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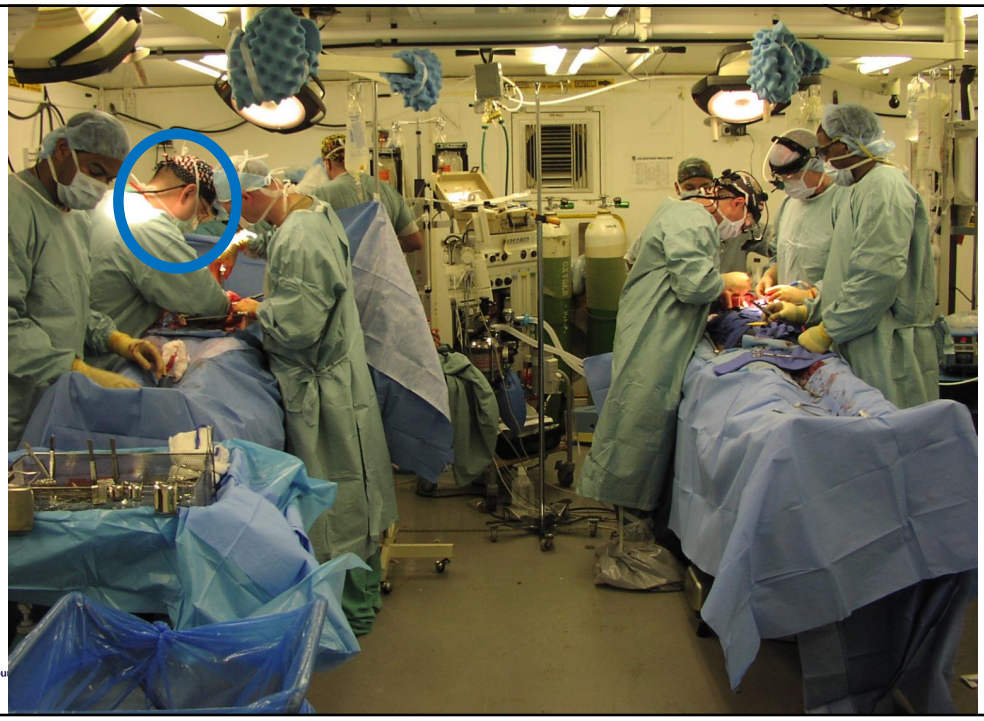
Mangled Extremity

(Warning: Contains Graphic Images)

Utah Trauma Network
October 24, 2024

David Morris, MD FACS
Regional Trauma Medical Director

1



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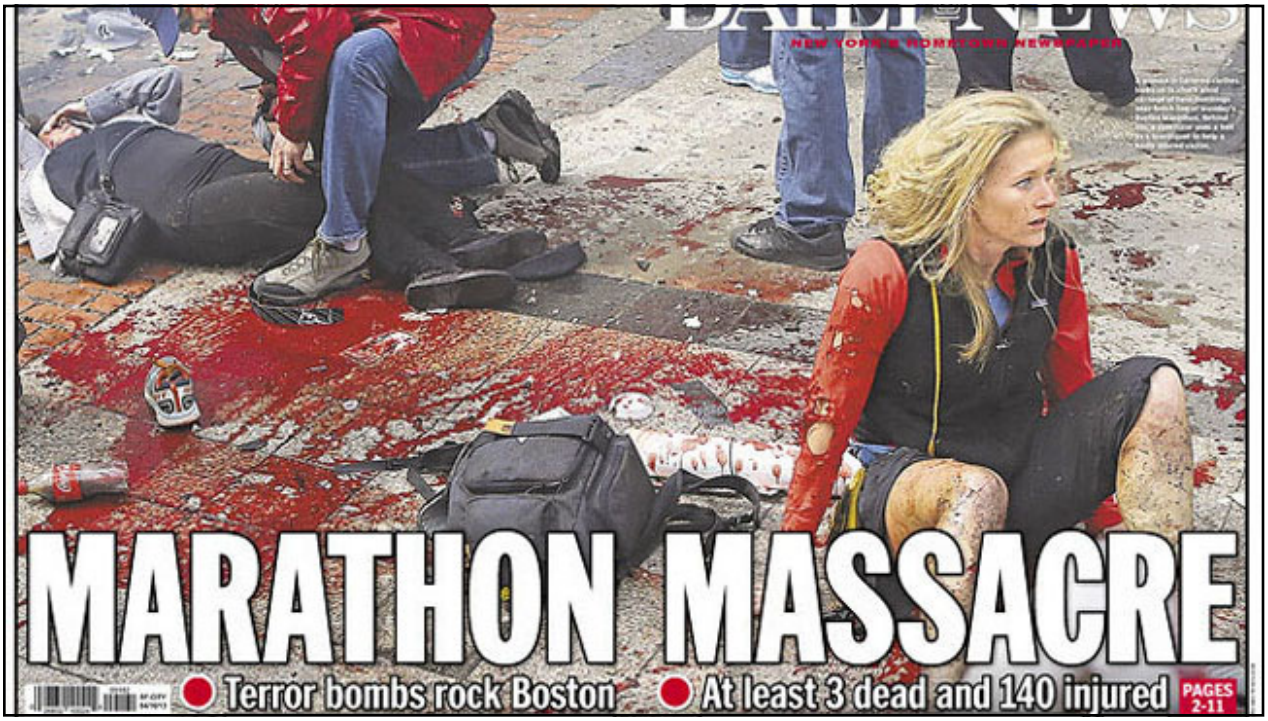
DAILY NEWS
NEW YORK'S HOMETOWN NEWSPAPER
MARATHON MASSACRE
Terror bombs rock Boston
At least 3 dead and 140 injured
PAGES 2-11

