

Practicing medicine in a war zone: Blast Injury

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Bangkok
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Haifa – Bus 37 March 5, 2003

18 killed (9 Kids)

> 30 wounded







Maxim restaurant October 4, 2003

21 Killed (7 Kids)

2 Families of 5

60 Wounded



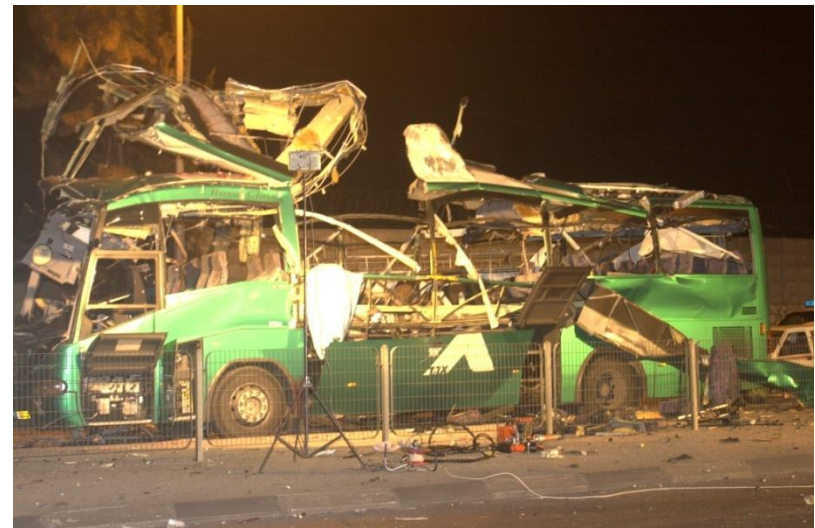


Second Lebanon War, August 6, 2006



Goal – increasing the “Death Effect”

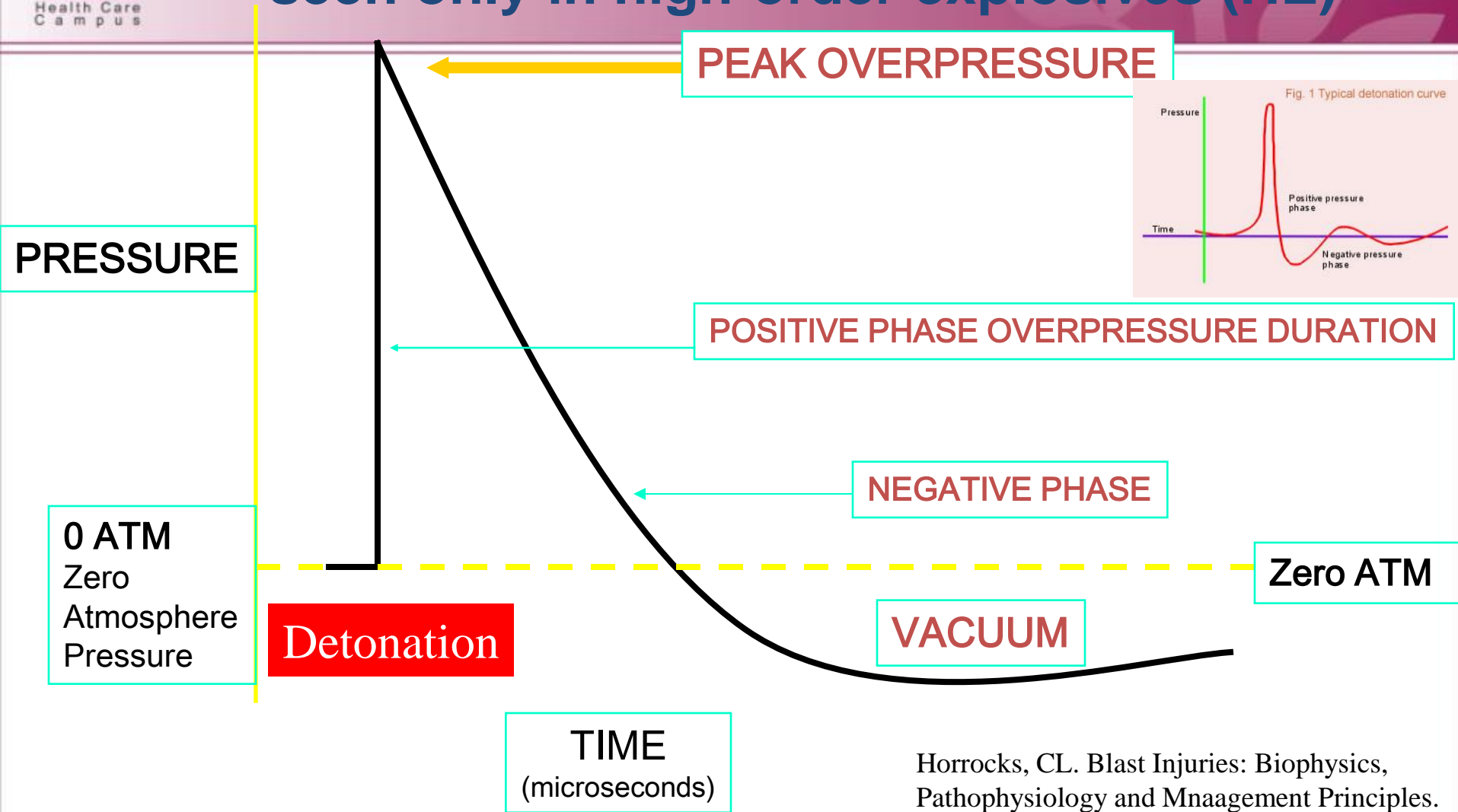
- Type & quantity of the explosive
- Distance & geography
- Medium (water X 6)
- Open Vs. Closed space
- Metal parts
- Toxins and biohazard.





