



## Gunshots, Explosions and penetrating trauma – a different situation



Robert Schwab

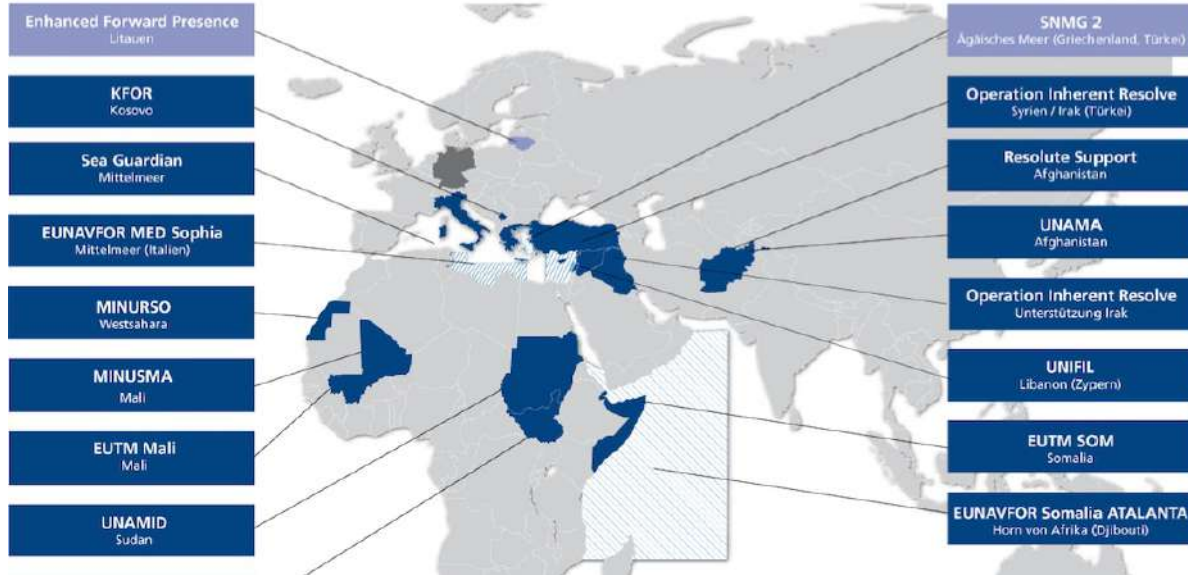
Mechelen, 23rd September 2022

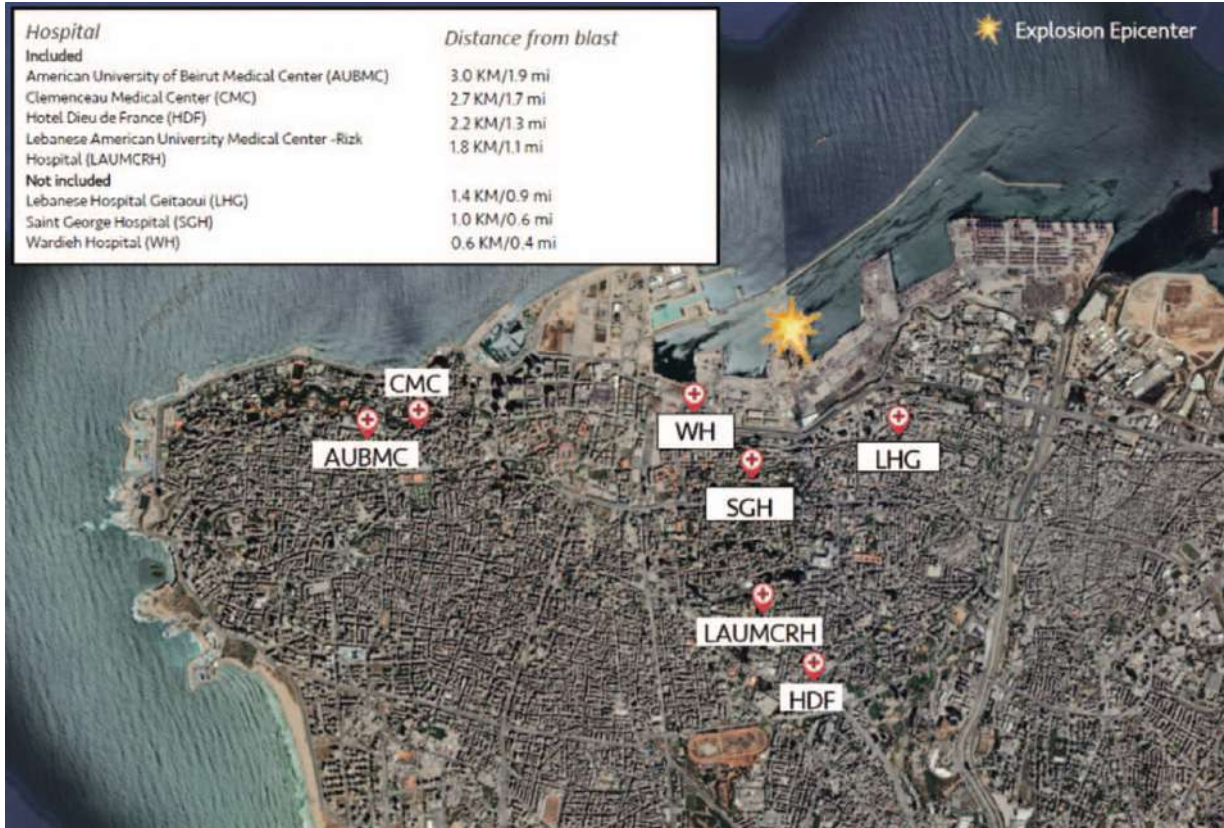


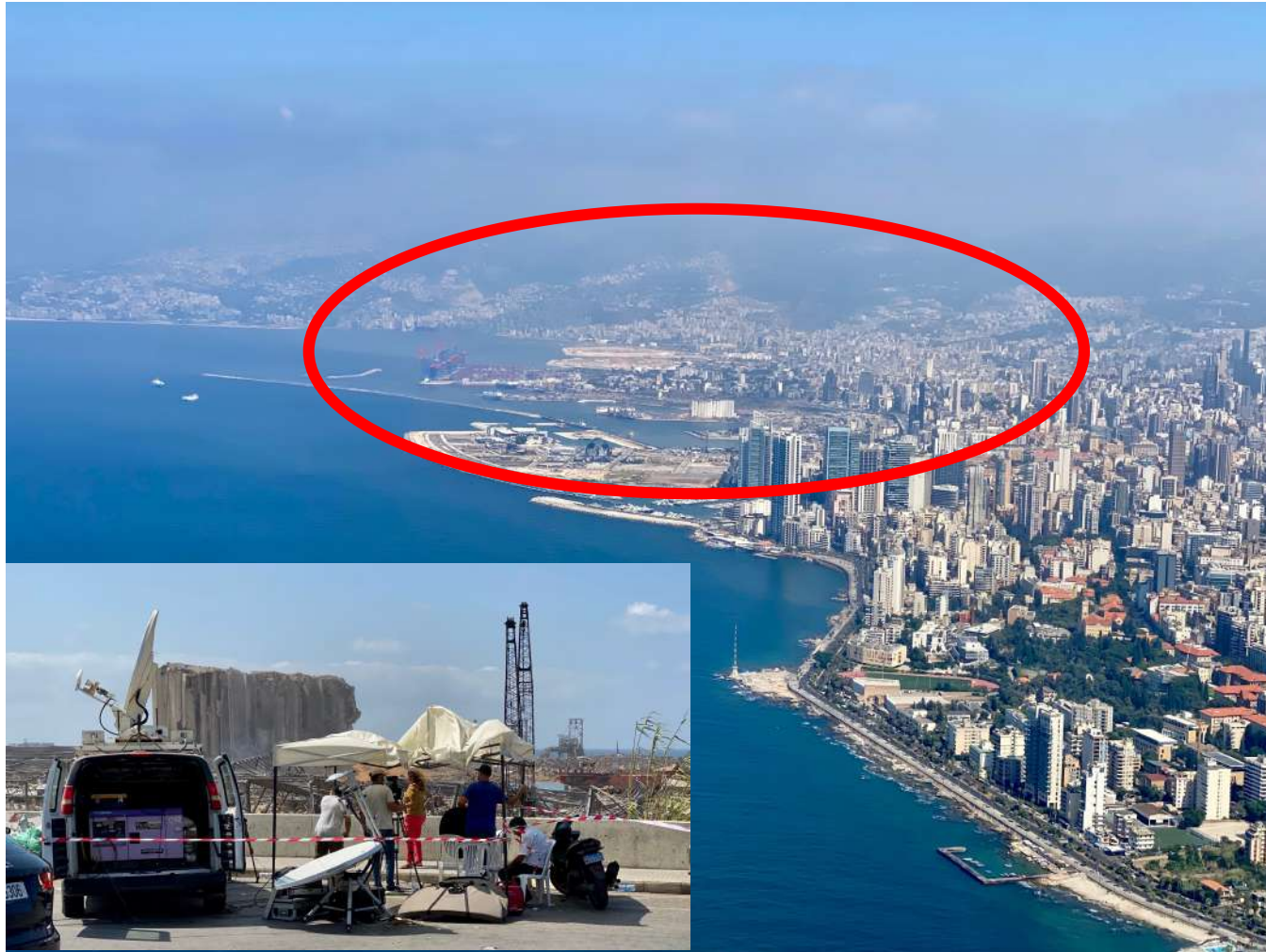


Prof. Dr. Robert Schwab  
Klinik für Allgemein-, Viszeral- und Thoraxchirurgie  
Bundeswehr Zentralkrankenhaus Koblenz











# TERROR IN BRÜSSEL



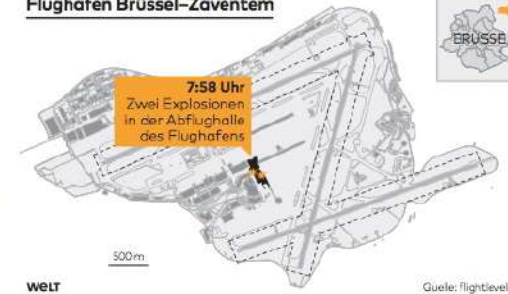
22nd March 2016



*Bilder des Grauens, der Zerstörung und des Leids: Das raucherfüllte Terminal im Brüsseler Flughafen kurz nach der Explosion (o.). Durch einen Metro-Schacht werden Menschen evakuiert (r.). Eine Bombe zerfetzt den mittleren Waggon eines Zuges, kurz nachdem dieser in die Haltestelle Maelbeek im EU-Viertel in Brüssel eingefahren ist (u.)*



## Flughafen Brüssel-Zaventem





## What is the different situation in WAR – DESASTER -TERROR?

- **Mechanism of Injuries:**  
Penetrating (ballistic, shrapnells, secondary)  
Thermo-mechanic
- **Limited resources, due to**  
MASCAL-Situation  
Damaged Infrasrtrucure  
Leak of human ressources  
Leak of material, Blood, Drugs, ...
- **Threads and risk for yourself, ...**



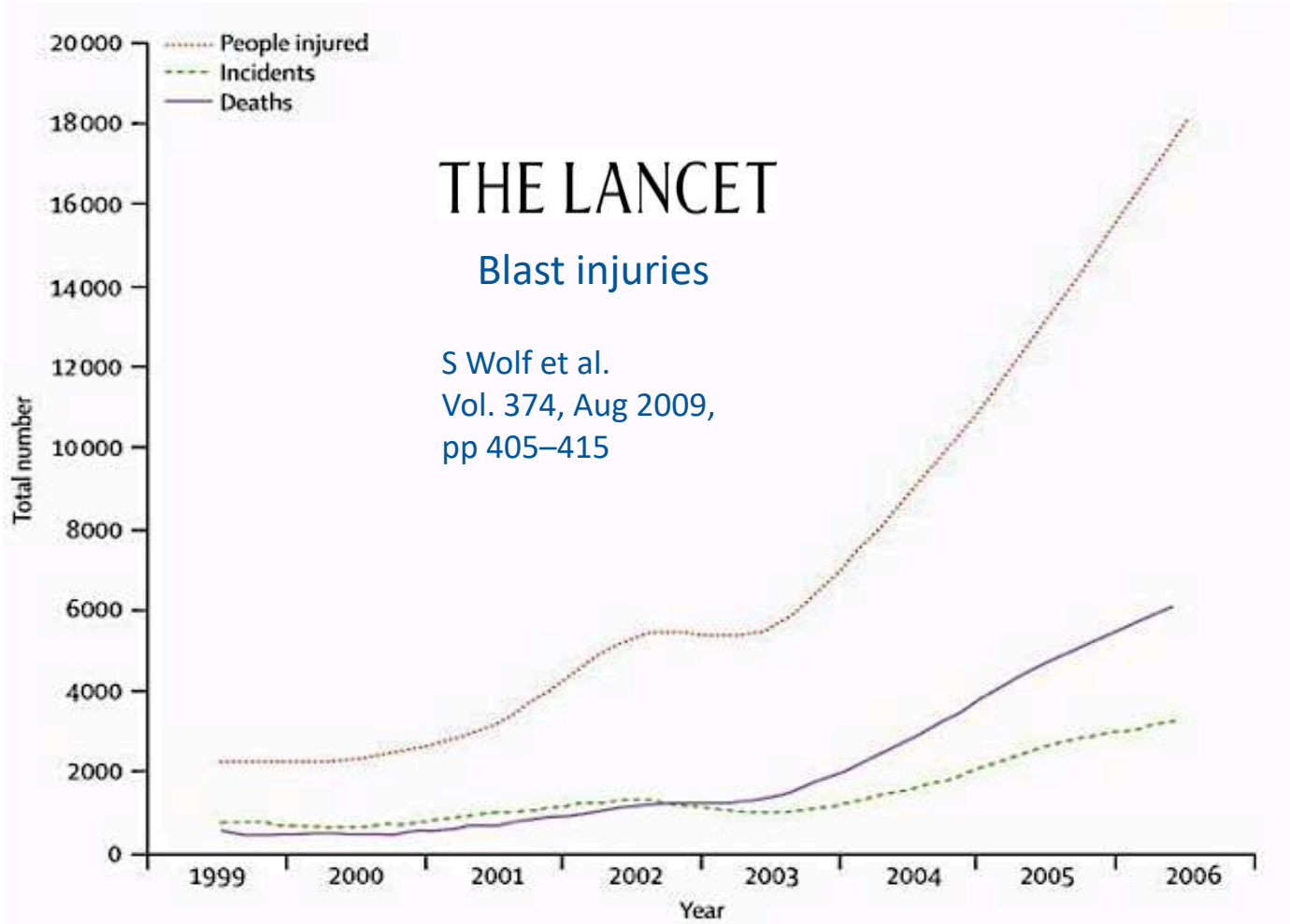
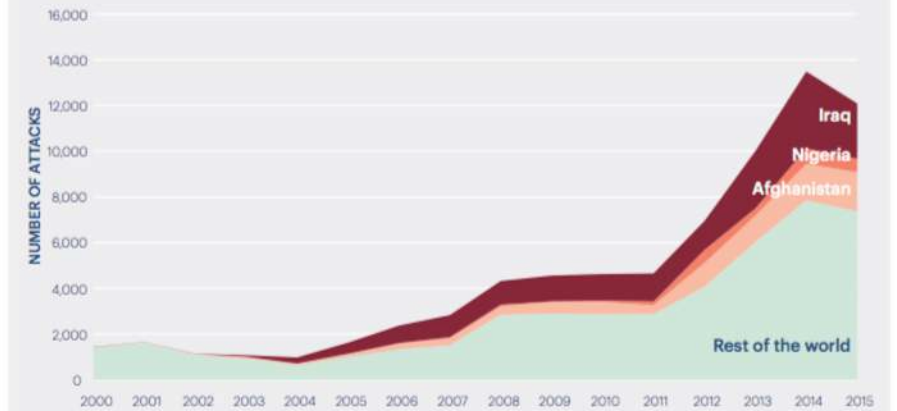


Figure 1. Worldwide trends in terrorist explosive events from 1999 to 2006. Data obtained from RAND®-MIPT Terrorism Incident Database.<sup>1</sup>

**FIGURE 1.6** TERRORIST ATTACKS, 2000-2015

Nearly 40 per cent of terrorist attacks in 2015 occurred in Iraq, Nigeria and Afghanistan.



Source: START GTD, IEP calculations

**FIGURE 2.5** DEATHS FROM ATTACKS TARGETING PRIVATE CITIZENS, 2000-2015  
 There has been a 550 per cent increase in the number of deaths of private citizens from terrorism since 2000.