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www.theatlantic.com

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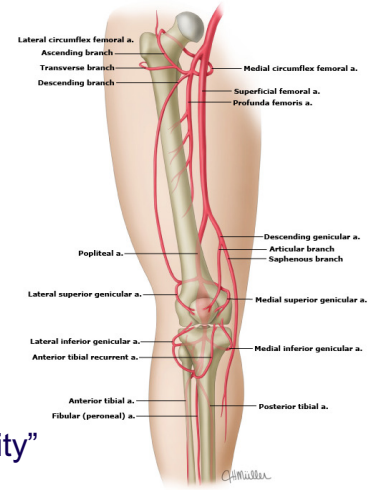
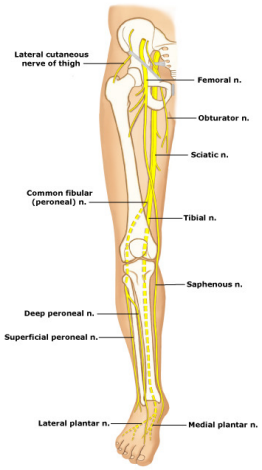
Extremity Injury

- Very common
- 4 components
  - Bone
  - Soft Tissue
  - Vessels
  - Nerves
- ≥ 3 involved = "mangled extremity"





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Differences

Military

Blast (IED, land mine, etc.)
High-velocity GSW

Civilian

Blunt (MVC, fall, power tools, farm)
12% penetrating

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It takes a village…

- Pre-hospital providers
- Emergency medicine
- Trauma
- Orthopedics
- Plastics
- Neurosurgery
- Vascular surgery
- Rehab specialists
- Prosthetics specialists
- Nursing
- Pharmacy
- Social Work
- Psychiatry
- Internal Medicine
- Family

Principles of Management: Prehospital

- Scene safety
- High suspicion of associated injuries
- "Ignore the gore"
  - Unless exsanguinating
- Splints
- Rapid transport

Care of Amputated Parts

- (If possible)
- Rinse
  - Saline vs. tap water
- Wrap in saline moist gauze
  - Several layers
- Waterproof bag
- Bag in Ice

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Avoid Maceration and Freezer Burn

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Fracture Blood Loss (ml)

	Closed	Open
Femur	1000-1500	> 2000-3000
Tibia	500-1000	> 1000-2000

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Control of Hemorrhage

Direct Pressure

Elevation

Wound packing

Indirect pressure (pressure points)

Tourniquet

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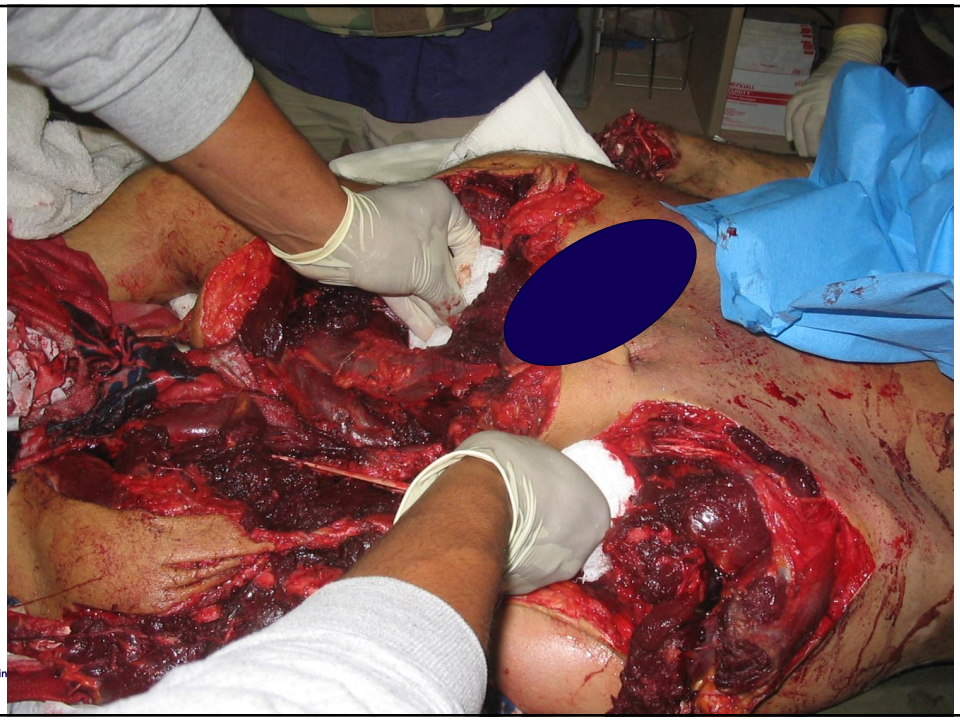