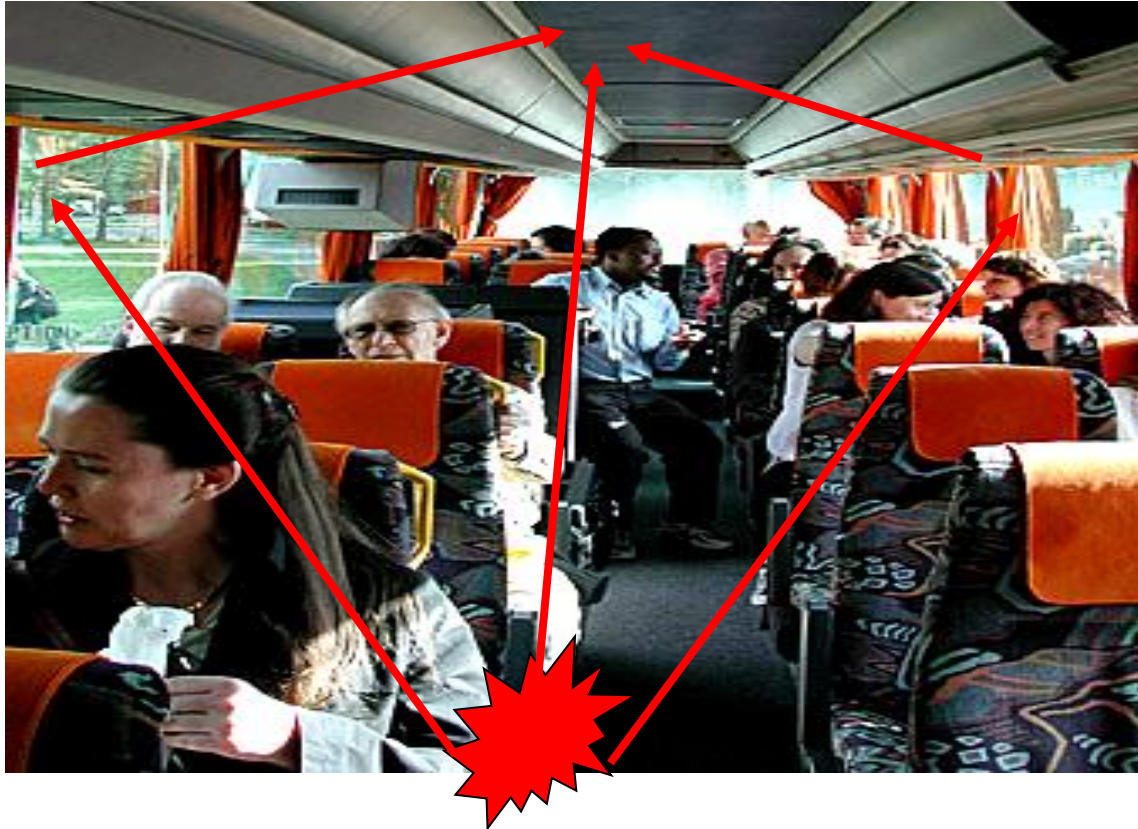


Idealized blast overpressure waveform seen only in high-order explosives (HE)



Horrocks, CL. Blast Injuries: Biophysics,
Pathophysiology and Mnaagement Principles.