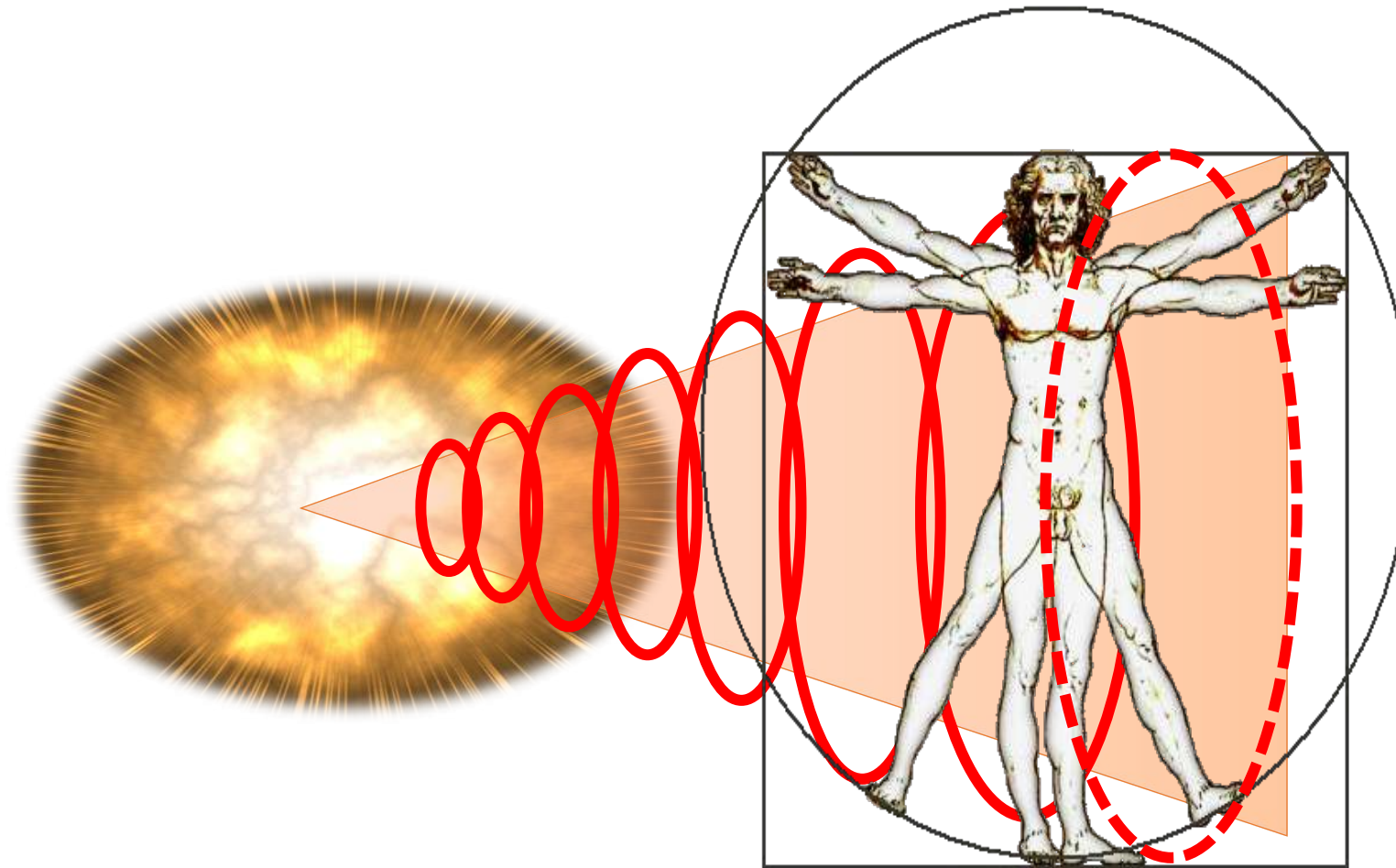
Source: START GTD, IEP calculations







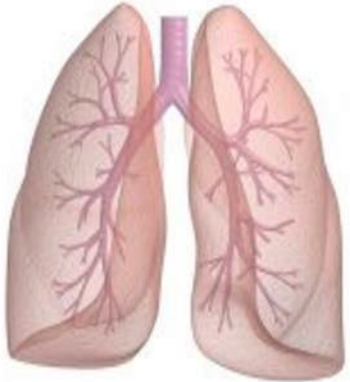
## Shockwave – Blast !



J Trauma. 2011 Sep;71(3):694-701.

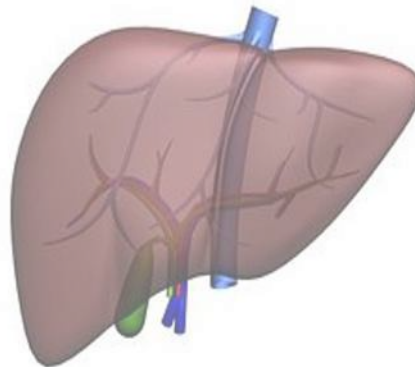
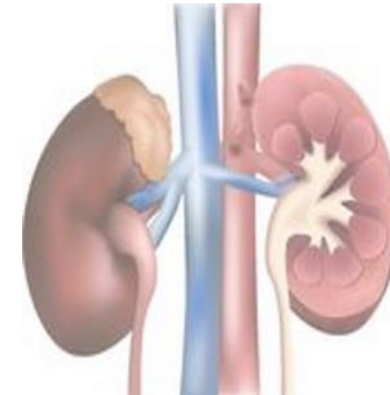
**Hemoconcentration caused by microvascular dysfunction after blast injuries to the chest and abdomen of rabbits.**

Zhang B. et al.

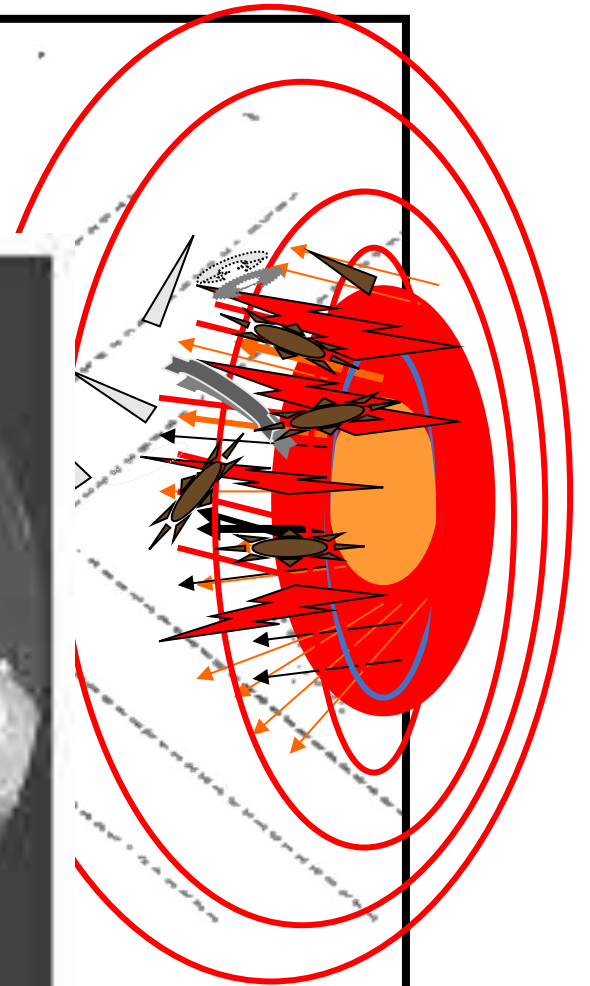
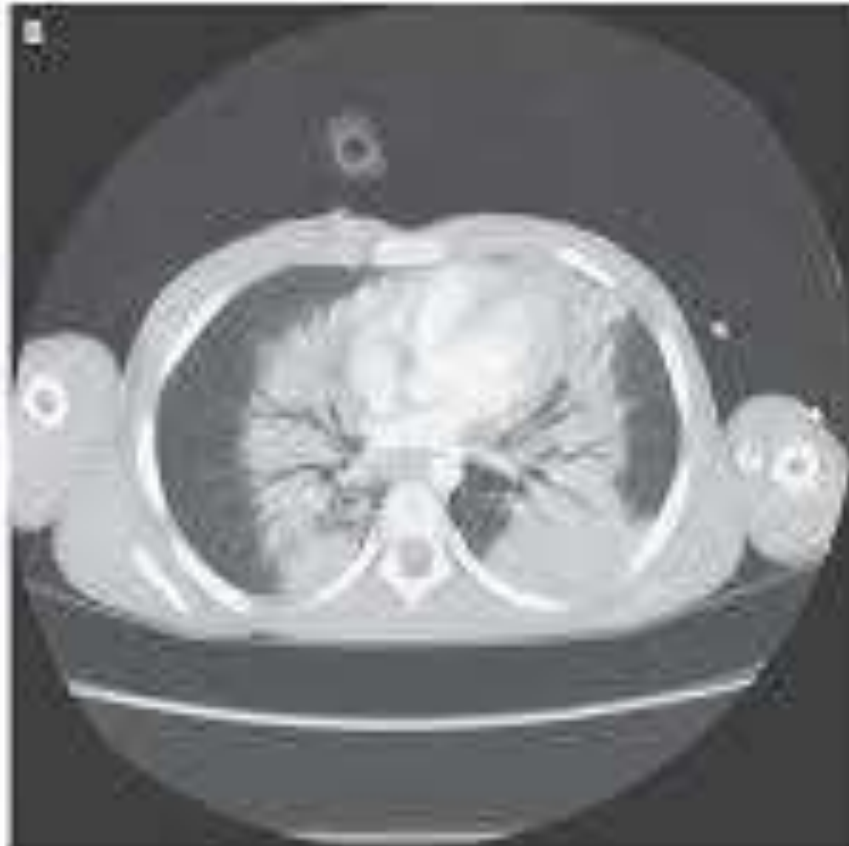


„...Chest-abdomen blast injuries from different distances induced in male rabbits...“

„...histologic evaluation results showed that the cells, microvessels, and organelles of the microvessel endothelial cells in the vital organs, such as the **kidneys**, **liver** and **lungs** were damaged.“



## „Blast Lung“



Br J Surg. 2011 Feb;98(2):168-79.

**Abdominal trauma in primary blast injury.**

Overs et al.

**Table 3** Anatomical distribution of abdominal injuries found in survivors or at autopsy for air and immersion blast exposure<sup>10,11,12,14-16,19,23,26,27,33</sup>

	Air blast		Immersion blast	
	Operative findings	Autopsy findings	Operative findings	Autopsy findings
<b>Hollow organs</b>				
Stomach	10	1	0	1
Duodenum	4	0	1	1
Jejunum	10	0	3	1
Ileum	54	2	36	7
Bladder	3	0	0	0
Colon	13	4	54	4
Gastrointestinal haematoma (NOS)	5	5	41	9
<b>Solid organs</b>				
Liver	39	2	2	2
Spleen	47	7	2	2
Kidney	15	4	0	0
Testes	1	1	0	0
Mesentery	14	8	0	0

## Primary blast injuries

- Perforation & Contusion of Small gut and Colon (Terminal Ileum & Coecum)



- Solid organs: Spleen & Liver



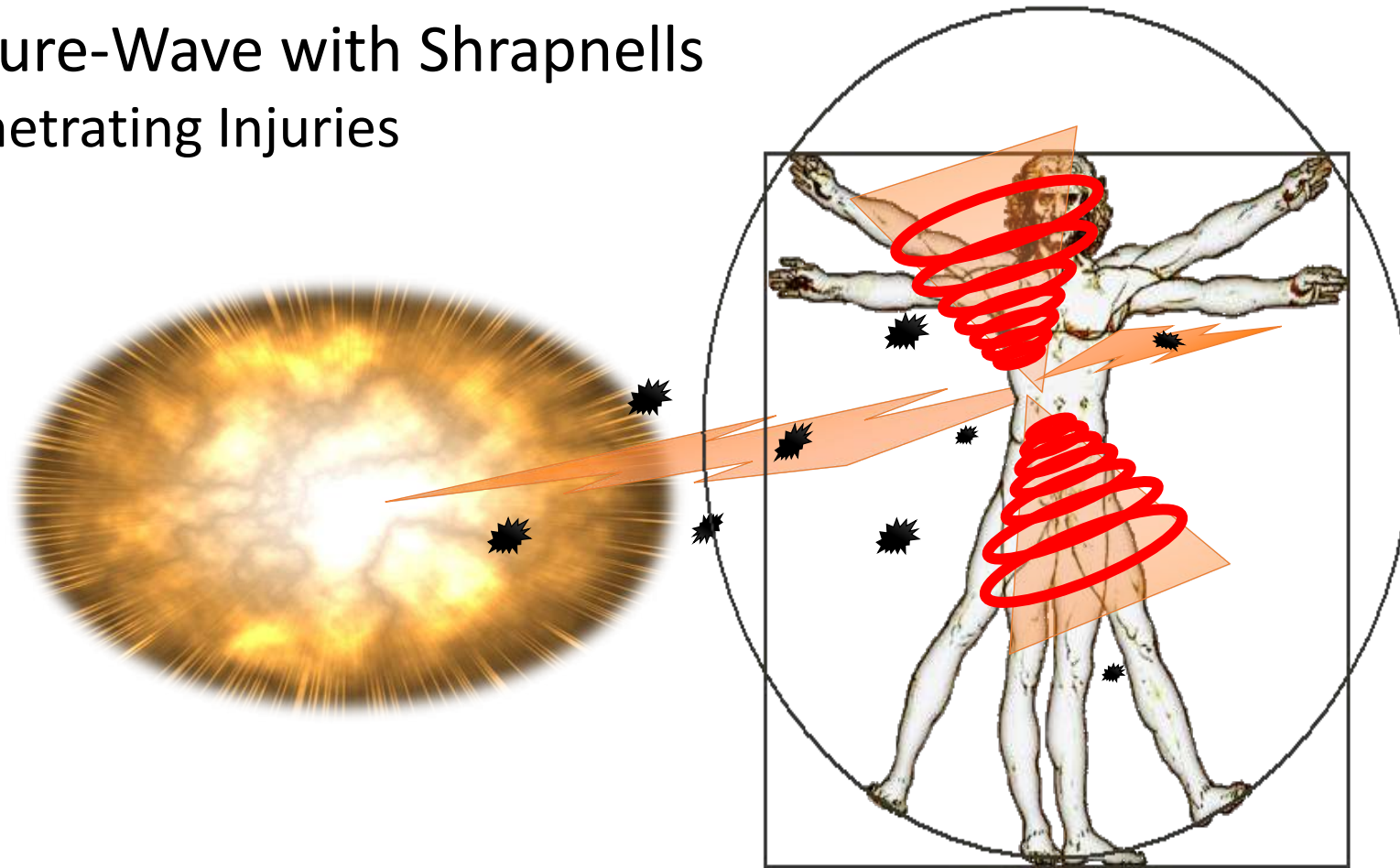
**Open abdominal Treatment  
„Laparostomy“  
following  
primary Blast  
&  
abdominal compartment Syndrome**