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www.seg-social.es

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Emergency and Medical Tourniquet (EMT)

- www.wikipedia.org

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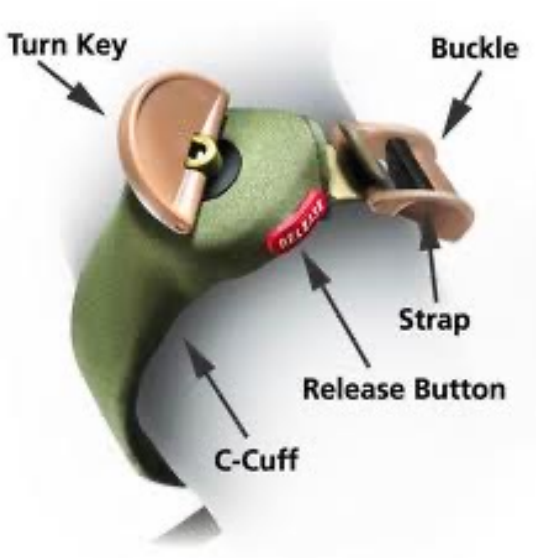
Mechanical Advantage Tourniquet (MAT)

- www.mountainside-medical.com



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A Preventable Death: 2003

This casualty was wounded by an RPG explosion.

He bled to death from his leg wound despite the placement of three improvised tourniquets.

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IED Casualty with Improvised Tourniquets

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Improvised Tourniquets: The Military Experience Kragh J Trauma 2008

Table 5 Tourniquet Device Counts, Effectiveness, and Morbidity

Tourniquet Name	Patients; N*	Devices; N*	Limbs; N*	Effective; N (%)	Ineffective (%)	Morbidity; N*(%)	Back-Up (%)
CAT	156	210	202	166 (79)	44 (21)	43 (21)	5
EMT	91	115	115	106 (92)	9 (8)	9 (8)	0
SOFT	50	62	61	41 (66)	21(34)	20 (33)	2
SATS	2	2	2	0 (0)	2 (100)	2 (100)	0
RMT	2	2	2	0 (0)	2 (100)	2 (100)	0
London bridge	1	1	1	1 (100)	0 (0)	1 (100)	0
Improvised	15	16	15	4 (25)	12 (75)	12 (80)	17
Unknown	14	18	17	14 (74)	5 (26)	8 (18)	0

16 tourniquets were improvised from cravats, dressings, a string, a belt, a cord, a band, and an intravenous tube; 14 tourniquet types were unknown.

* Patients had 1–4 devices of 1–4 types on 1–4 limbs with 0–3 morbidities. A tourniquet that required another or more tourniquets on the same limb was said to require back up. There were 35 limbs where the effectiveness was unknown.

CAT indicates Combat Application Tourniquets; EMT, Emergency Military Tourniquets; SOFT, Special Operations Forces Tactical Tourniquet; SATS, Self-Applied Tourniquet System; RMT, Ratcheting Medical Tourniquets.

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What's the problem with improvised tourniquets?

- Pressure is transmitted directly to nerves and vessels
- Deep pressures are similar to surface

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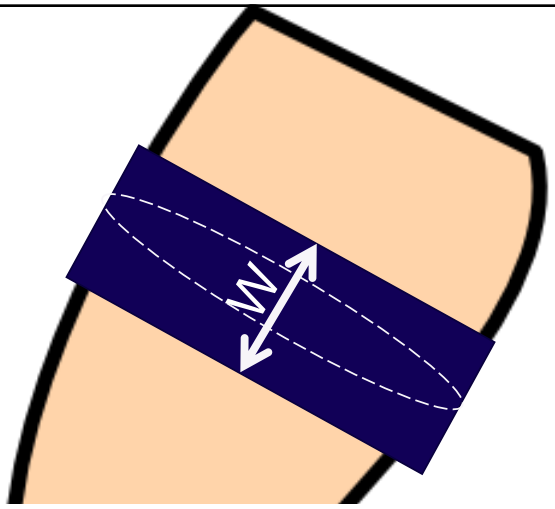