Blast in ultra closed space

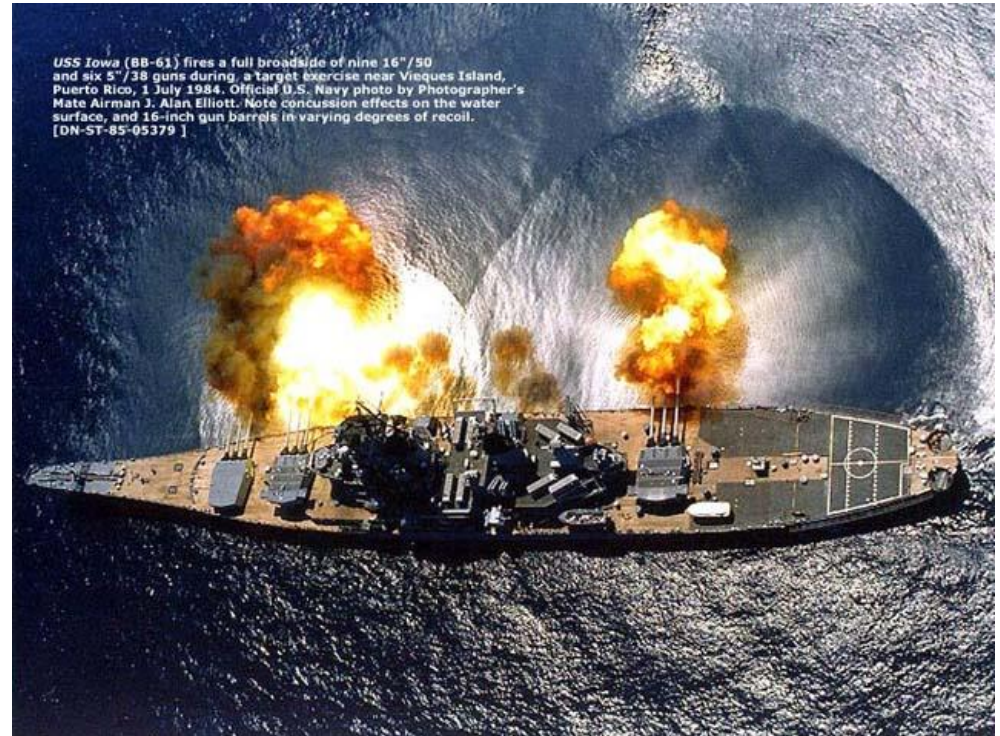


Wave reinforcement



Blast Injuries (BI) - physics & physiology

- Explosion: rapid chemical conversion of solid or liquid to gas with subsequent release of energy

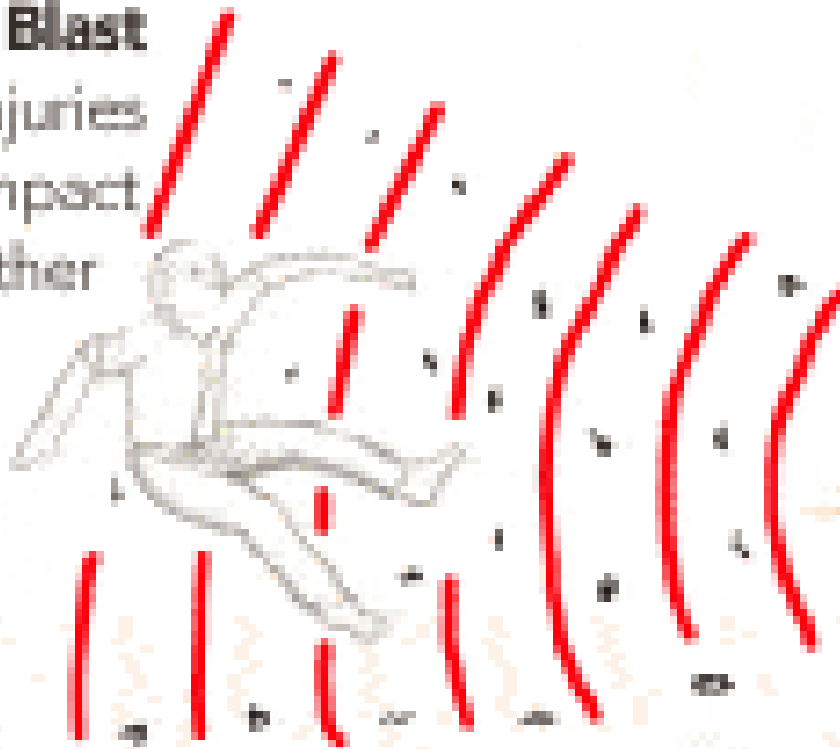


Mechanism of Blast Injury (BI)

