- 22% fatal

William F. Ketchum (1798-1876)

- Buffalo, New York
- Ketchum Grenades- 1861

Gabriel J. Rains (1803-1881)

- Land Mines- 1862

Ketchum Grenades. Courtesy of the National Museum of Health and Medicine

Herr et al, J Urol 2004

American Civil War

Urinary diversion

- Perineal urethrostomy, catheterization, or suprapubic cystostomy

First battlefield triage

- Jonathan Letterman (1824-1872)- "Father of Battlefield Medicine"
- After the first Battle of Bull Run (1861)

Wound Care

- Sequela
- Antibiotics not discovered until 1928 (Alexander Fleming)

Herr et al, J Urol 2005

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Renal and Bladder Trauma

Most common GU blast injury

- Late 18th century and early 19th century

World War I (1914-1918)

- Significantly increased incidence of GU injury
  - 2/3 of all battlefield casualties
- Nephrectomy
- Difficulty with expeditious care

World War II (1939-1945)

- First C-4 explosive- Great Britain
- Manhattan Project
  - First nuclear blast injury in 1945 Hiroshima, Japan

"Bombs and Airplanes", 1936. Courtesy of the US Library of Congress

Hudak et al, Urology 2005

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Medical and Surgical Advancements

World War II (1939-1945)

- Antibiotics
- First use of muscle flaps to cover GU injuries

Korean War (1950-1953)

- First vascular reconstructive techniques

Eugene Bricker (1908-2000)

- Ileal Conduit Urinary Diversion- 1950

"Fort Belvoir, Virginia- Grenade throwers", 1944. Couresy of US Library of Congress

Baker et al, Ann Vasc Surg 2016

Battlefield Developments

Norman Macleod patent

- Claymore mine- 1961
- Vietnam War (1955-1975)

Staged urethral repairs

- Improved outcomes
- Decreased complications

Mobile army surgical hospital (MASH) units and helicopter evacuation

- Increase in GU injury, but decrease in overall mortality

Salvatierra et al, J Urol 1969
Busch et al, J Urol 1967

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Body Armor

Gulf War (1990-1991)

- First implementation
- Reduced casualties
- Increased incidence of external genitalia blast injuries

Bosnian War (1992-1995)

- Majority of injuries due to improvised explosive devices (IED)
- Most common surgical procedures:
  - Nephrectomy, retroperitoneal hematoma evacuation, and orchiectomy

Zalihić et al, Coll Antropol 2011

Increased Blast Injury

Operation Iraqi Freedom (2003-2011) and Operation Enduring Freedom (2001-Present)

- Three-quarters of battle injuries being due to an explosive mechanism
- Dismounted complex blast injury (DCBI)
  - Blast injury to a dismounted troop
  - Extensive genitoperineal wounds

Department of Defense Trauma Registry (DoDTR)

- 30,000 military- 1,462 (5.3%) who sustained one or more GU injuries
- 74.1% were caused by an explosive mechanism
  - 73.2% had at least one injury to the external genitalia

Janak et al, J Urol 2017
Cannon et al, J Am Coll Surg 2016

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Medical and Surgical Advancements

Survivable injuries

- Improved prevention- pelvic kevlar
- Rapid casualty evacuation
- Advanced resuscitation techniques
- Multidisciplinary damage control surgery

Wei-Ping Andrew Lee, MD

- First penoscrotal transplant for a combat victim – 2018

Phalloplasty

- Increased due to DCBI

Reduction of GU injury with use of PPE

Janak et al, J Urol 2017

Conclusion

Over the centuries, the increased advances in technological warfare have coincided with an increased incidence of GU blast trauma.

The improved surgical technique, technological innovations, and improved urologic care continue to meet the increasing patient care demands caused by evolving GU blast injury.

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