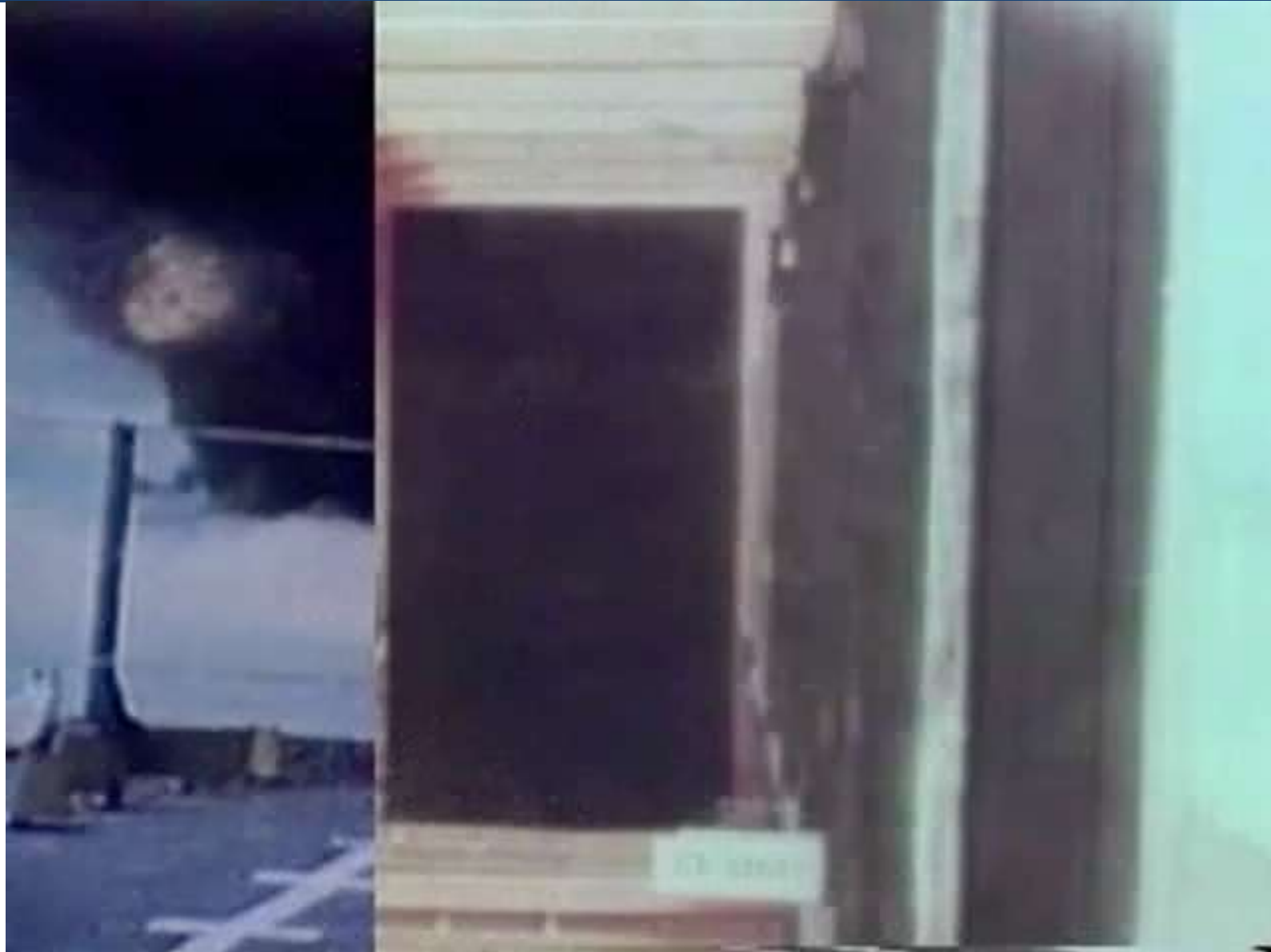
Pressure-Wave with Shrapnells

➔ Penetrating Injuries





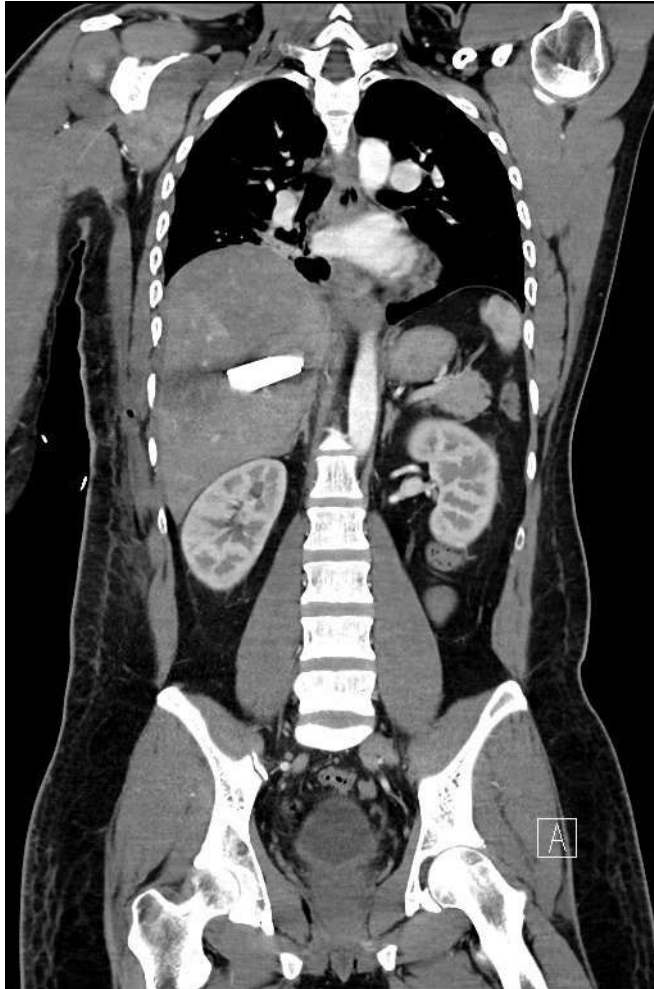
# secondary Blast







# scondary Blast



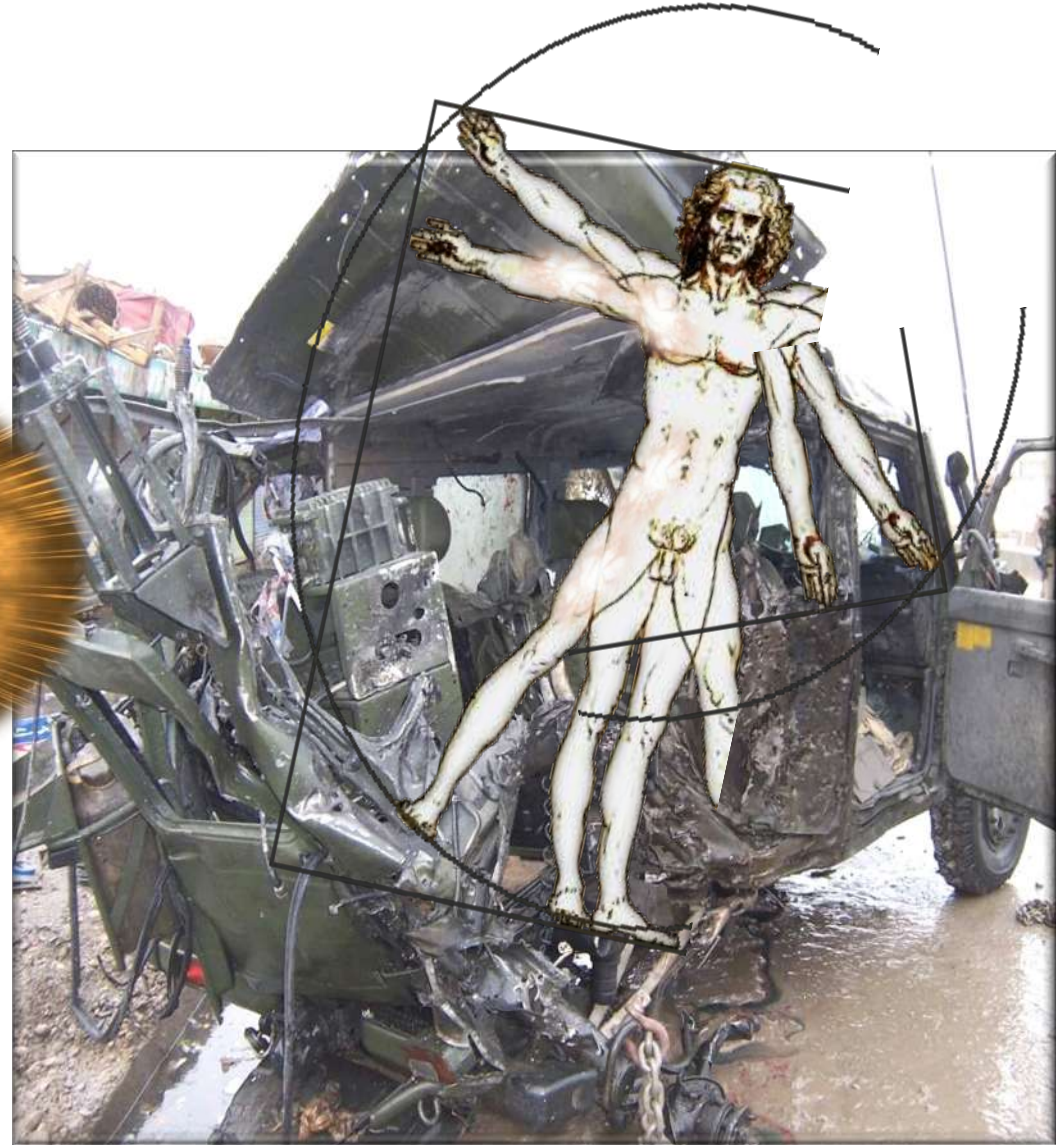
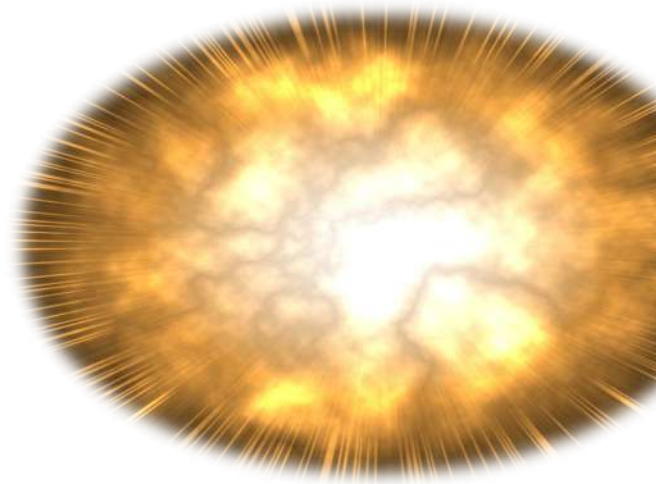