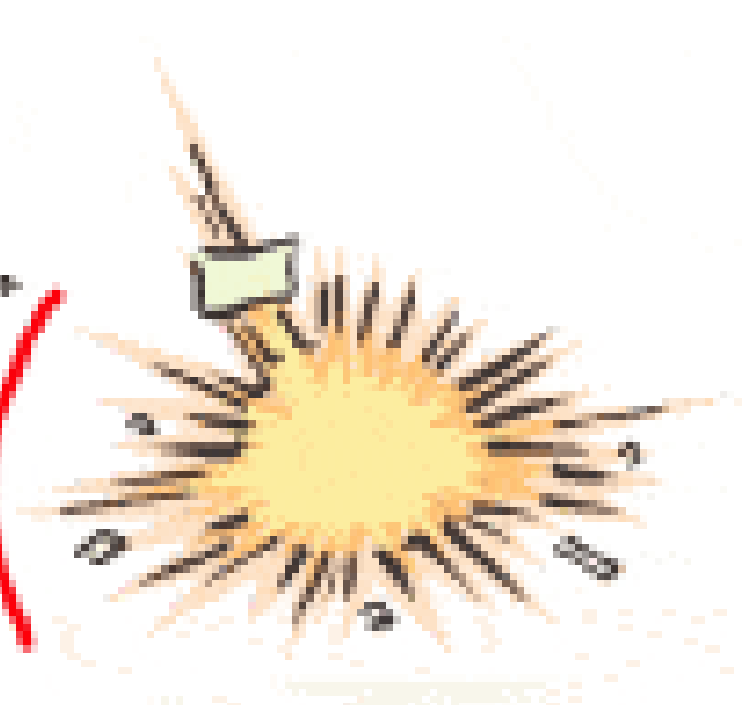
- **Primary BI** – Direct effect of atmospheric pressure change on tissue (lungs, ears, gut).
- **Secondary BI** - Result of projectiles thrown by blast.
- **Tertiary BI** - Result of victim displacement.
- **Miscellaneous Blast Injury (“Quaternary”)** - Result of toxins, heat, structural collapse, etc.

Mechanism of Blast Injury (BI)

Tertiary Blast Injury
(Injuries due to impact with another object)

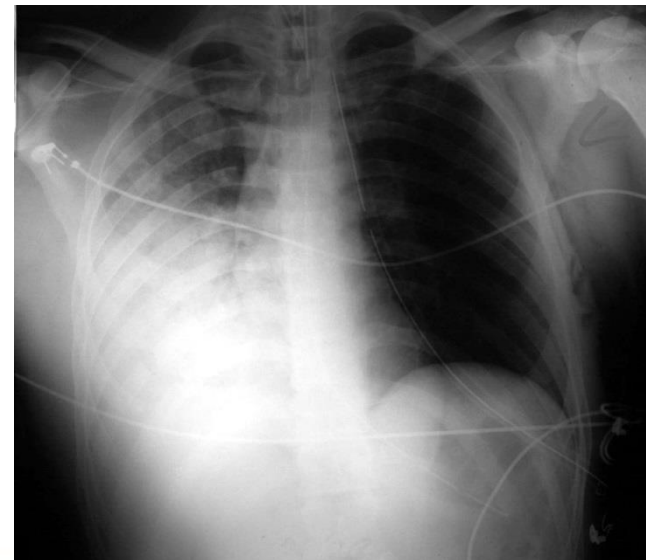
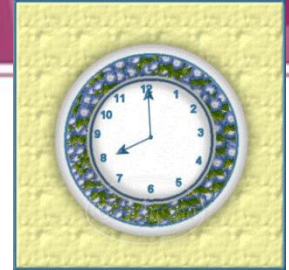
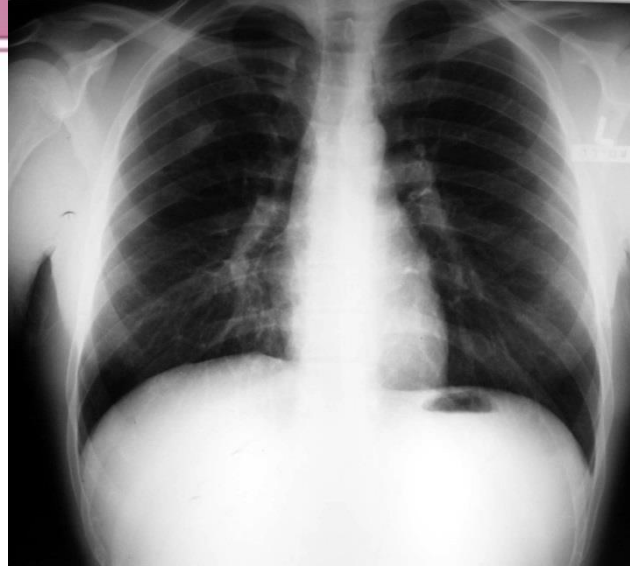


Secondary Blast Injury
(Injuries due to missiles being propelled by blast force)



Primary Blast Injury
(Injuries due to the blast wave itself)

Blast Lung Injury



“White Butterfly Sign”



Blast Lung – 70% fatal

- A clinical diagnosis, confirmed with X-ray
- A severe pulmonary contusion from air compression – re-expansion