As Width/Circumference ↑

Occlusion Pressure ↓

Lower Pressure is needed for wider tourniquets on thinner limbs

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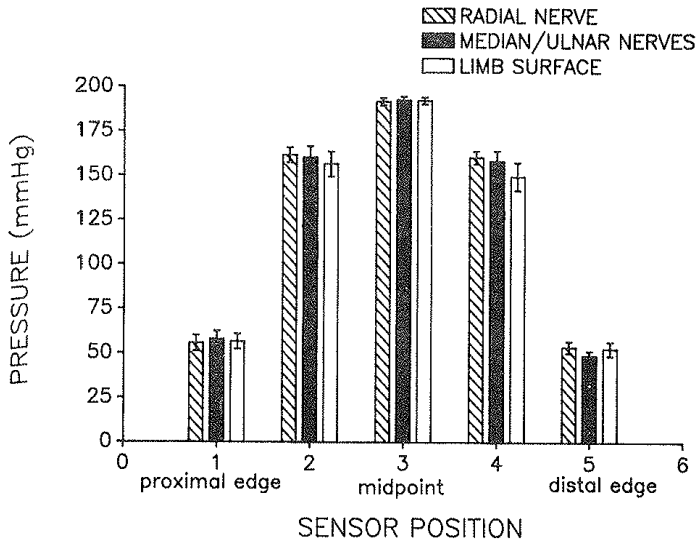

Graham B. Jour Hand Surg (Brit) 1992

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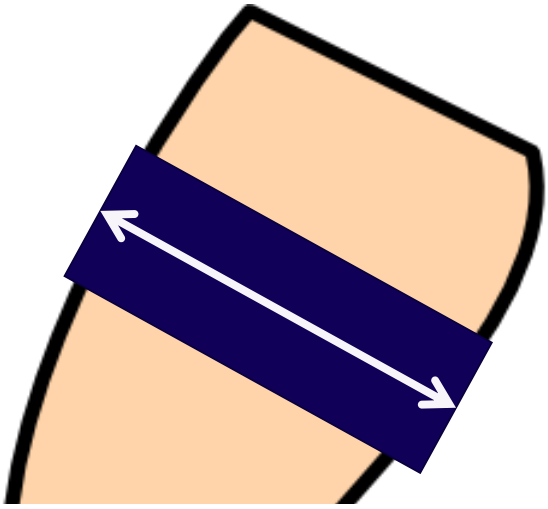

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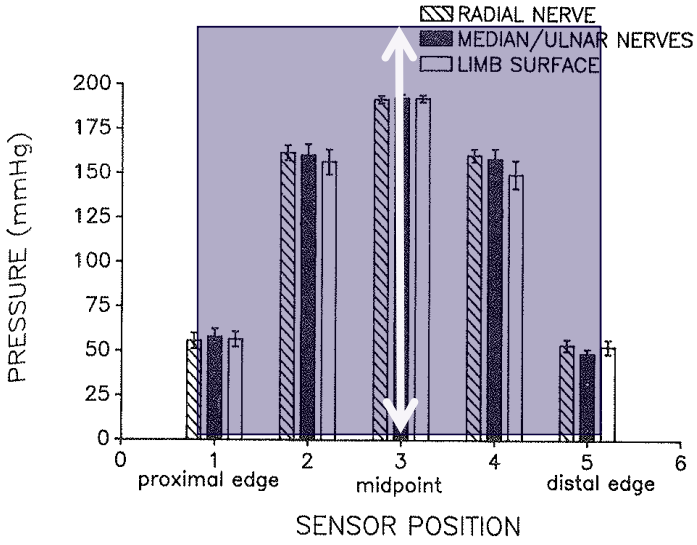

Graham B. Jour Hand Surg (Brit) 1992

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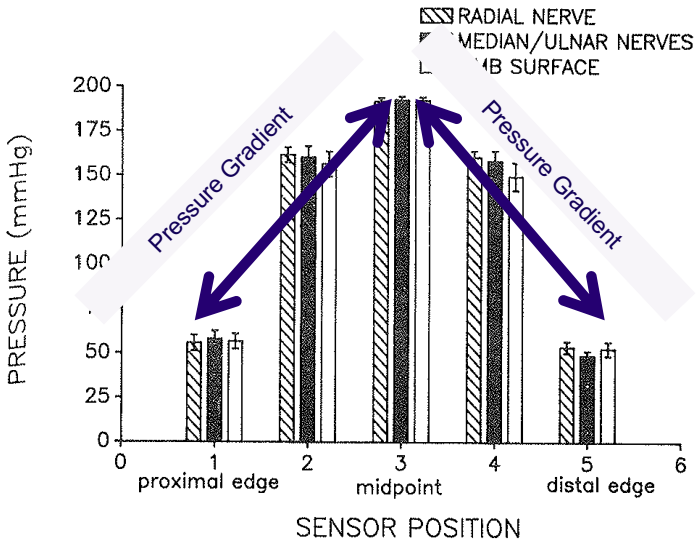

Graham B. Jour Hand Surg (Brit) 1992

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But the Bleeding Won't Stop!!!

- Twist it Tighter!!!!
- Right???