# scondary Blast





**Trauma following impact of the body...**



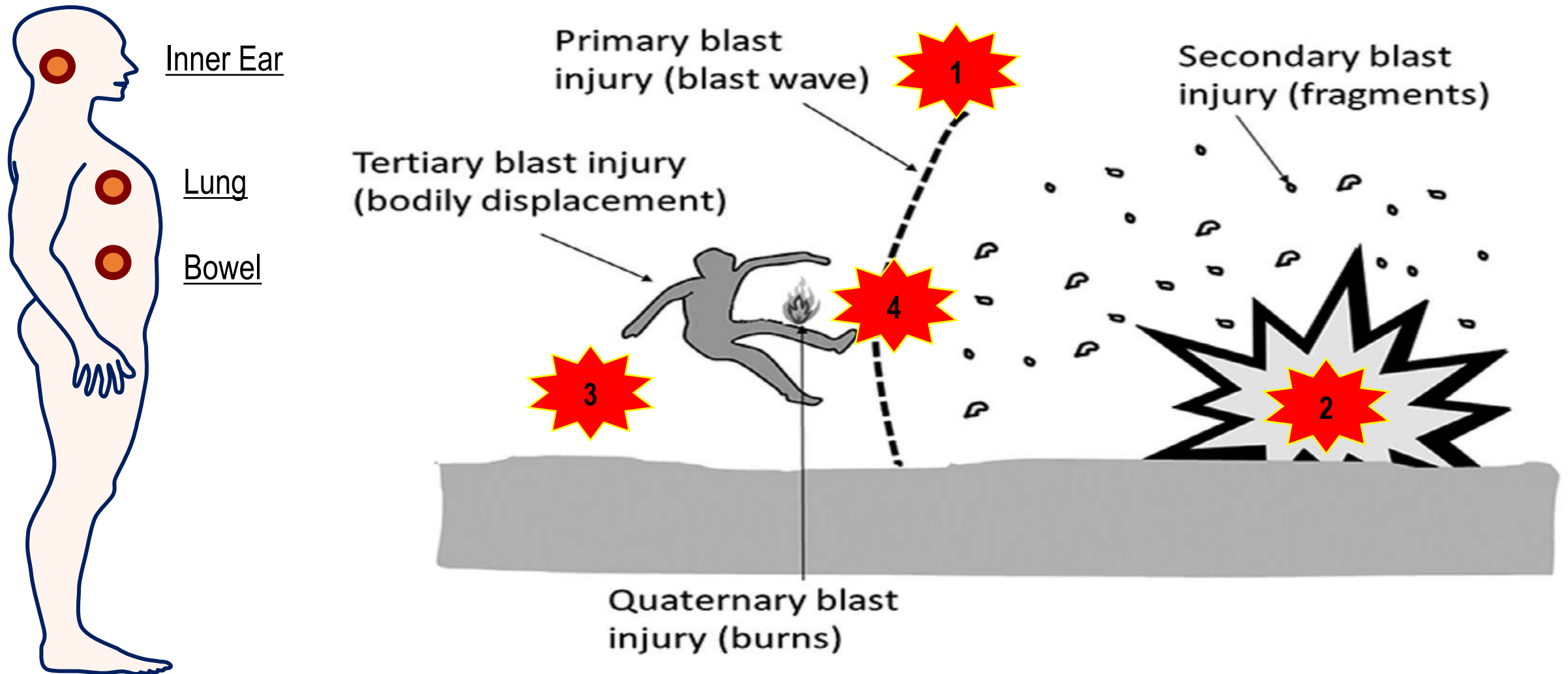


# tertiary Blast





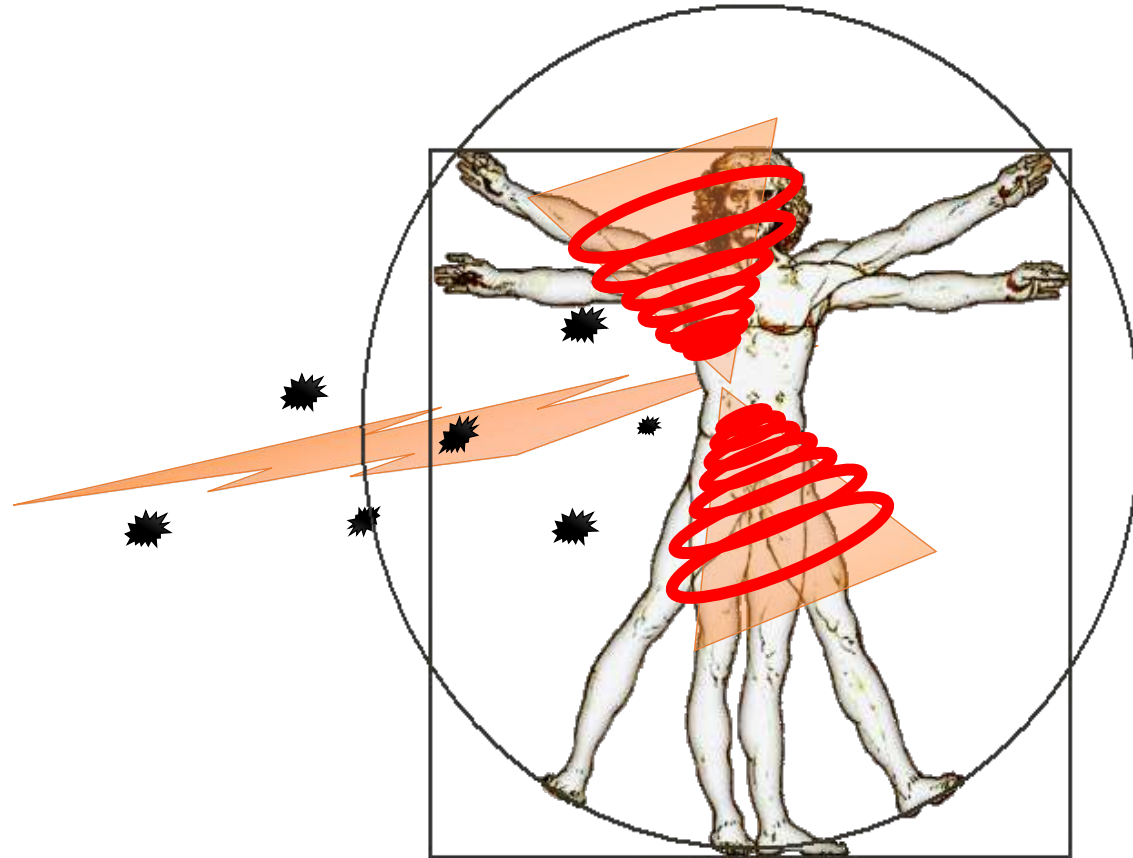
# tertiary Blast







- Burns
- Inhalation-Trauma



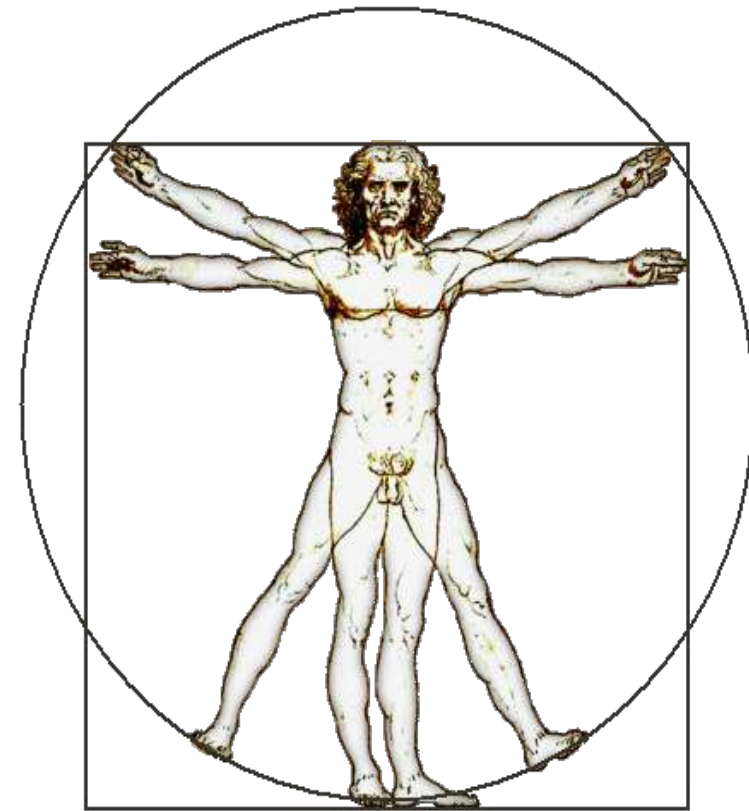
Toxix agents

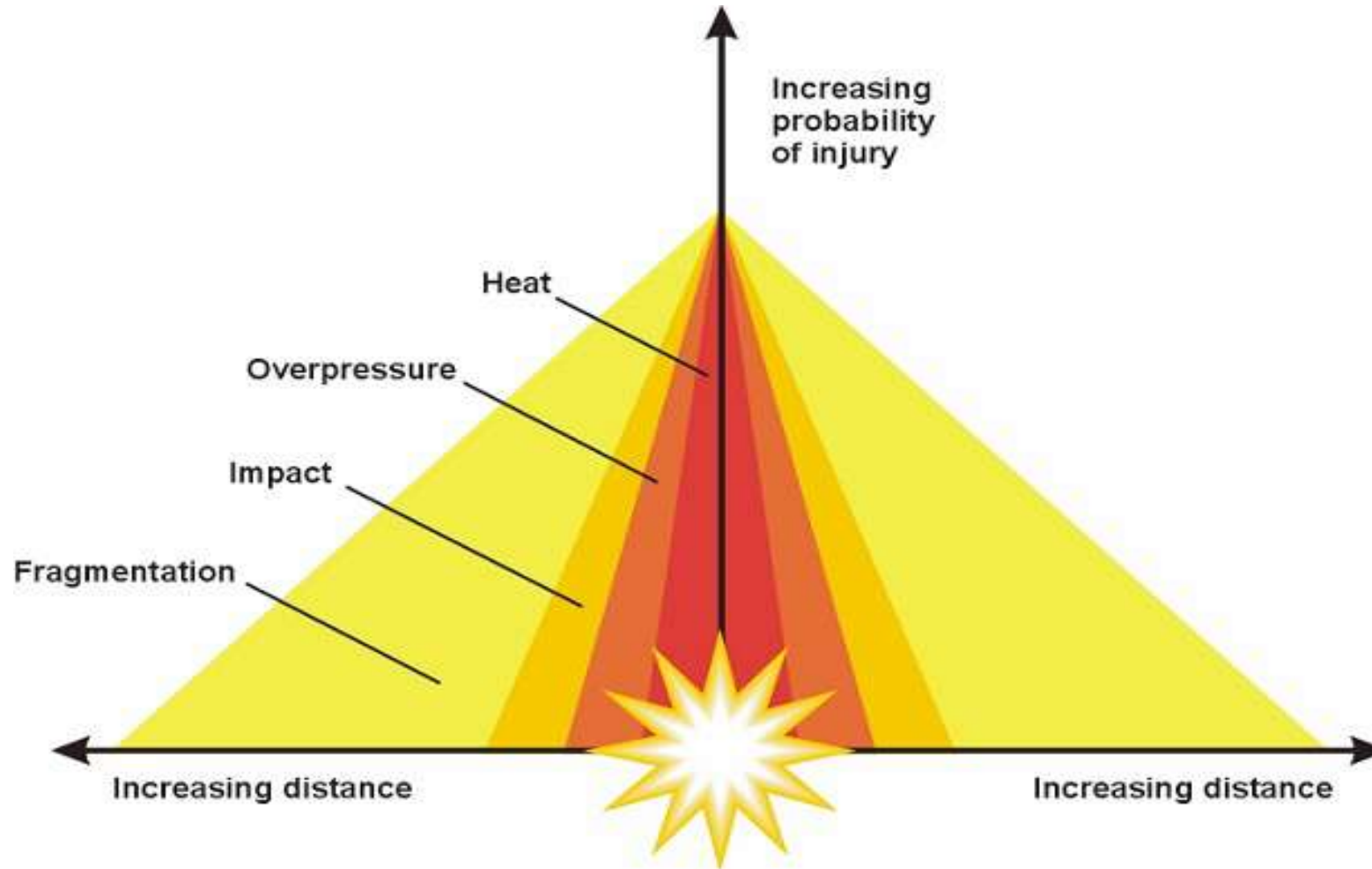
(„Dirty Bomb“)

Hepatitis C or HIV – Infections

(incorporation of foreign body parts)

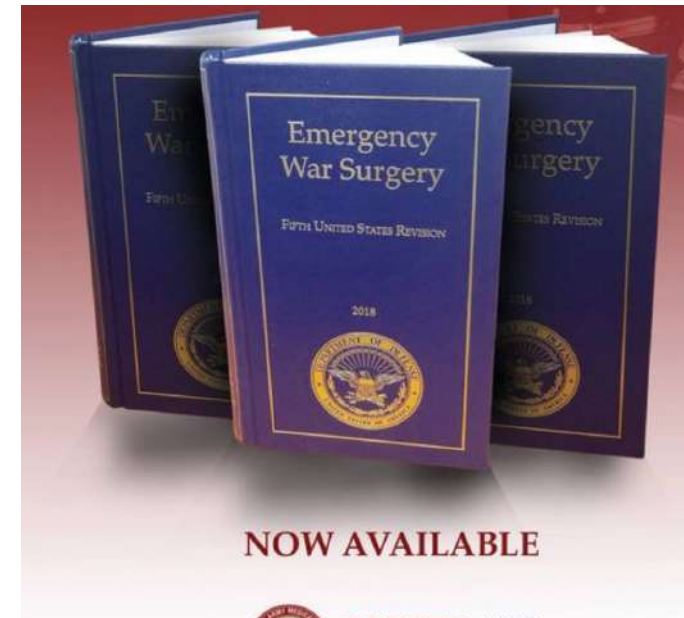
Post traumatic psychic disorders





34% - relevant Blast injuries on the free field

78% - relevant Blast injuries in closed rooms / vehicles / trains ...



NOW AVAILABLE



**BORDEN**  
INSTITUTE



[www.cs.amedd.army.mil/borden](http://www.cs.amedd.army.mil/borden)

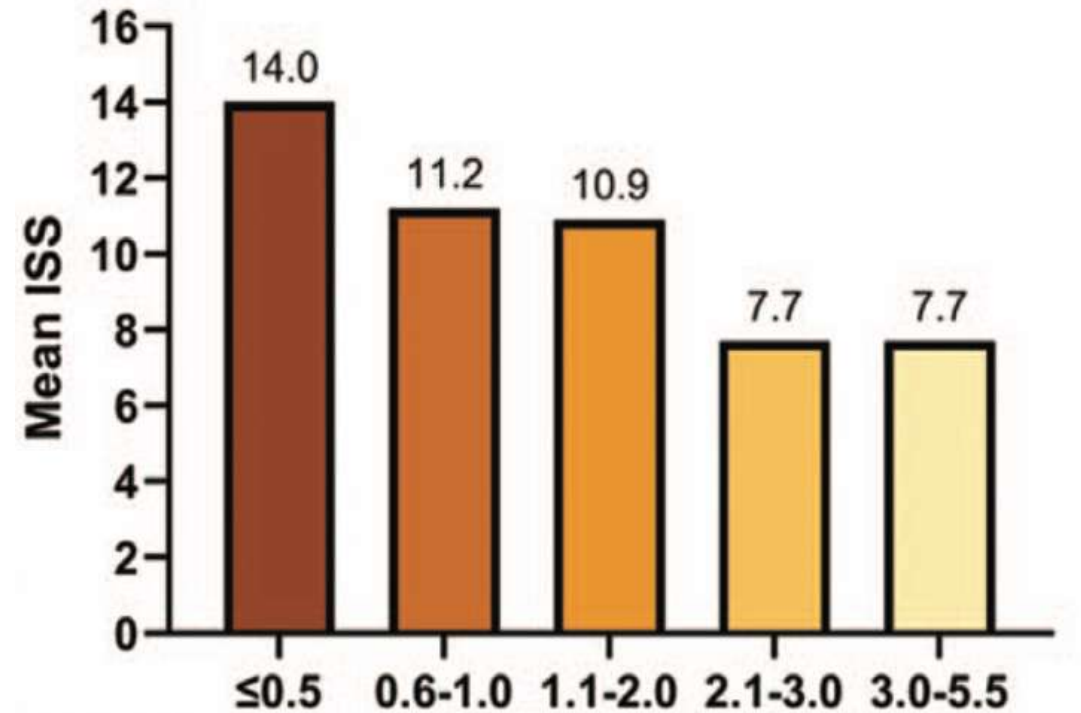
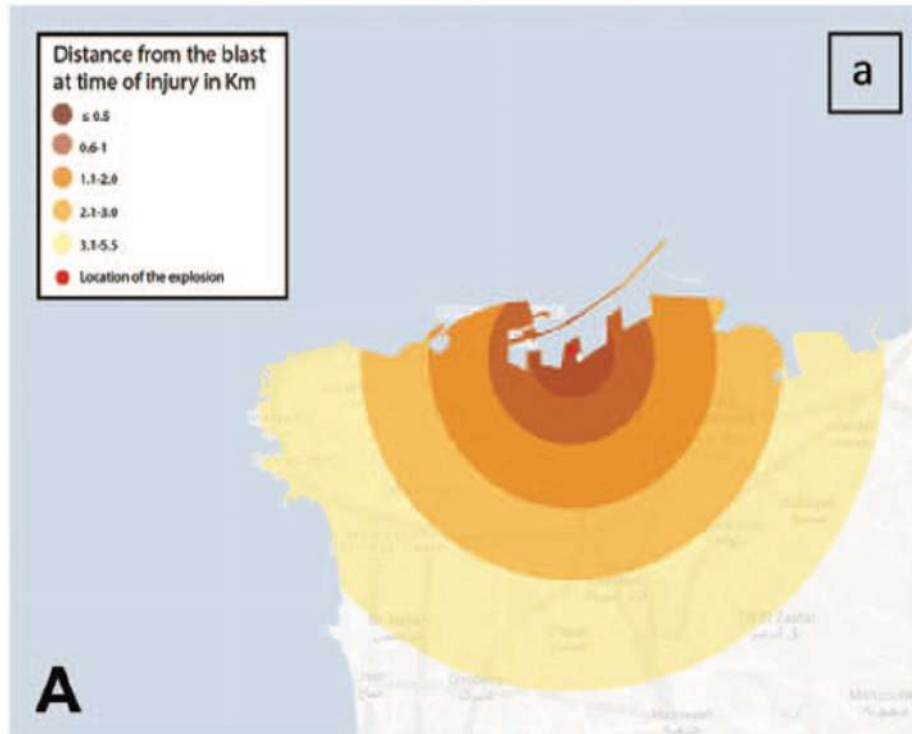
ORIGINAL ARTICLE

## The Beirut Port Explosion Injuries and Lessons Learned

Results of the Beirut Blast Assessment for Surgical Services (BASS) Multicenter Study

Anthony Gebran, MD,<sup>\*\*\*</sup> Elissa Abou Khalil, MD,<sup>†</sup> Mohamad El Moheb, MD,<sup>\*\*\*</sup> Obey Albaini, MD,<sup>‡</sup>  
 Mohamad El Warea, MD,<sup>§</sup> Rand Ibrahim, MD,<sup>¶</sup> Karin Karam, MD,<sup>‡</sup> Mohamad Othman El Helou, MD,<sup>‡</sup>  
 Elie P. Ramly, MD,<sup>||</sup> Majed El Hechi, MD,<sup>\*\*\*</sup> Ayah Matar, BS,<sup>¶</sup> Jana Zeineddine, BS,<sup>¶</sup>  
 George Dabar, MD,<sup>†</sup> Assem Al Hajj, MD,<sup>§</sup> George Abi Saad, MD,<sup>¶</sup> Jamal Hoballah, MD,<sup>¶</sup>  
 Bassem Safadi, MD,<sup>‡</sup> and Haytham M. A. Kaafarani, MD, MPH<sup>\*\*\*</sup>✉

*Annals of Surgery* • Volume 275, Number 2, February 2022



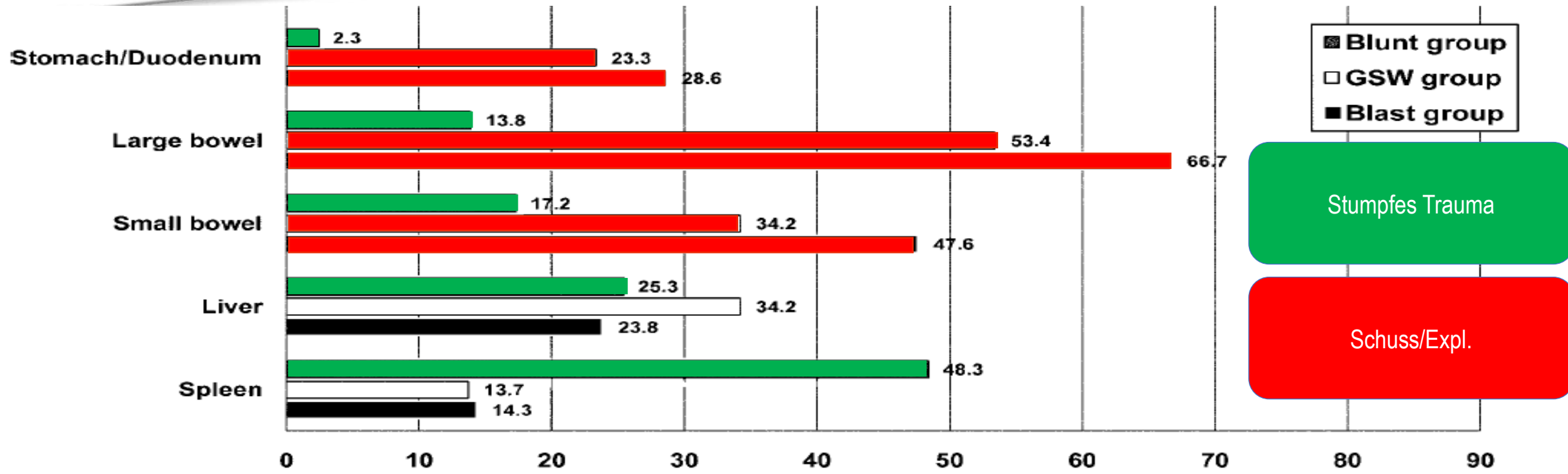
**B** Distance from the blast at time of injury in Km

## Abdominal Trauma After Terrorist Bombing Attacks Exhibits a Unique Pattern of Injury

Miklos Bala, MD, Avraham I. Rivkind, MD, FACS, Gideon Zamir, MD, Tal Hadar, MD, Iryna Gertsenshtein, MSc, Yoav Mintz, MD, Alon J. Pikarsky, MD, Dalit Amar, MD, Noam Shussman, MD, Mahmoud Abu Gazala, MD, and Gidon Almogy, MD



	stumpf	Schuss	Explosion
Patienten	87	73	21
Injury Severity Score (0-75)	29 (17-41)	18 (13-25)	34 (22-41)





# Gunshot - Injuries

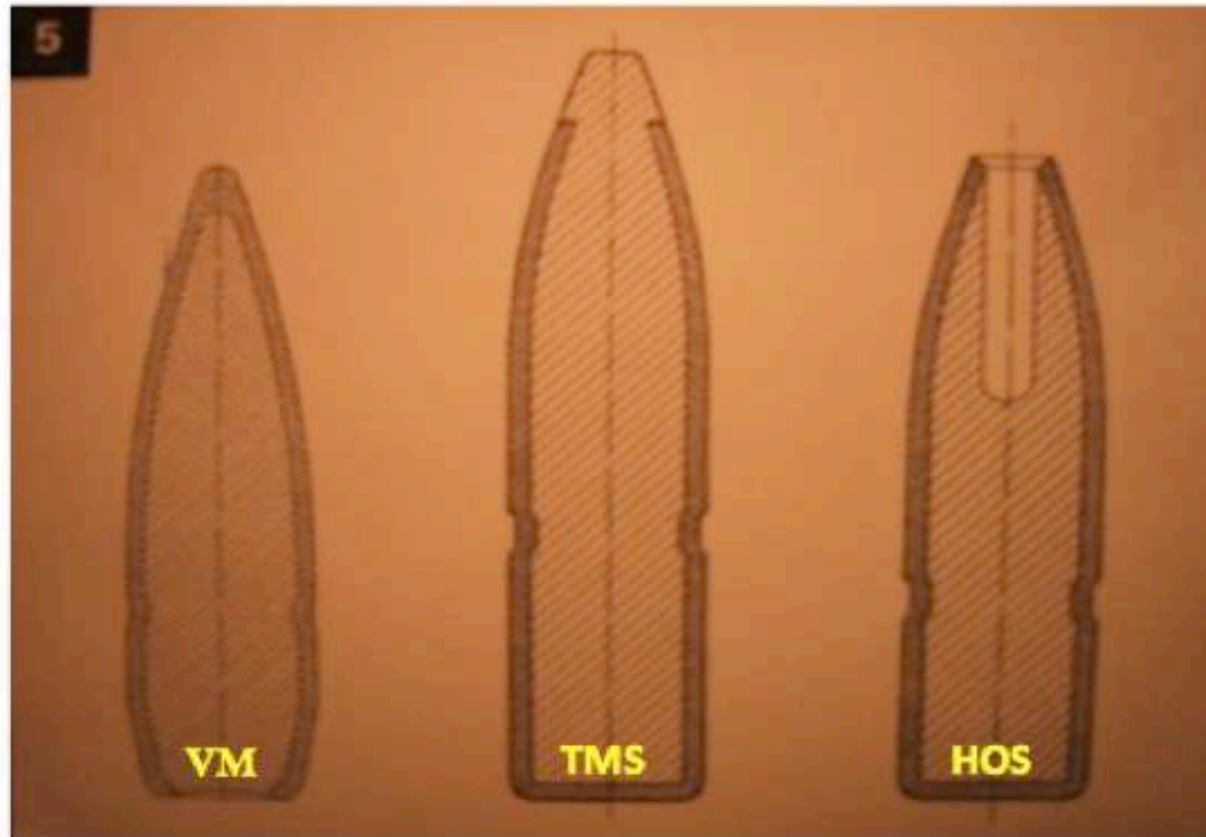
AK - 47



H&K P 8

## The effects of the shot-gun-injury are depending on:

- Type of the gun
- Amunition (type of Jacket, Calibre, ...)
- Velocity of the projectile
- Distance
- Hidden tissue in the body
- ...