Symptoms – exposure plus SOB, cough, hemoptysis, retrosternal pain

Signs – Tachypnea, cyanosis, decrease BS, dull to percussion, rales / crackles, hemo/pneumo-thorax, subcutaneous emphysema, retro-sternal crunch, air emboli, retinal artery emboli

Management – Similar to severe pulmonary contusion

- complex fluid management
- mechanical ventilation further increases chance of air emboli

Blast Injury - Abdomen

- Bowel perforation
 - Rare (0-1.2%)
- Late clinical presentation
 - Slow dissection of mucin between bowel wall layers
- Solid organs
 - Rarely injured by primary blast

Bowel perforations are more common
in underwater explosions

Blast Abdomen

Delayed onset > 8-36 hours – more common in submersion

1. Intestinal intra-wall hemorrhages
2. Shearing of local mesenteric vessels
3. Sub-capsular and retroperitoneal hematomas,
4. Fracture of liver and spleen, and testicular rupture

Symptoms – exposure plus abdominal pain, nausea, vomiting, hematemesis (rare), rectal pain and tenesmus, testicular pain

Signs – abdominal tenderness, rebound, guarding, absent bowel sounds, signs of hypovolemia

Management – Resect small bowel contusions > 15 mm, and large bowel contusions > 20 mm

Secondary Injury

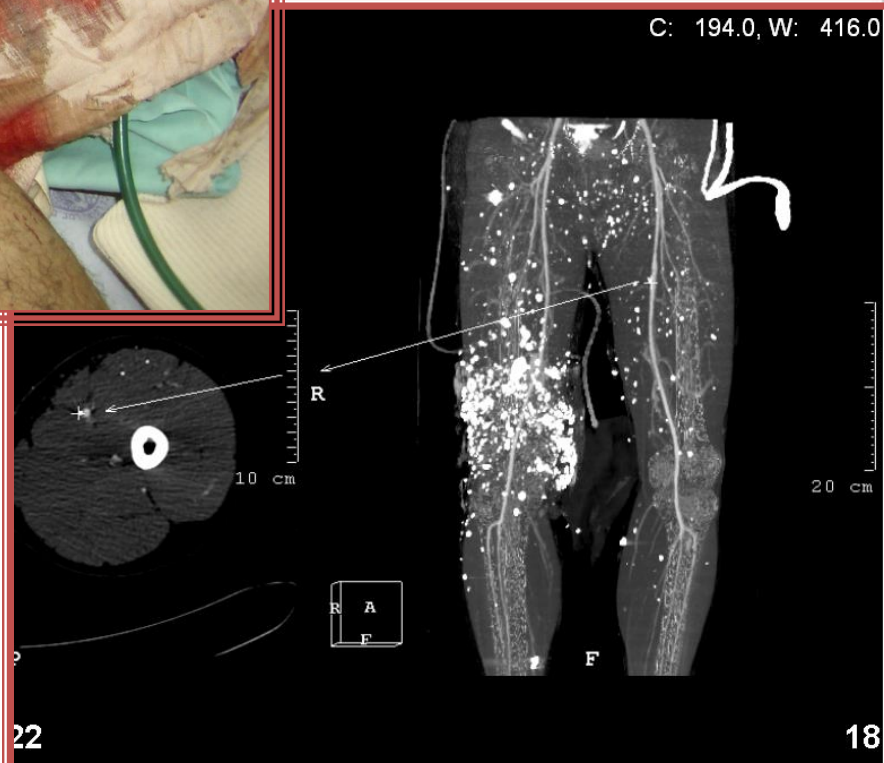
Penetrating Injury







C: 194.0, W: 416.0





Tertiary Blast Injury

"Tertiary" applied exclusively for high-order (HE) injuries

1. Caused by displacement of body, or body parts, by force of blast wind
– includes **traumatic amputations**
2. Blunt trauma – solid object strikes, or victim is thrown against solid object, includes impalement
3. Care follows standard blunt trauma protocols

Courtesy: Battlefield Wounds, John R. Mechtel, RN, MSN – DMRTI

Quaternary Blast Injury

“Quaternary” applied exclusively for high-order (HE) injuries

Classified by some disciplines as “miscellaneous”

1. Crush injuries

2. Suffocation and Fume poisonings

3. Burns

4. Exacerbation of chronic disease

- Asthma, COPD, diabetes, hypertension, CAD, PUD, alcohol and drug abuse, mental health

5. New behavioral problems

Thermal Effect

- **Burns result from the ignition of flammable materials**
- **Very high temperature for short periods during explosion**
- **Local fires and flash burn to victims closed to explosion**
- **High temperature air lead to heat-inhalation lung injury**

Flash Burn



Patterns of injury in hospitalized terrorist victims.