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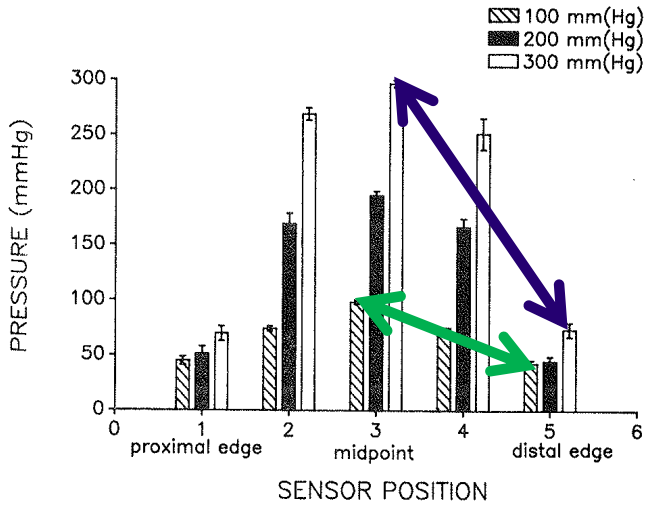

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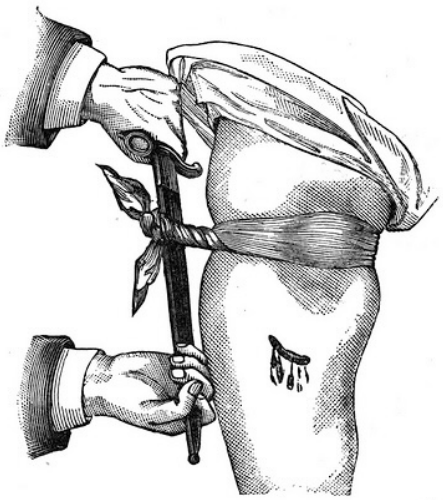

FIG. 164. Showing how Hemorrhage from the Femoral Artery may be arrested by the Use of an Improvised Tourniquet.

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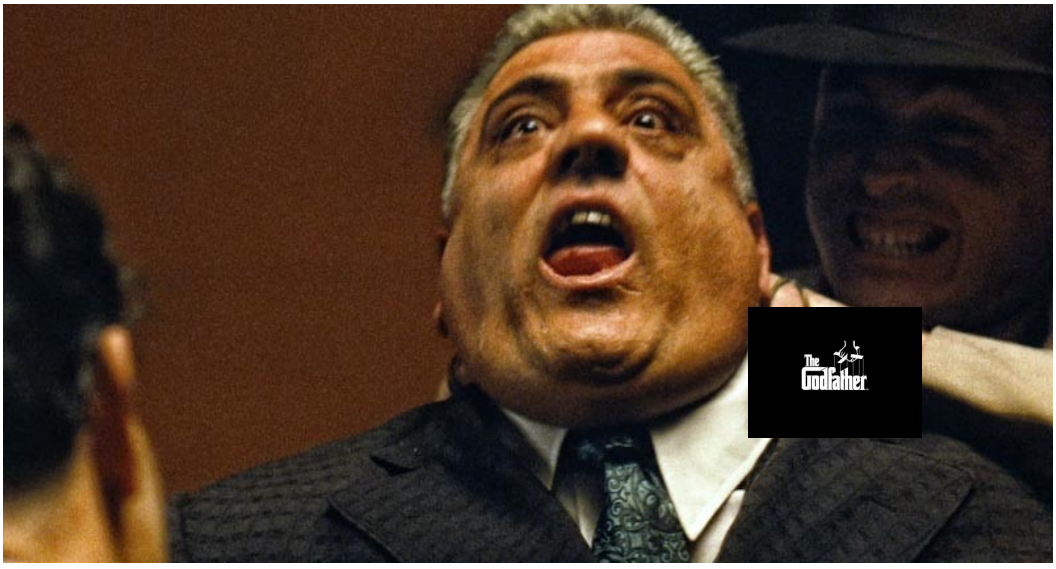

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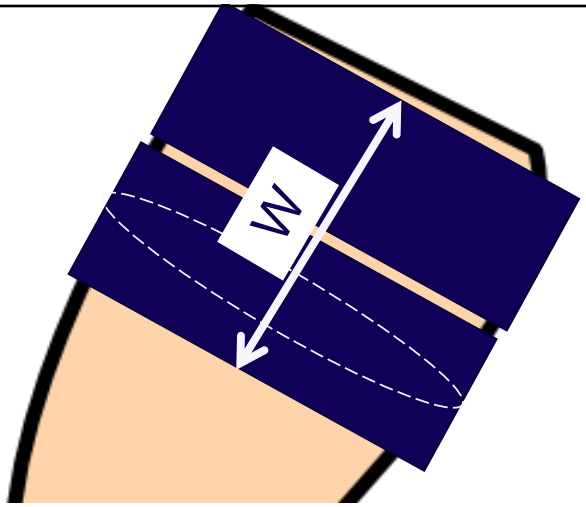

As W/C ↑

Occl P ↓

2 Tourniquets in series increases W/C ratio

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Venous Tourniquets

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Failure to occlude arteries
=
Venous Tourniquet

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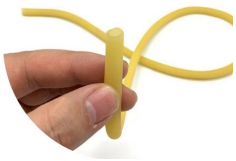
Occlusion Pressure is Dynamic!