Vollmantel

Teilmantel

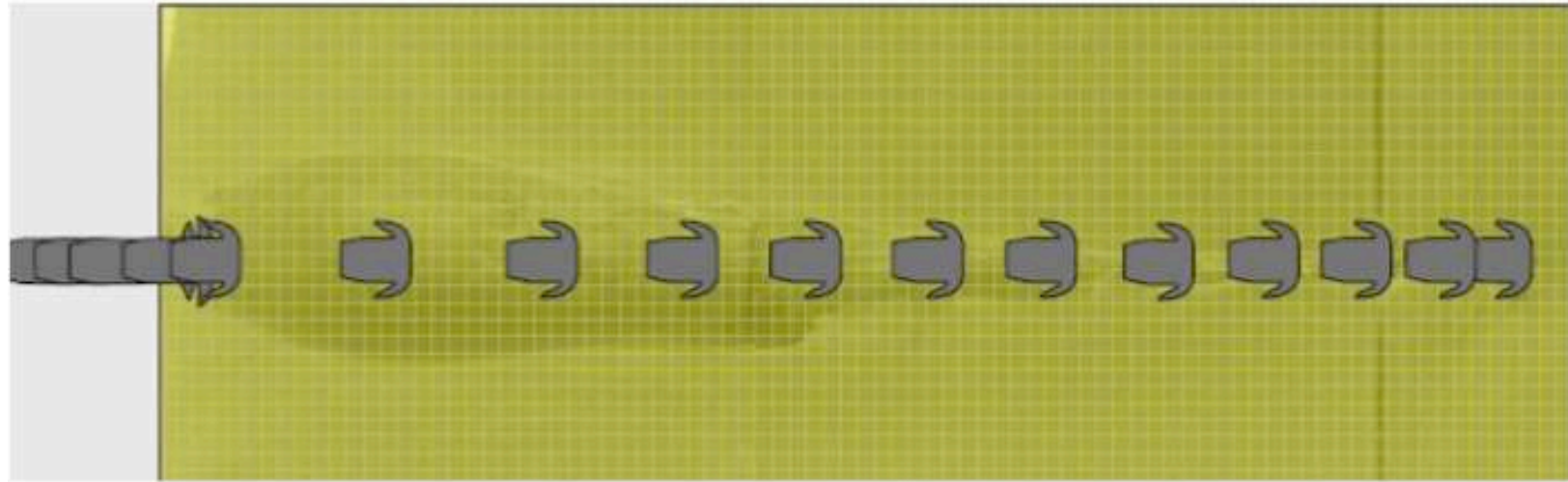
Hohlspitz







# Deformation - Bullet



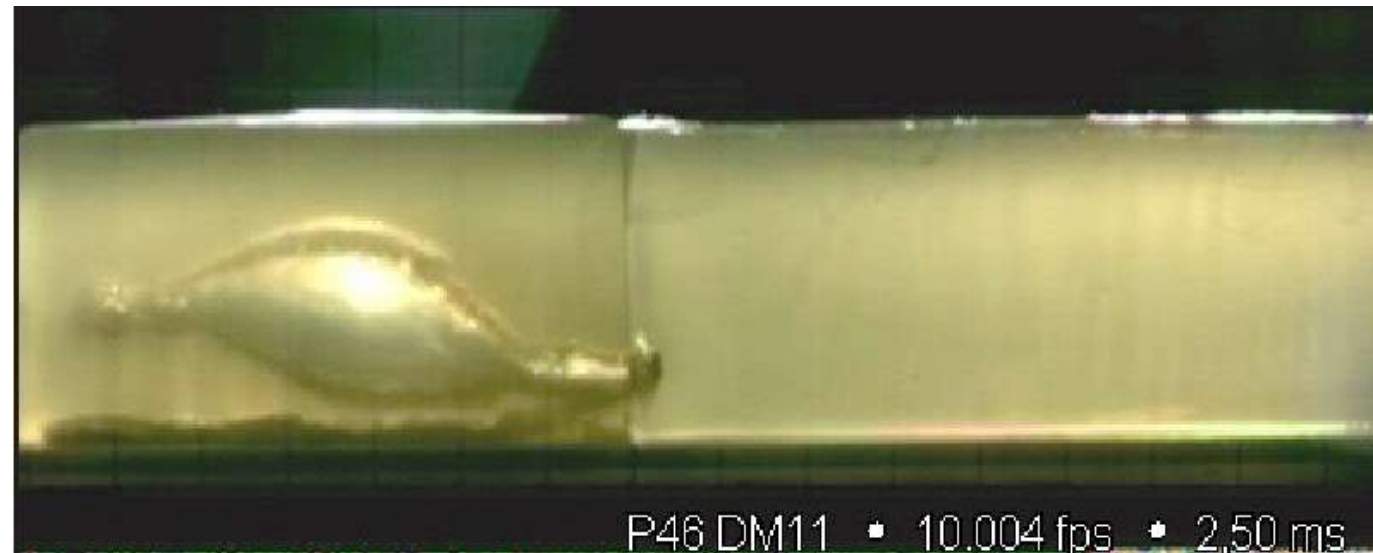


# Full-Metal vs. Deformation

P8



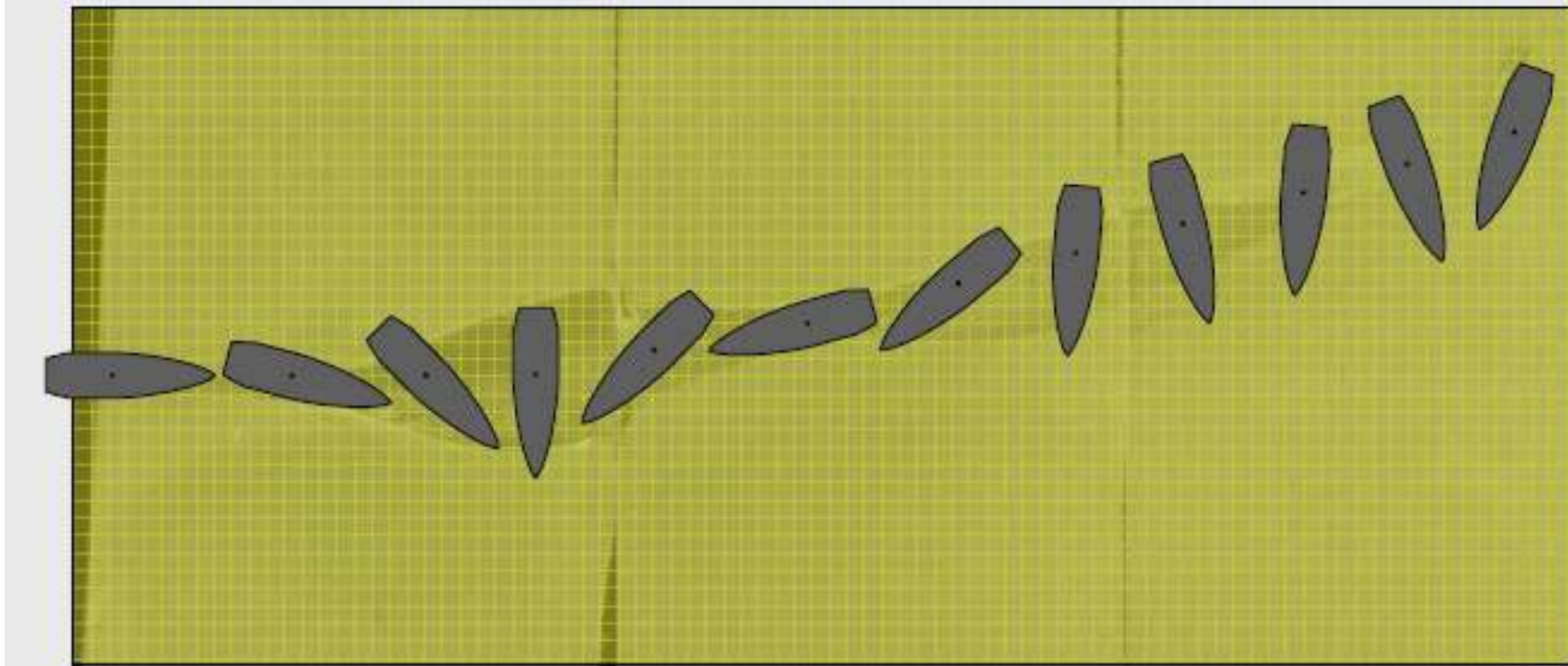
P46





## “Yawing“ during the flight in the air



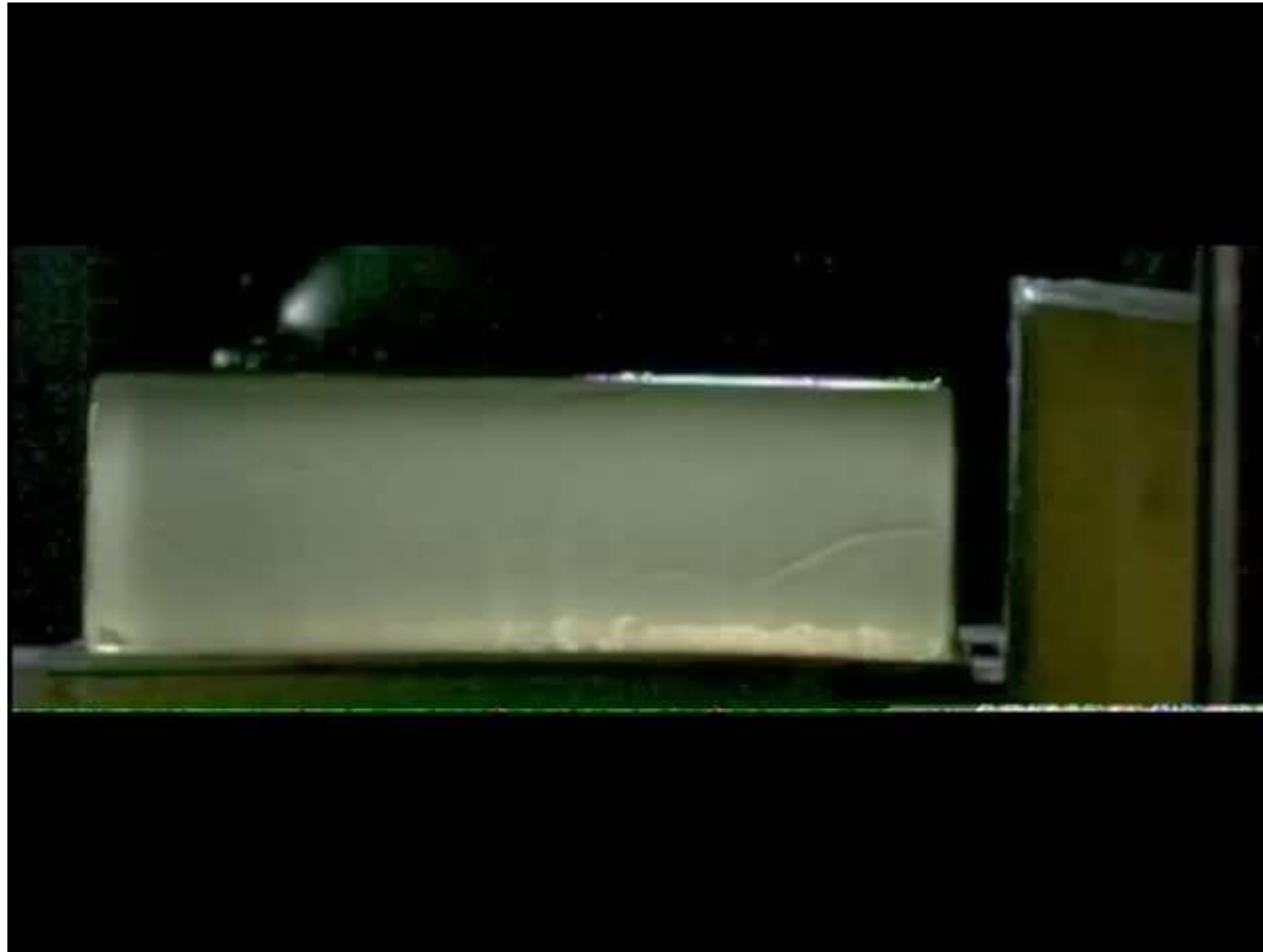


**AK 47**  
**7,62 x 39**



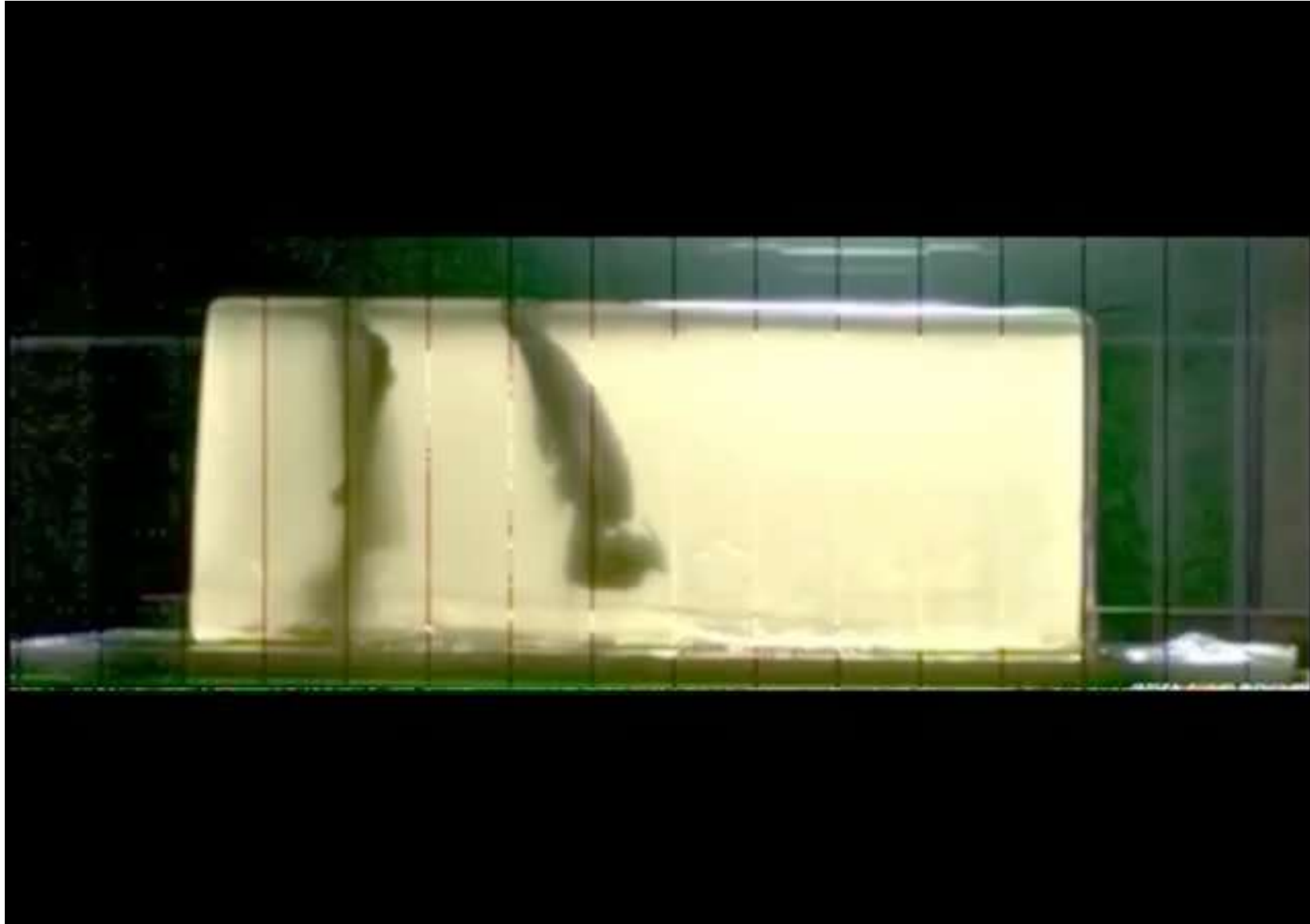


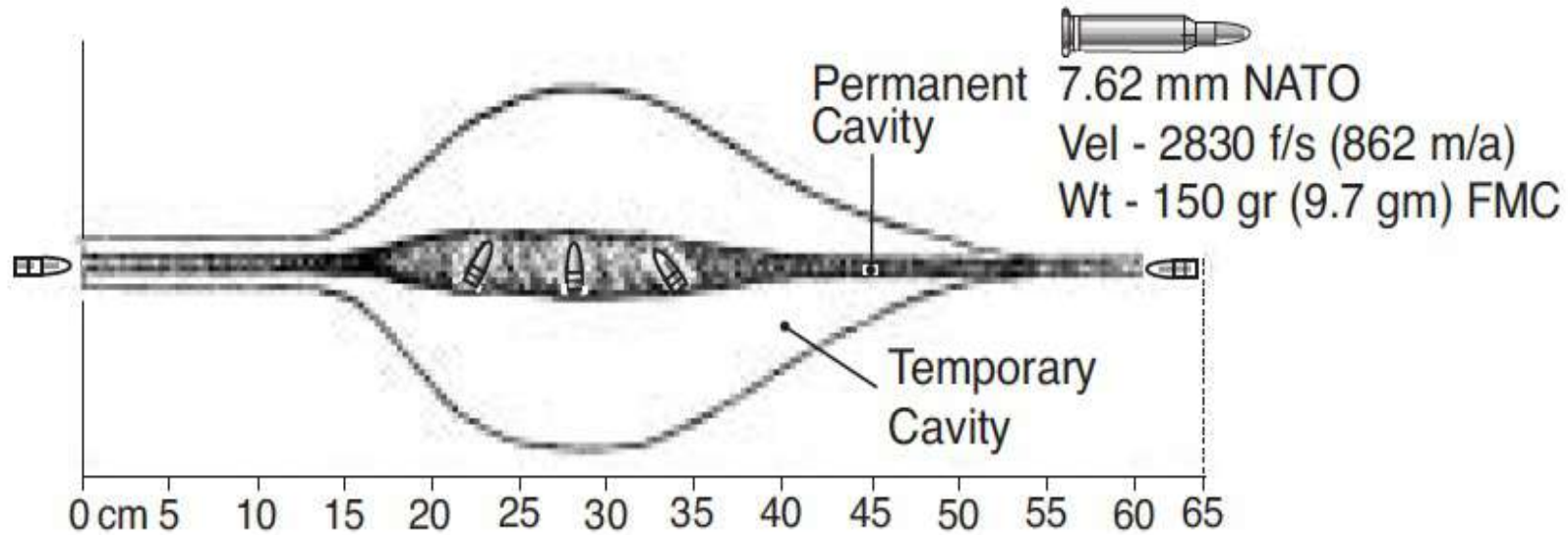
# „Solid organ“





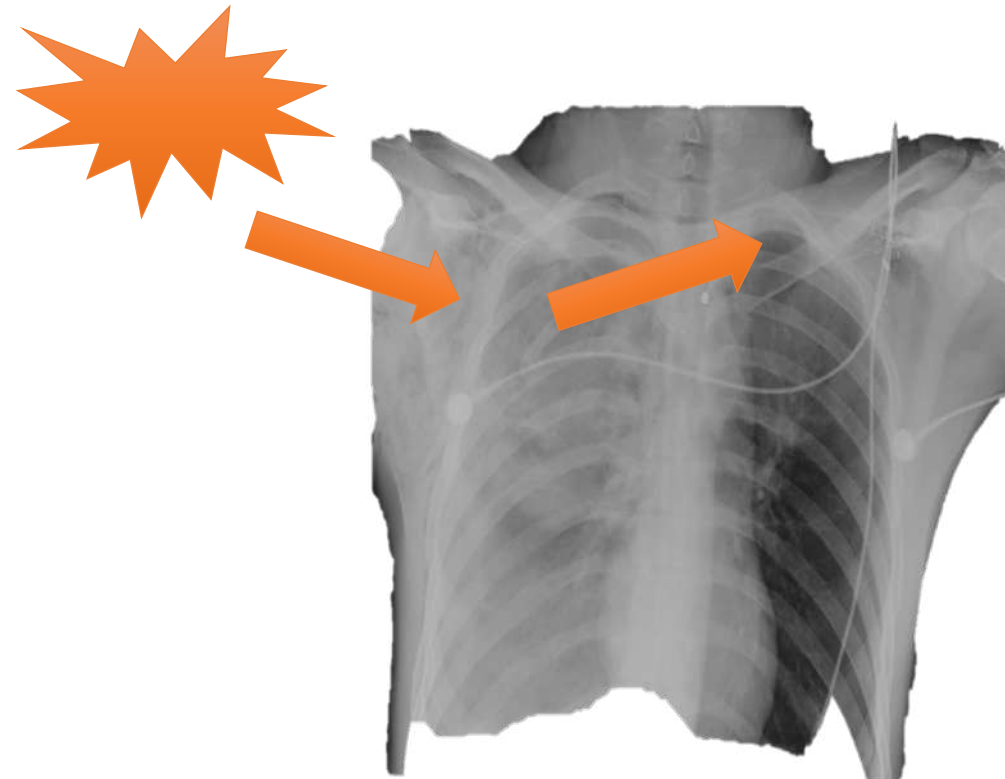