[Peleg K](#), [Aharonson-Daniel L](#), [Michael M](#), [Shapira SC](#); [Israel Trauma Group](#).

Israel National Center for Trauma and Emergency Medicine Research, Gertner Institute for Epidemiology and Health Policy Research, Sheba Medical Center, Tel Hashomer, Israel 52621.
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- 9 acute care hospitals; 15 months
- 23048 casualties; 561 (2.4%) terror related
- < 29y – 70%; Males – 75%
- Explosions 269 (48%); Gunshot – 266 (47%)
- ISS \geq 16 30%; Mortality 35 (6%)
- ICU – 142 (26%); OR – 298 (50%)
- Internal (31%); Open – 55%; Fractures – 39%

Suicide bombers form a new injury profile.

[Aharonson-Daniel L](#), [Klein Y](#), [Peleg K](#); [ITG](#).

Gertner Institute for Epidemiology and Health Policy Research, Tel Hashomer, Israel.
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- October 1, 2000 – December 31, 2004
- 1155 casualties by explosion
- ISS $\geq 16 \sim 30\%$; $\uparrow\uparrow$ AIS ≥ 3
- CT scan – 36.6%; US – 26.8%; X-Ray – 53%
- OR – 28.3%; ICU – 10.1%; Ward – 58.4%
- $\uparrow\uparrow$ Internal inj. Open, Burns, Nerves, Vessels
- Conclusion – change triage, organization, treatment & surge capacity.

Epidemiology of terror-related versus non-terror-related traumatic injury in children.

[Aharonson-Daniel L](#), [Waisman Y](#), [Dannon YL](#), [Peleg K](#); [Members of the Israel Trauma Group](#).

Israel National Center for Trauma and Emergency Medicine Research, Gertner Institute for Epidemiology and Health Services ResearchTel Hashomer, Israel. limorad@gertner.health.gov.il

1/10/00 - 31/12/01

<18y

	Terror related	Non Terror
#	138	8363
Age	12.3y (SD-5.1)	6.9 (SD-5.3)
Penetrating Inj.	54% (n=74)	9% (n=725)
Torso Injury	11%	4%
Open Head Inj.	13%	6%
I.S.S. ≥ 25	25%	3%
C.C.U.	33%	8%
Hospital Stay	5days	2days
Rehab.	17%	1%

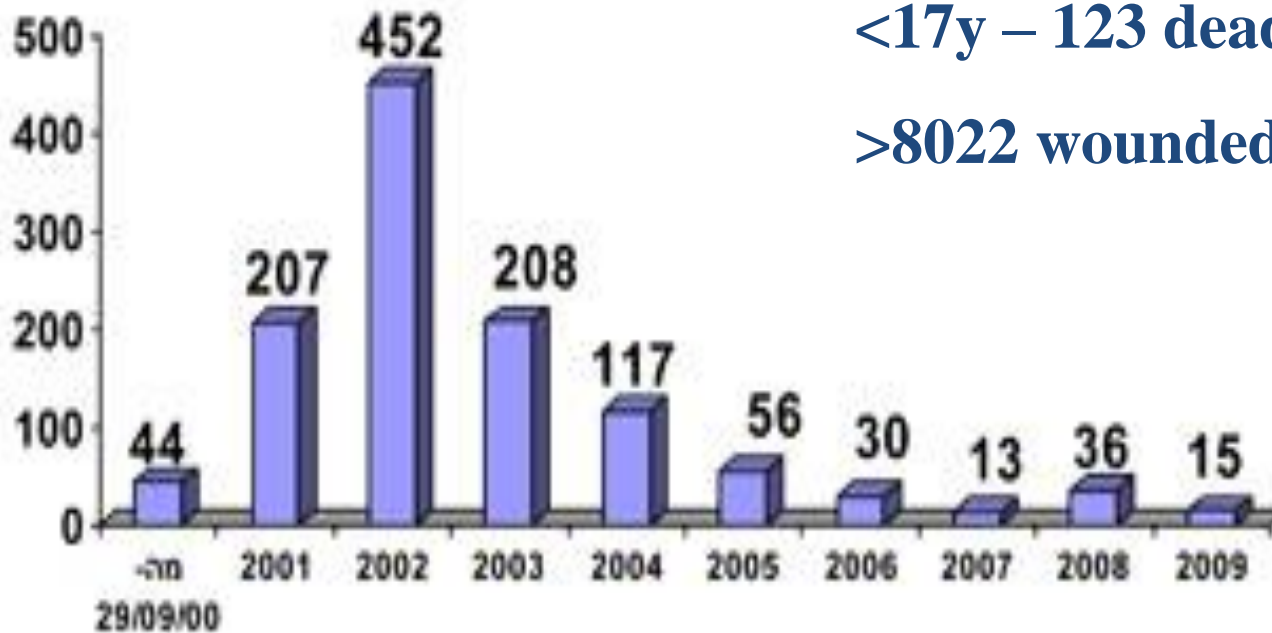
Terror - death toll 2000-2009

סה"כ: 1,178 הרוגים

Total – 1178 dead (70% civilians)