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Which Tourniquet?

MILITARY MEDICINE

EFFECTIVENESS OF SELF-APPLIED TOURNIQUETS IN HUMAN VOLUNTEERS

Thomas J. Walters, PhD, Joseph C. Wenke, PhD, David S. Kauvar, MD,
John G. McManus, MD, John B. Holcomb, MD, David G. Baer, PhD

PREHOSPITAL EMERGENCY CARE 2005;9:416–422

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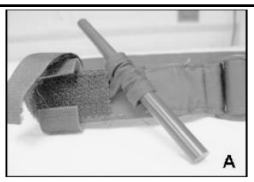
CAT

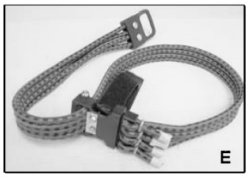


SOFTT

EMT

SATS

H-Dyne



MAT

LRT

PREHOSPITAL EMERGENCY CARE 2005;9:416–422

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TABLE 3. Results of Experiment I*

	CAT	SOFTT	EMT	MAT	LRT	SATS	H-Dyne
Percent effective	100	100	100	88	67	44	22
Number effective	18/18	18/18	18/18	14/16†	12/18	8/18	4/18
Failures (number of devices)							
Circumferential pain	n/a	n/a	n/a	1	2	2	4
Pinch pain	n/a	n/a	n/a	1	1	0	0
Slipping	n/a	n/a	n/a	0	3	0	5
Physical limitation	n/a	n/a	n/a	0	0	8	5

*See footnote of Table 1 for explanations of tourniquet abbreviations.
† $N = 16$ due to failure to replace and retest two devices following mechanical failures.

TABLE 4. Results of Experiment II*

	CAT	SOFTT	EMT	MAT
Percent effective	100	100	100	75
Number effective	12/12	12/12	12/12	9/12†

*See footnote of Table 1 for explanations of tourniquet abbreviations.
‡Failure in all cases was due to introlerable pinching pain.

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PREHOSPITAL EMERGENCY CARE 2005;9:416–422

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Improvised Tourniquet

Boston Marathon 2013

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Boston Trauma Surgeon

"Everyone had improvised, largely ineffective tourniquets from the field, all converted to CATs upon arrival at the Trauma Center."

- Attending surgeon at Boston trauma center
- Operated on multiple bombing victims
- Hospital had a box of CATs in the ED

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Preventable Combat Deaths from Not Using Tourniquets (or Improvised Tourniquets)

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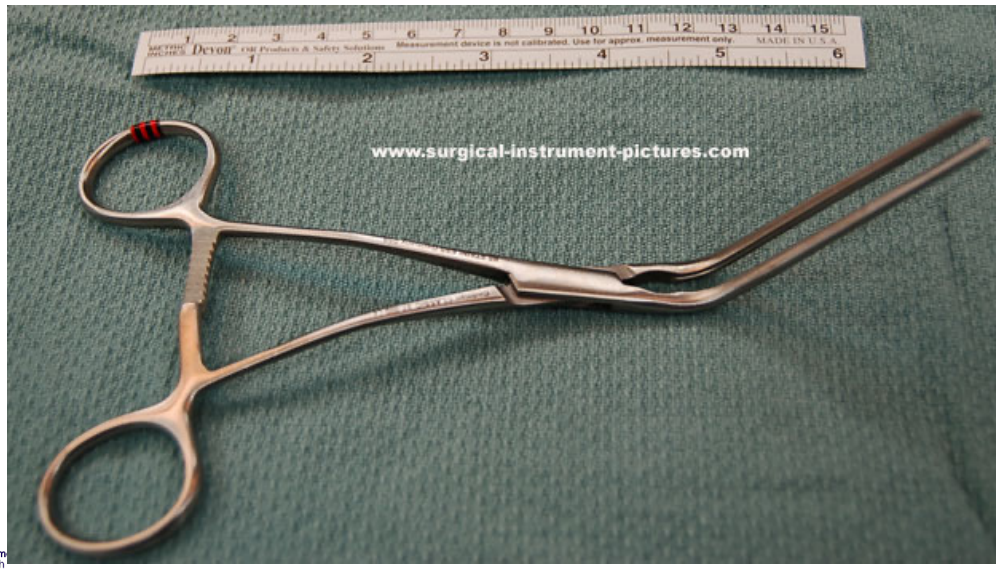
BAD Idea!!!