# „Solid organ & bones“



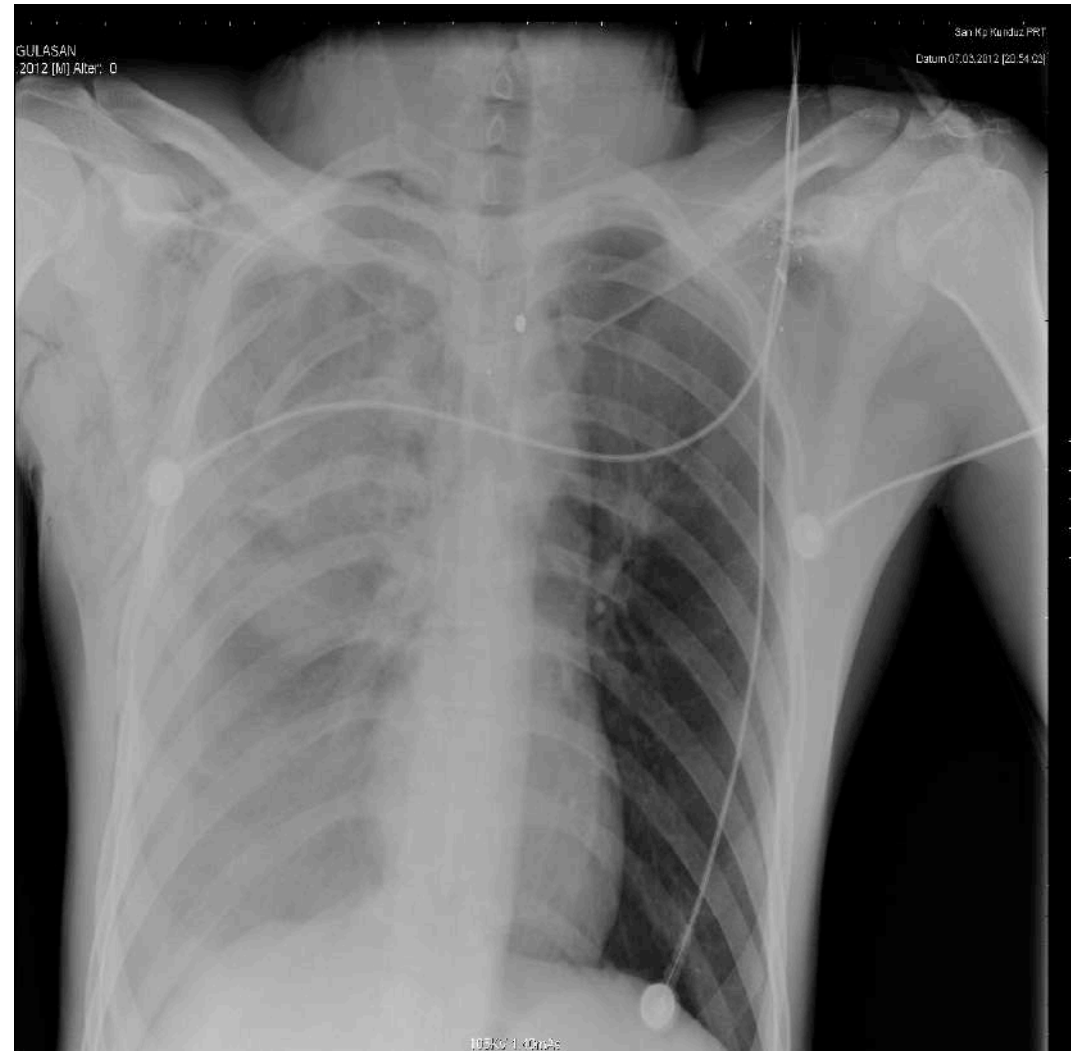


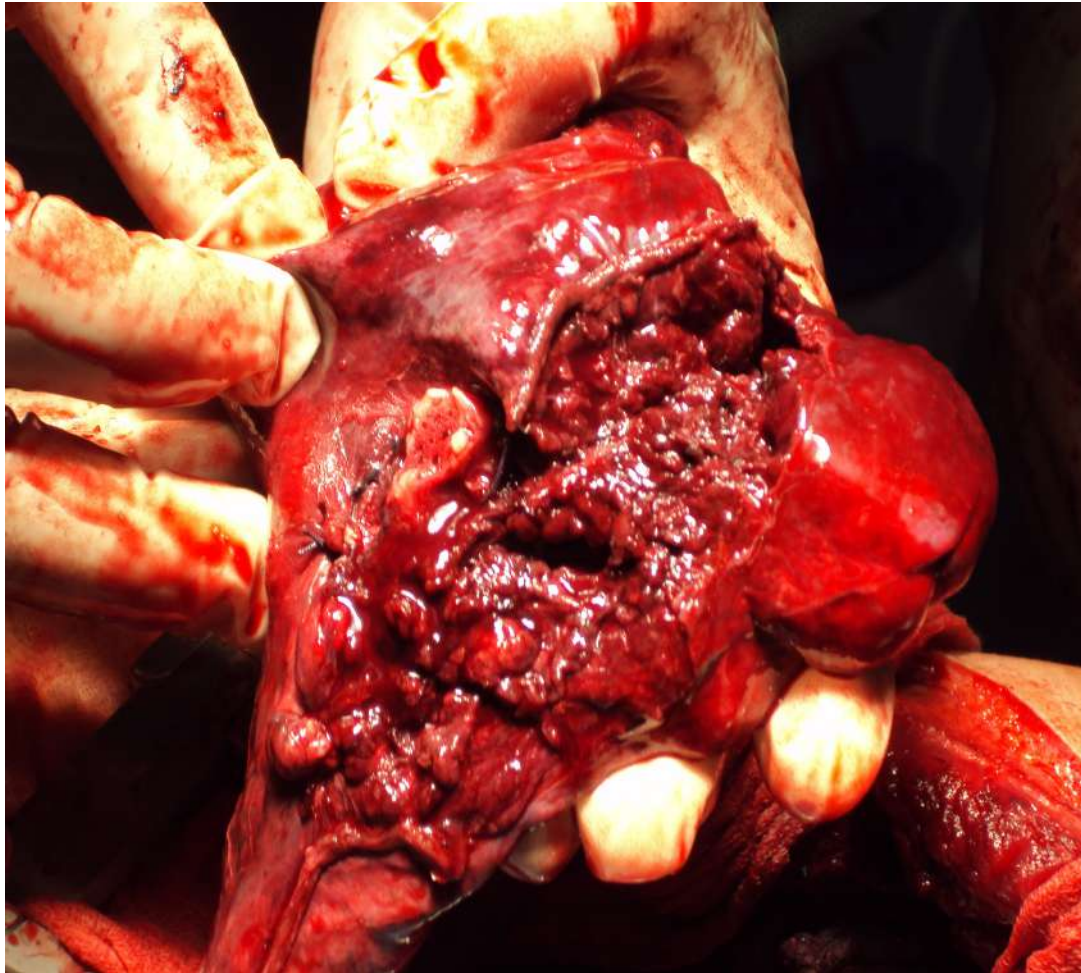
(aus: *Emergency War Surgery – Weapon Effects*;  
*The Borden Institute, 2004, Washington D.C.*)

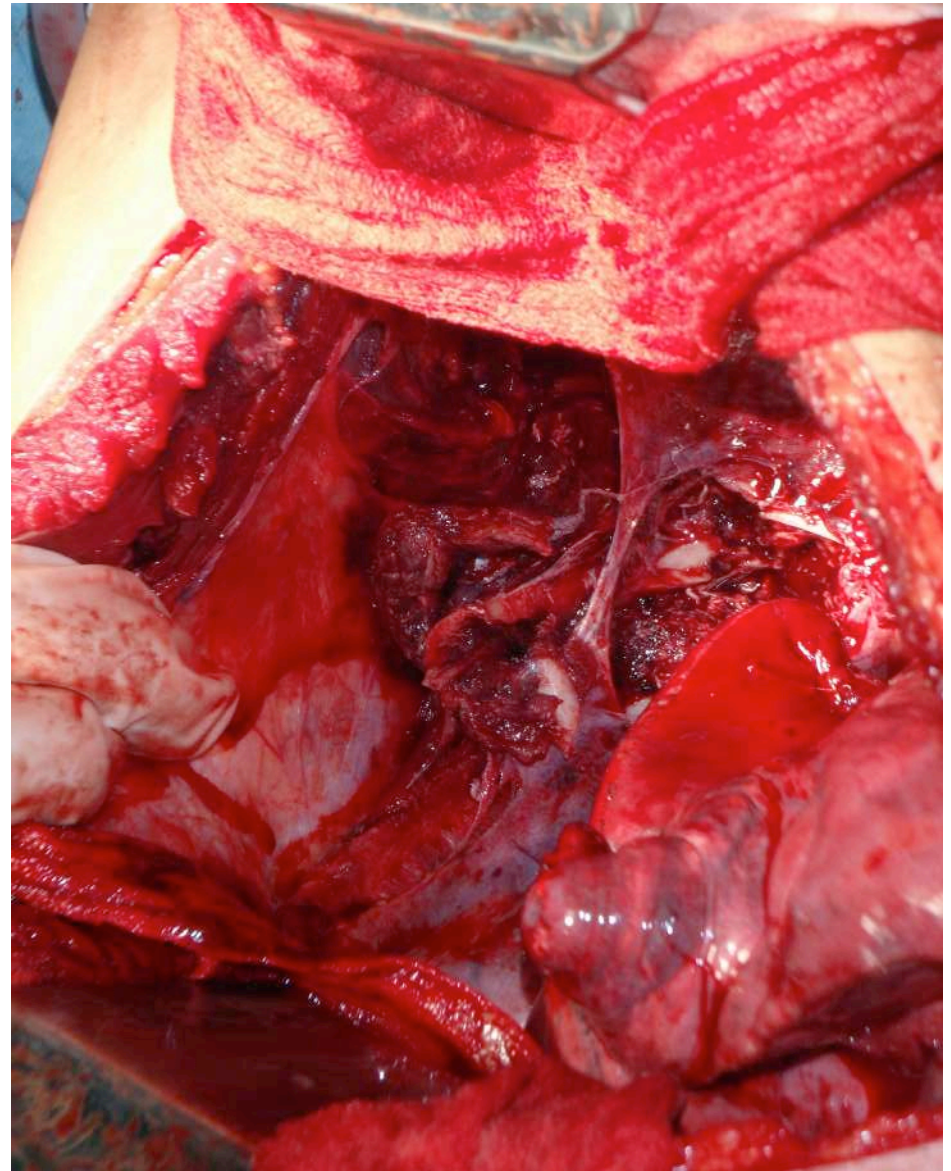
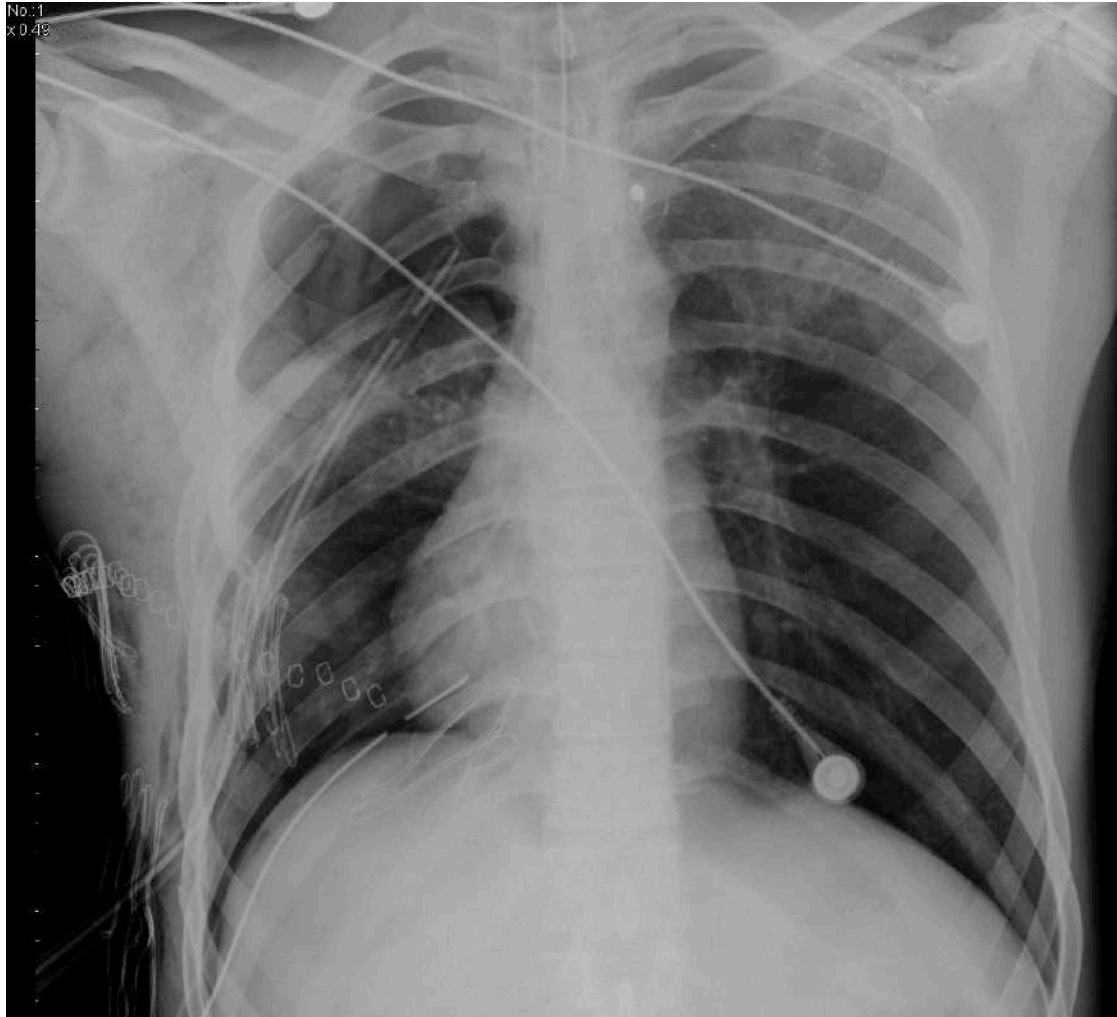
The diameter of the Temporary Cavity – is 10-40 x the bullet-diameter

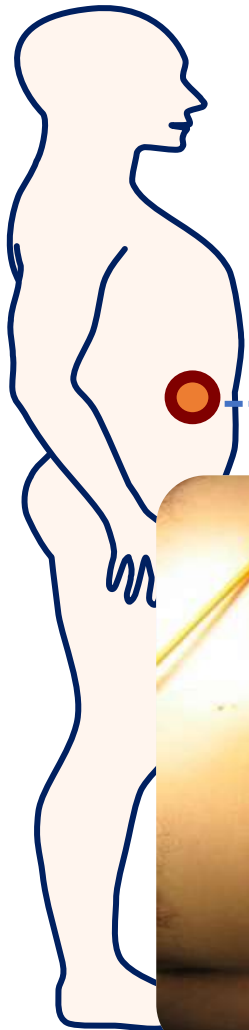












- multiple Injuries
- Always contaminated (Cavitation)
- Secondary necrosis after 24-72 hrs.