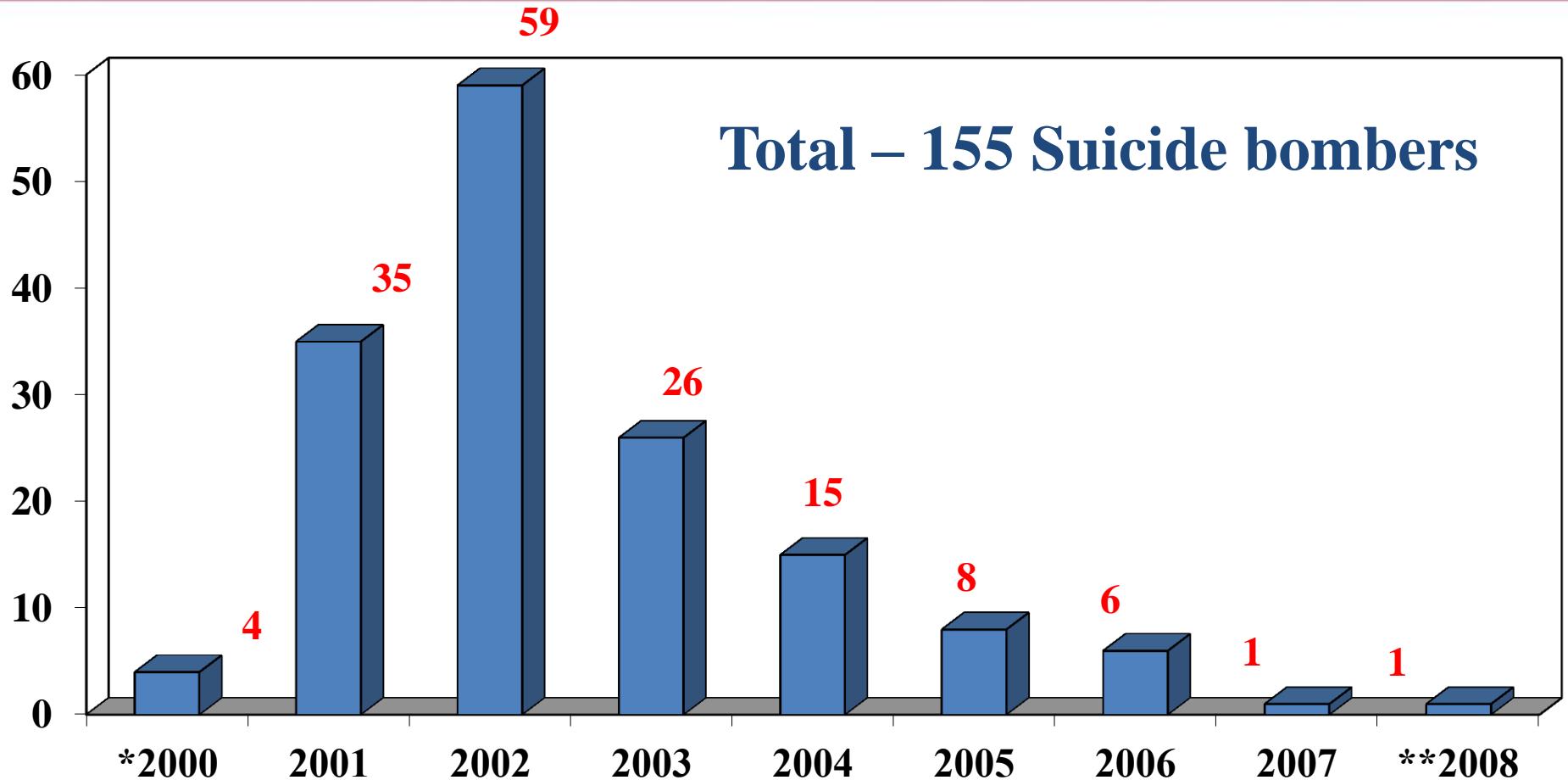
<17y – 123 dead (11%)