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Principles of Management: Trauma Bay

- ABCs
- “Ignore the gore”
- Neurovascular exam
- Restore length, alignment
- Plain film imaging (with amputated limb)
- Other imaging if needed and pt. stable
- Antibiotics
- Tetanus

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Damage Control Resuscitation

- "Permissive hypotension"
- Aim for SBP ~ 90
- Early use of blood products
- Key component of "Damage Control Surgery"

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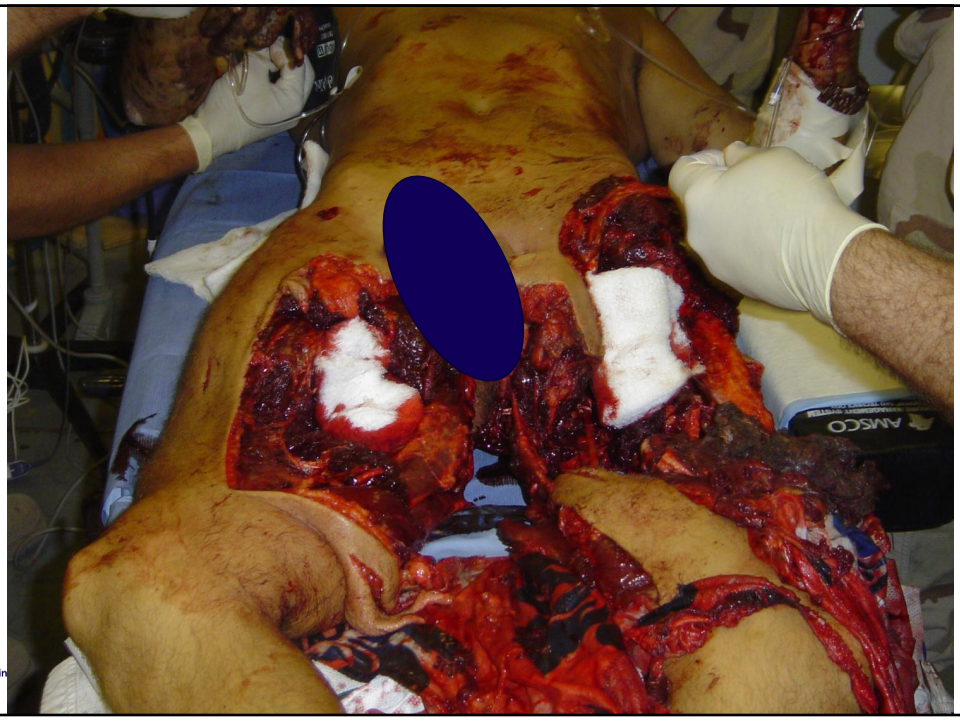

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Examination – Vascular

- "Hard" signs of arterial injury
  - Pulsatile bleeding
  - Expanding hematoma
  - Pulselessness
  - Bruit/thrill
  - Cold/pale extremity
- Operative exploration
  - Hybrid OR

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Examination – Vascular

- "Soft" signs of arterial injury
  - Pulse discrepancy
  - Peripheral nerve deficit
  - History of moderate hemorrhage at scene
  - ABI (AAI) <0.9
- Further imaging workup

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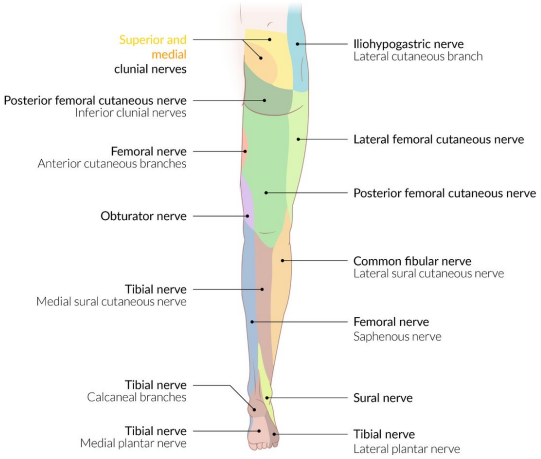
Neuro exam: Lower extremity

- Femoral –sensation of medial thigh, hip flexion, knee extension
- Sciatic – sensation posterior thigh and lower most of lower leg, knee flexion
- Tibial – sensation of sole of foot, plantarflexion, flexion of toes, inversion of the foot
- Peroneal – sensation first webspace, foot drop



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Scoring Systems

- Mangled Extremity Severity Score (MESS)
- Limb Salvage Index (LSI)
- Predictive Salvage Index (PSI)
- Nerve Injury, Ischemia, Soft-Tissue Injury, Skeletal Injury, Shock, and Age of Patient Score (NISSSA)
- Hannover Fracture Scale-97 (HFS-97)
- Gustilo-Anderson open fracture grading system

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Gustilo-Anderson

TABLE 1. Open Fractures—Gustilo Classification[1,2]

Type I	Open fracture with a skin wound <1 cm in length and clean.
Type II	Open fracture with a laceration >1 cm in length without extensive soft tissue damage, flaps, or avulsions.
Type III	Open segmental fracture with >10 cm wound with extensive soft tissue injury or a traumatic amputation (special categories in Type III include gunshot fractures and open fractures caused by farm injuries).
III_A	Adequate soft tissue coverage.
III_B	Significant soft tissue loss with exposed bone that requires soft tissue transfer to achieve coverage.
III_C	Associated vascular injury that requires repair for limb preservation.

crashingpatient.com

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MESS

Mangled Extremity Severity Score (MESS Score)

Estimates viability of an extremity after trauma, to determine need for salvage vs empiric amputation.