## Shot – Gun – Injuries with „War Weapons“

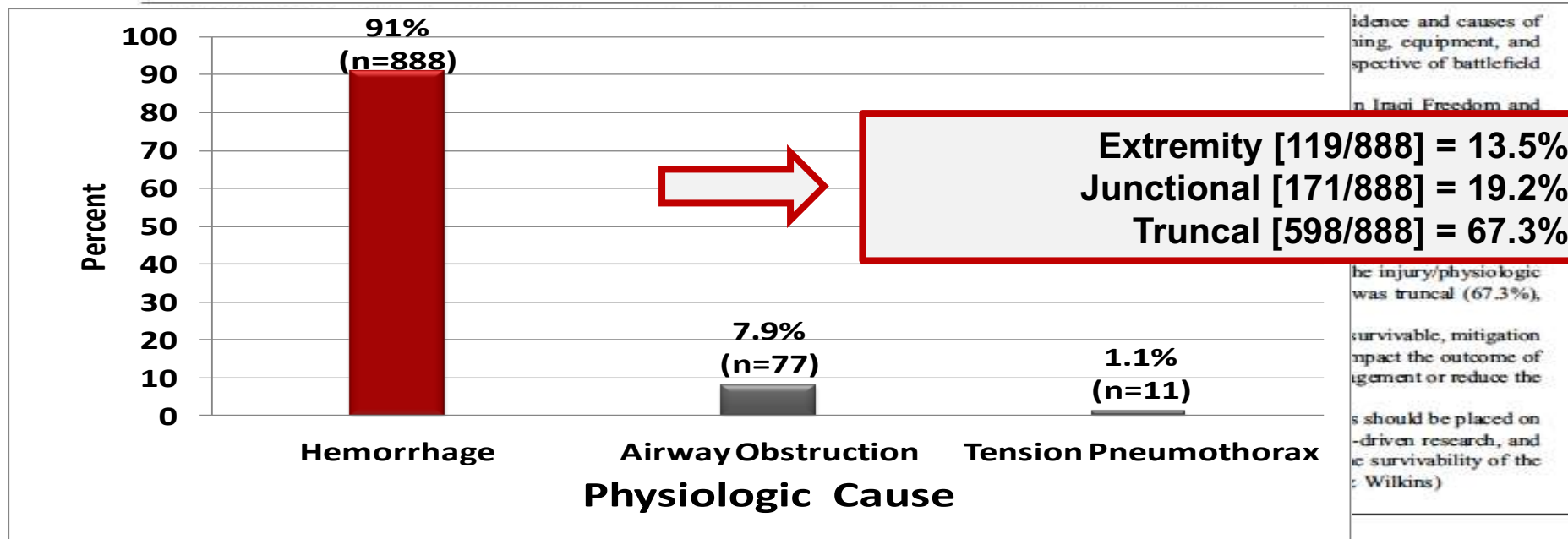
- ... Have to be considered as life-threatening
- ... Bleeding is the main cause of Death within the first 24 hrs.
  - ... later Sepsis, due to Contamination (Bowel, ...)
  - ... negative Rate of Laparotomies is smaller than 5%

***„Penetrating injuries below the nipples,  
above the symphysis pubis  
and between the posterior axillary lines  
must be treated as injuries to the abdomen  
and mandate exploratory laparotomy“***

*Emergency War Surgery, Chapter 17 – Abdominal Injuries*

## Death on the battlefield (2001–2011): Implications for the future of combat casualty care

**Brian J. Eastridge, MD, Robert L. Mabry, MD, Peter Seguin, MD, Joyce Cantrell, MD, Terrill Tops, MD, Paul Uribe, MD, Olga Mallett, Tamara Zubko, Lynne Oetjen-Gerdes, Todd E. Rasmussen, MD, Frank K. Butler, MD, Russell S. Kotwal, MD, John B. Holcomb, MD, Charles Wade, PhD, Howard Champion, MD, Mimi Lawnick, Leon Moores, MD, and Lorne H. Blackbourne, MD**



The vision of the Joint Trauma System is that every soldier, marine, sailor, or airman injured in the battlefield or in the theater of operations has the optimal chance for survival and

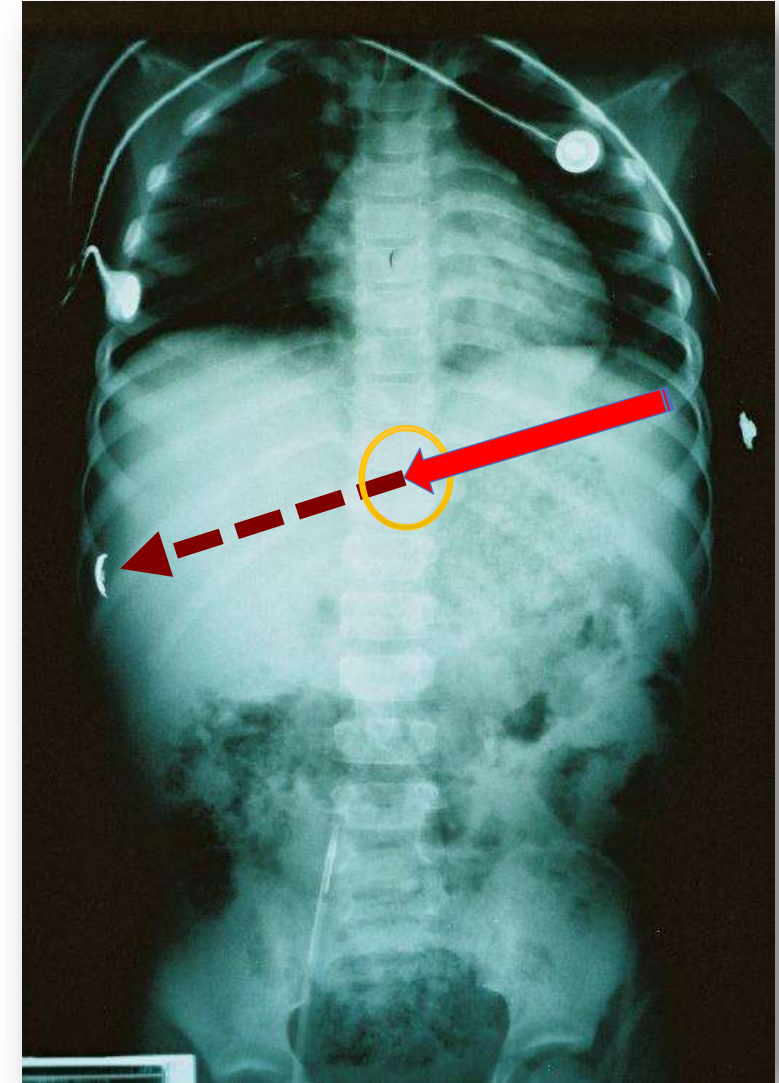
performance improvement driven by evidence-based medicine across the entire continuum. A preliminary study evaluated these issues in Special Operations forces early in the war.<sup>1</sup>



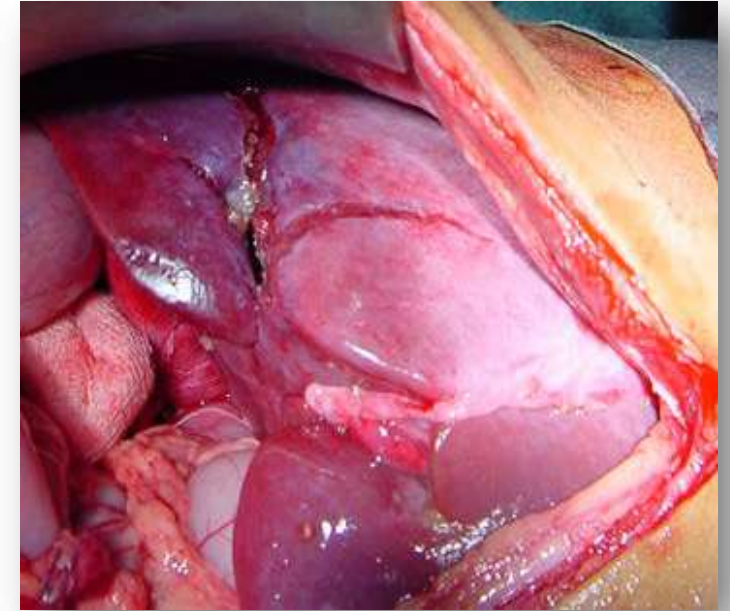
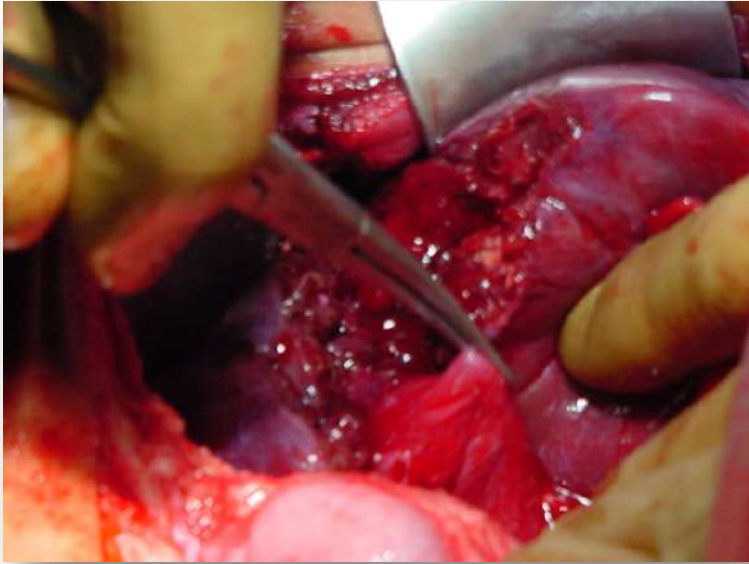
**„Stop the bleeding“**

**„Stop the contamination“**

# Blast Injury – abdominal shrapnell







Damage of  
front wall stomach  
GB  
right Liver-Lobe





## Damage Control

Removal of the blood and liver packing

Temporary gastric occlusion using intestinal clamp -

Revision of the abdomen

Gall-bladder Removal

Stomach: Sutures

Temporary abdominal closure

Second Look after 48h:

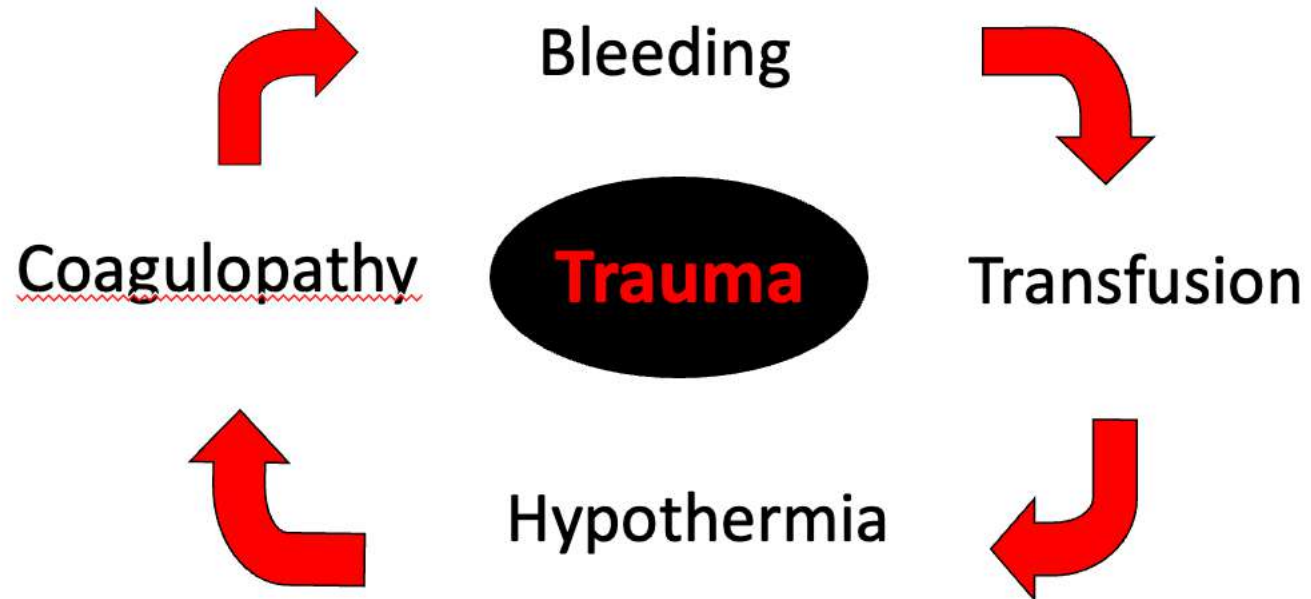
Removal liverpacking

Revision abdomen

liver reconstruction / cholecystectomy



## “The Bloody Vicious Cycle”





- Stop the Bleeding
- Stop the Contamination
- Be fast and non-traumatic
- Pack and come back later, when physiology is restored

Gold Medal Paper  
*Use of Damage Control and the Open  
Abdomen in Combat*

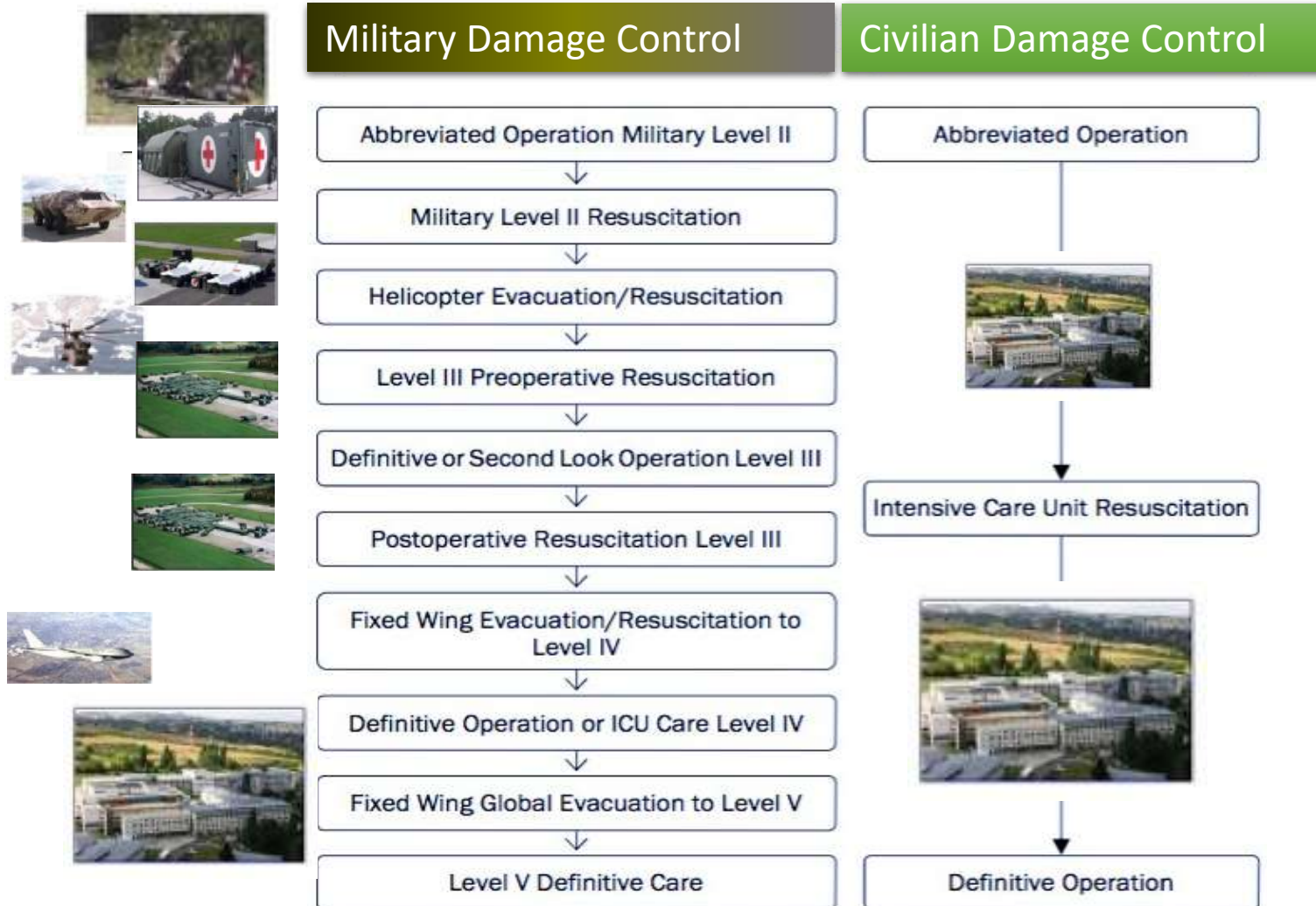
BENJAMIN BOGRAD, D.O.,\* CARLOS RODRIGUEZ, D.O.,\* RICHARD AMDUR, Ph.D.,‡ FRED GAGE,\*  
ERIC ELSTER, M.D.,\*† JAMES DUNNE, M.D.†‡

From the \*Department of Surgery, Walter Reed National Military Medical Center, Department Bethesda, Maryland; the †Department of Surgery, Uniformed Services University of the Health Sciences, Bethesda, Maryland; and the ‡Department of Surgery, George Washington University, Washington, DC

„These forward surgical teams (FSTs) have the ability to establish a functional operating room within 1 hour of arriving on scene and caring for **30 critically wounded patients for as long as 72 hours**“

Military Setting...