>8022 wounded



* From Sep 29, 2000 ** Until March 31, 2008

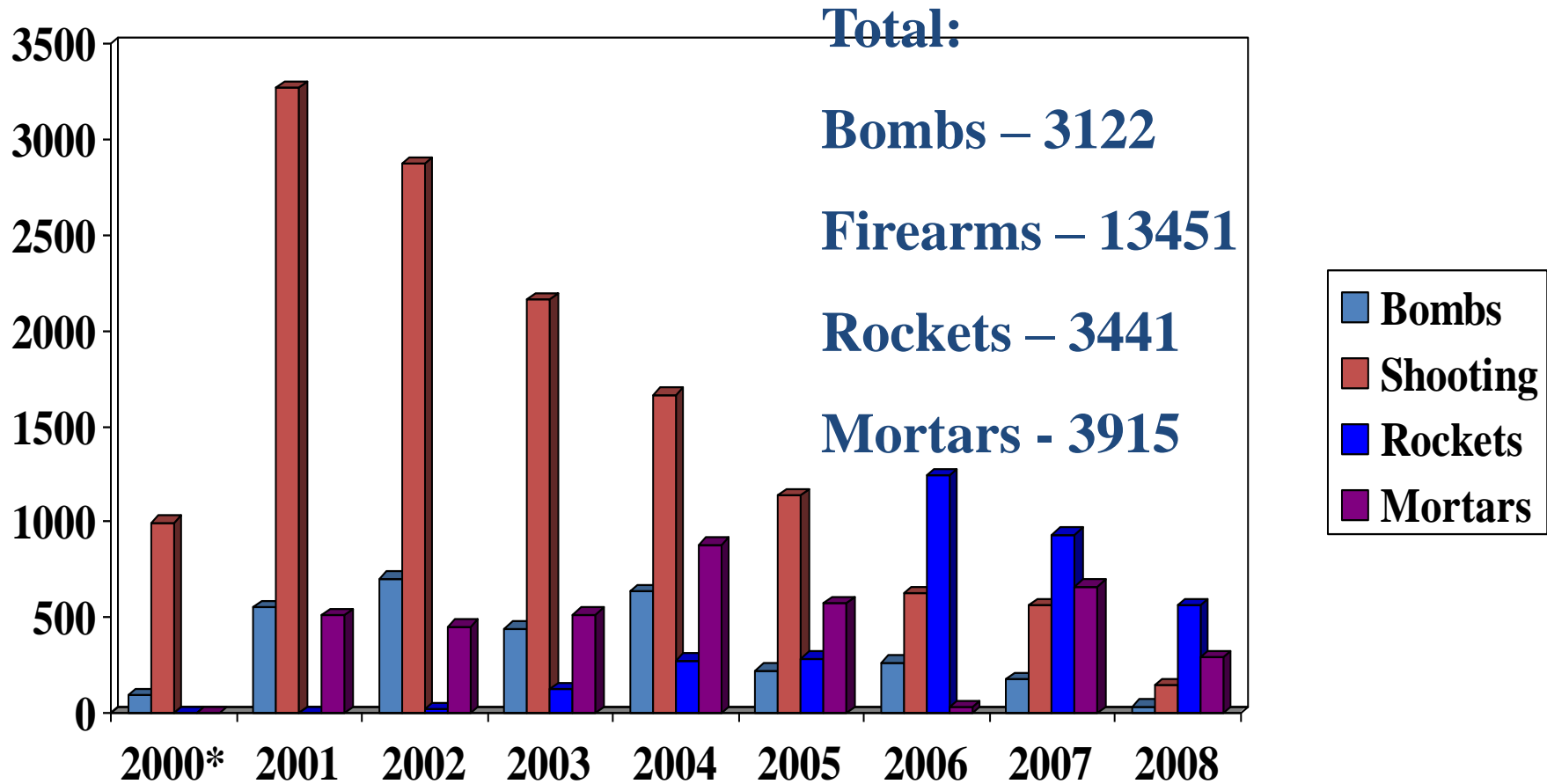
Suicide bombers 2000-2008



* From Sep 29, 2000 ** Until March 31, 2008

Attacks 2000-2008

(Bombs, Firearms, Rockets, Mortars)



* From Sep 29, 2000 ** Until March 31, 2008

In-hospital resource utilization during multiple casualty incidents.

[Einav S](#), [Aharonson-Daniel L](#), [Weissman C](#), [Freund HR](#), [Peleg K](#); [Israel Trauma Group](#).

Intensive Care Unit, Shaare Zedek Medical Center, Jerusalem, Israel. bromi@md2.huji.ac.il

- Terror MCS ; X6 level I TC Oct. 2000-July 2003
- 352 casualties/ 32 events; ISS>16 – 34%
- 30% in 10min; 65% in 30min !!!
- CT – 40%; OR – 60%; ER»OR – 36%
- Peak OR 60-90min; Multidisciplinary (Abd./Thoracic/vascular)
- ICU – 33%; ER»ICU 31%.
- ↑↑ Staff demand: ED, OR, ICU.

Blast Injury - Remember

- **Injuries are multi-dimensional and include many mechanisms of injury, such as blast, burn, penetrating, and blunt**
- **Missing injury**
- **Tertiary survey**





Thank you