„As such, the current study revealed a **51 per cent rate of damage control surgery** in combat casualties with a nontherapeutic laparotomy rate of 14.7 per cent...“





## War /Desaster / Terror

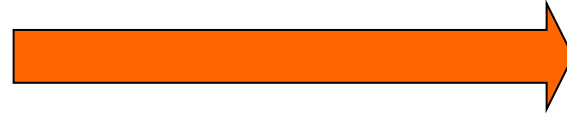


- NOM (Option)
- Interventional radiological techniques
- OR-Intensive Care -OR
- More Capacities
- Minimal invasive Surgery (Option)
- Specialists

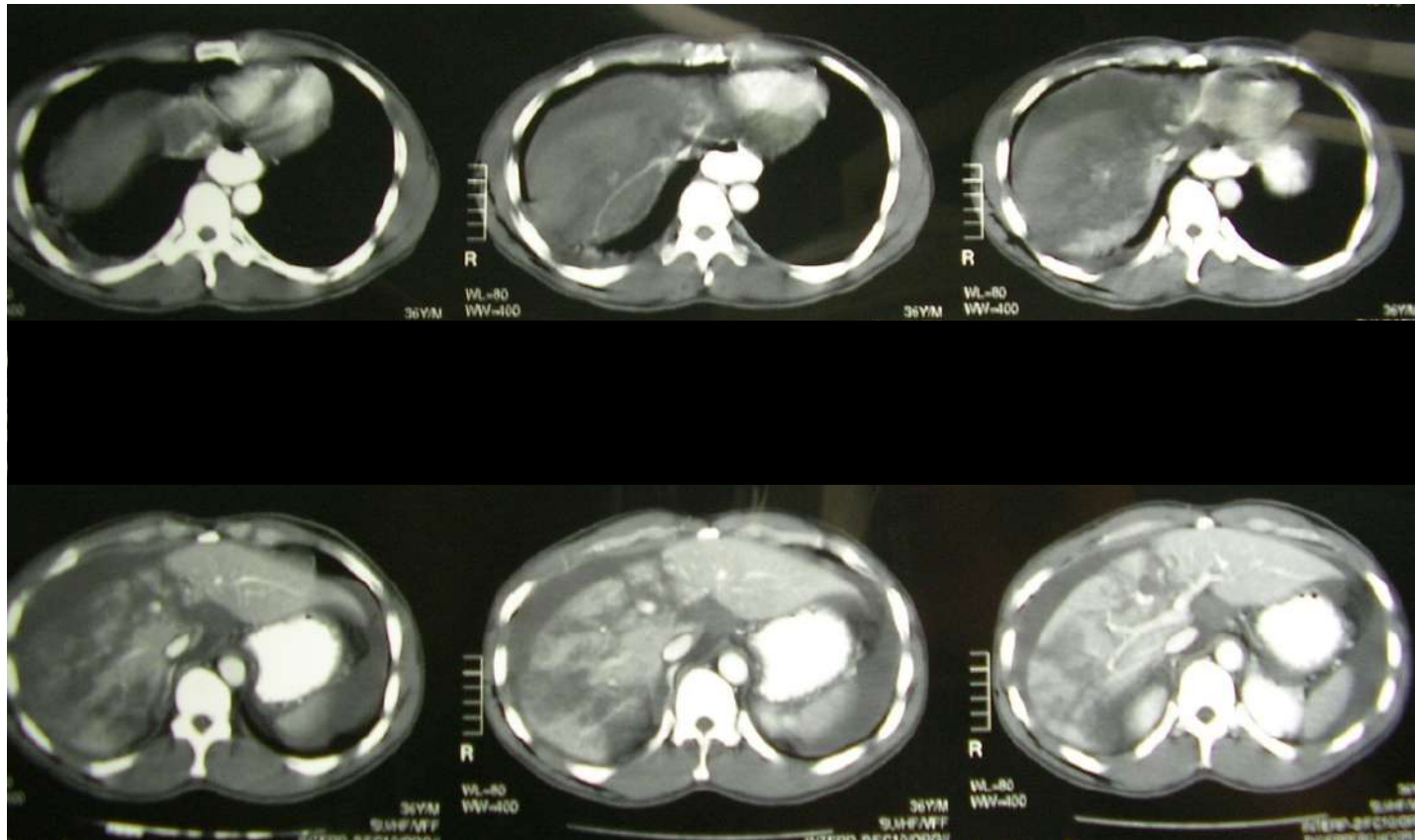
- **NOM is not an Option!**
- **Mainly no interventional radiological techniques**
- **Limited Ressources – Trigger DCS!**
- More Penetrating Trauma ↑↑↑
- More Blast Injury ↑↑↑
- No Minimal invasive Surgery
- General Surgeon
- MASCAL ↑↑↑

# PLAN OF ACTION

**Resuscitate**



**Laparotomy**



**PUSH**



**PRINGLE**



**PLUG**

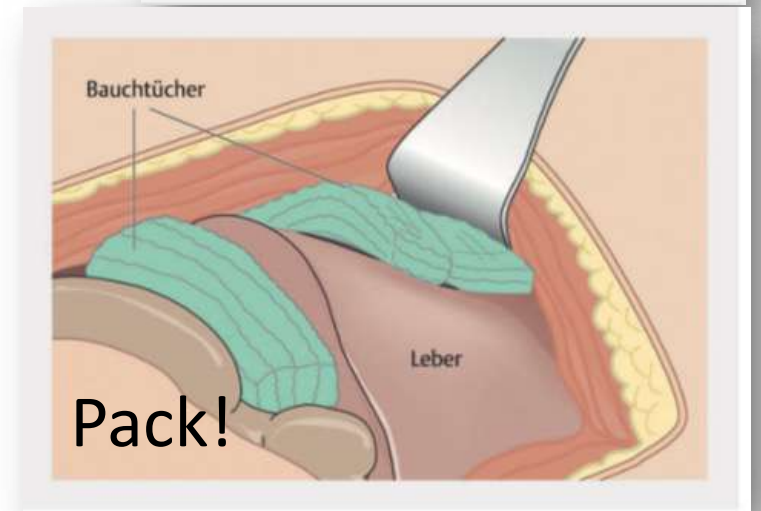
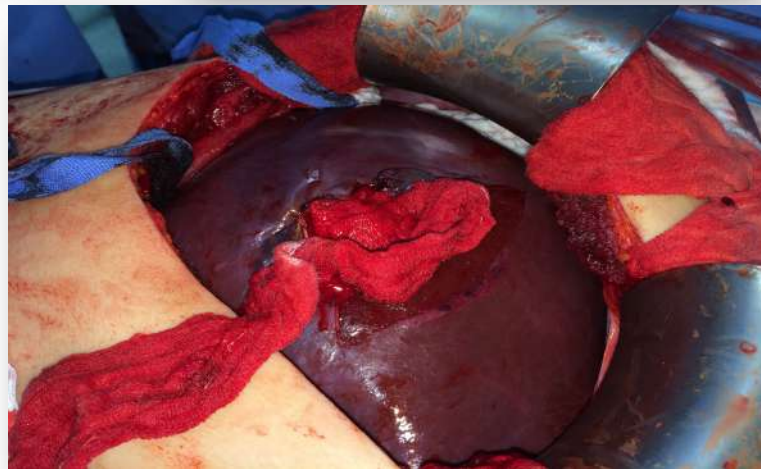
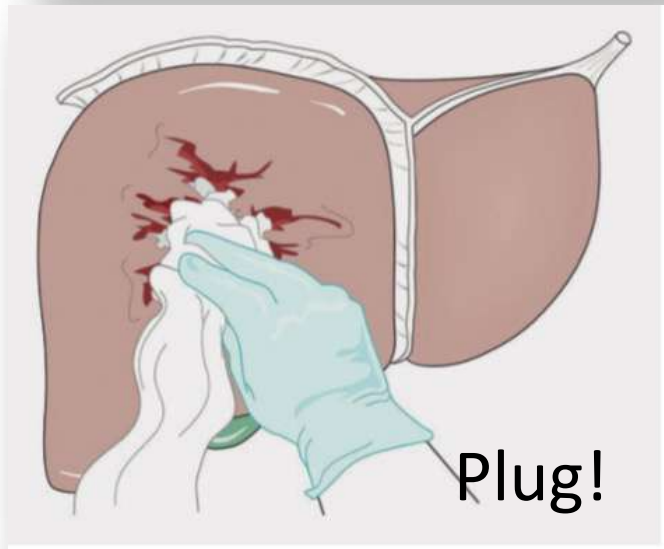
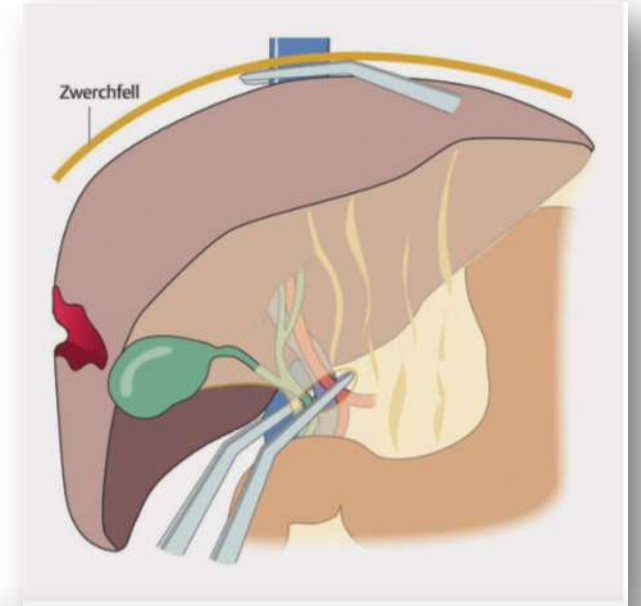
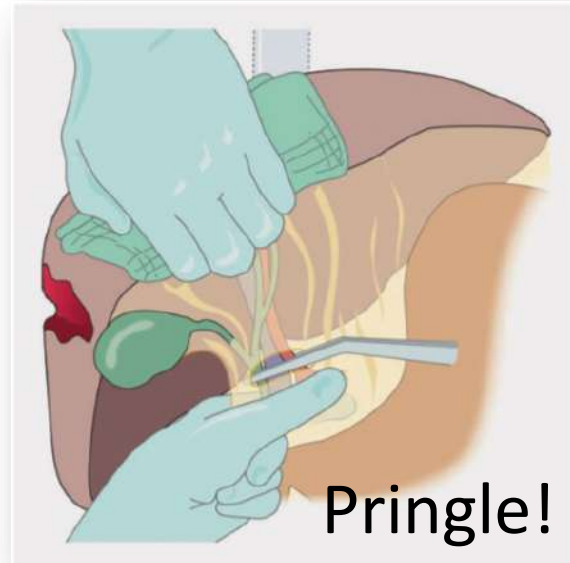
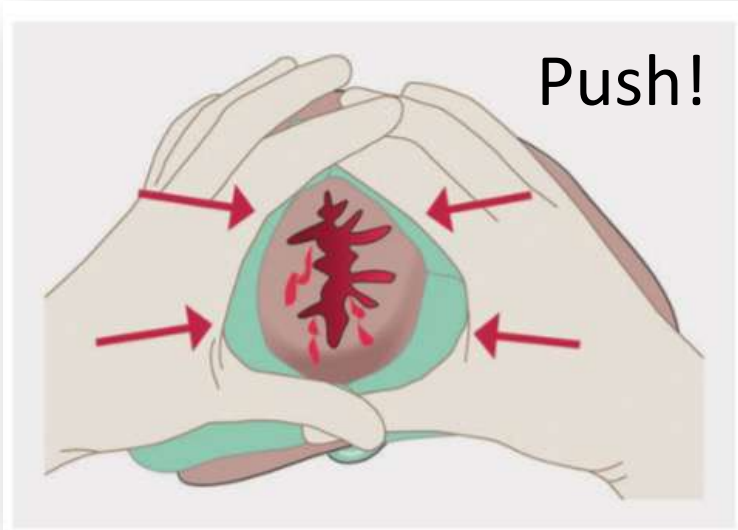


**PACK**

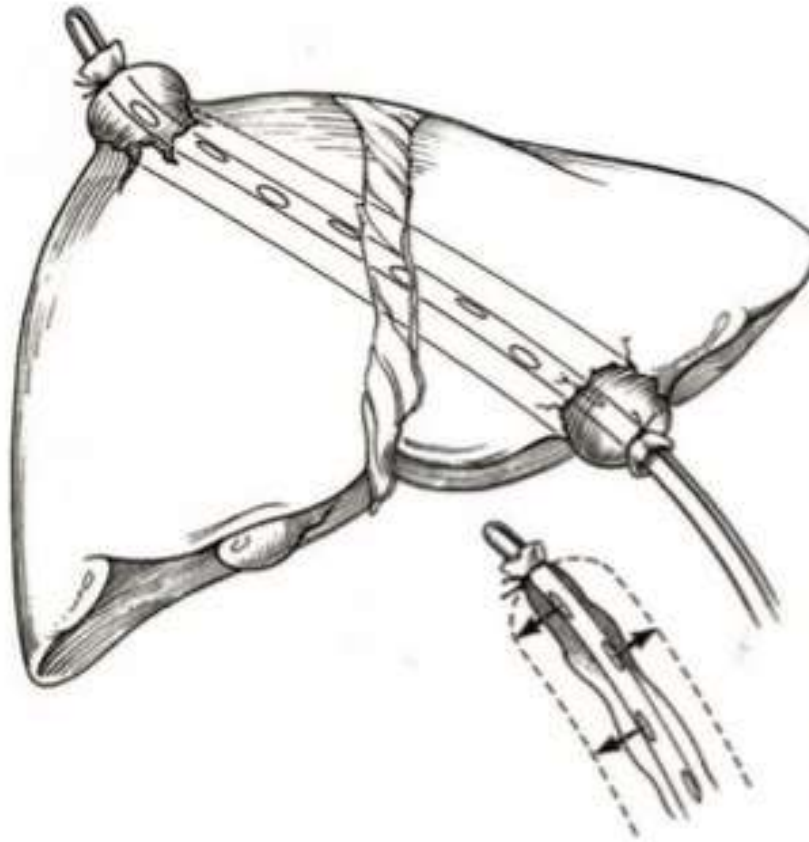




# ... for the Liver



## Balloon tamponade...



Poggetti, Moore et al. Balloon tamponade for bilobar transfixing hepatic gunshot wounds. J Trauma. 1992;33:694 – 697.





Table 3 Studies reporting the use of intrahepatic balloon in transfixing hepatic injuries

Authors	No. patients	Intrahepatic balloon used	Complications	Mortality
Branco et al. [8]	9	Penrose and Nelaton	22.2 %	11.1 %
Poggetti et al. [20]	2	Penrose and red rubber catheter	0	0
Fávero et al. [19]	13	Penrose and Levine	46.1 %	15.4 %
Demetriades [10]	3	Foley	0	0
Smaniotto et al. [7]	18	Nasogastric tube and Penrose	61.1 %	61.1 %
Ball et al. [11]		Blakemore balloon, Penrose drain with red rubber Robinson catheter, and Foley catheter	–	33.3 %



### Gunshots, Explosions and penetrating Trauma

- ✓ Understanding the mechanism of Injuries is mandatory
- ✓ Limited resources require a modified mind-set...
- ✓ Stop the bleeding – is the first goal!
- ✓ DCS – AND – Correction of the „bloody vicious circle“
- ✓ The Domain of severe liver trauma is „DCS“!  
... and the domain of liver-DCS is: push – (pringle) – plug & pack!



[robertschwab@bundeswehr.org](mailto:robertschwab@bundeswehr.org)