Limb Ischemia for > 6 Hours?	☐ Yes Limb Ischemia Points x2
Limb Ischemia	○ Reduced Pulse but Normal Perfusion +1 ○ Pulseless, Paresthesias, Slow Capillary Refill +2 ○ Cool, Paralysis, Numb/Insensate +3
Patient Age Range	○ 0 ○ 30-50 years old +1 ○ 50 years old +2
Shock	○ SBP > 90 Consistently 0 ○ Hypotension Transiently +1 ○ Persistent Hypotension +2
Injury Mechanism	○ Low Energy (stab, gunshot, simple fracture) +1 ○ Medium Energy (dislocation, open/multiple fractures) +2 ○ High Energy (high speed MVA or rifle shot) +3 ○ Very High Energy (high speed trauma with gross contamination) +4
MESS Score	Click! points

A score >7 predicts a low likelihood of limb/extremity viability.

Objective criteria accurately predict amputation following lower extremity trauma. Johansen, K. Journal of Trauma, 1990.

Posted in: Orthopedics · Surgery

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High Risk for Limb Loss

- Long ischemic time
- Blunt mechanism
- High-velocity penetrating trauma
- Lower extremity
- Older age
- Shock
- Resource-limited environment
- Multicasualty event

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Operative Management

- Plan based on patient status
- Function
- All “mangled” wounds need washout at minimum
  - Military wounds

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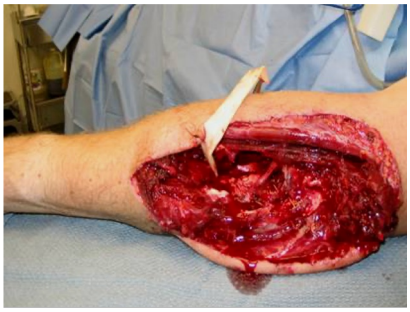

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Operative Management

- Plan based on patient status
- Function
- All “mangled” wounds need washout at minimum
  - Military wounds
- Primary amputation

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Operative Management

- Plan based on patient status
- Function
- All “mangled” wounds need washout at minimum
  - Military wounds
- Primary amputation
- Salvage

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Damage Control Surgery

- Stop hemorrhage
- Revascularize

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Damage Control Surgery

- Stop hemorrhage
- Revascularize
- Stabilize bony injury
  - External fixation

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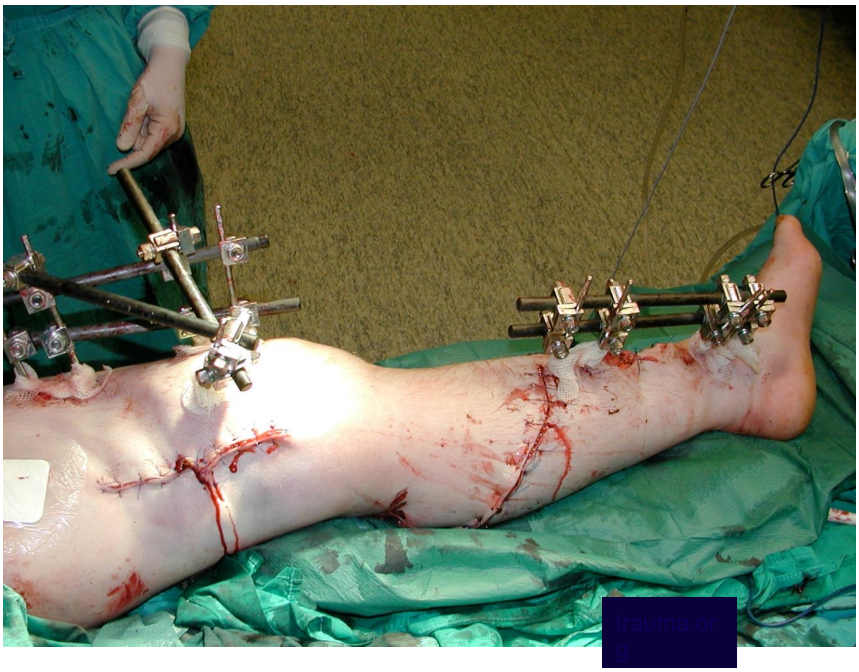

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Damage Control Surgery

- Stop hemorrhage
- Revascularize
- Stabilize bony injury
  - External fixation
- Fasciotomy

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Damage Control Surgery

- Stop hemorrhage
- Revascularize
- Stabilize bony injury
  - External fixation
- Fasciotomy
- Only do as much as necessary
- Ongoing resuscitation in ICU

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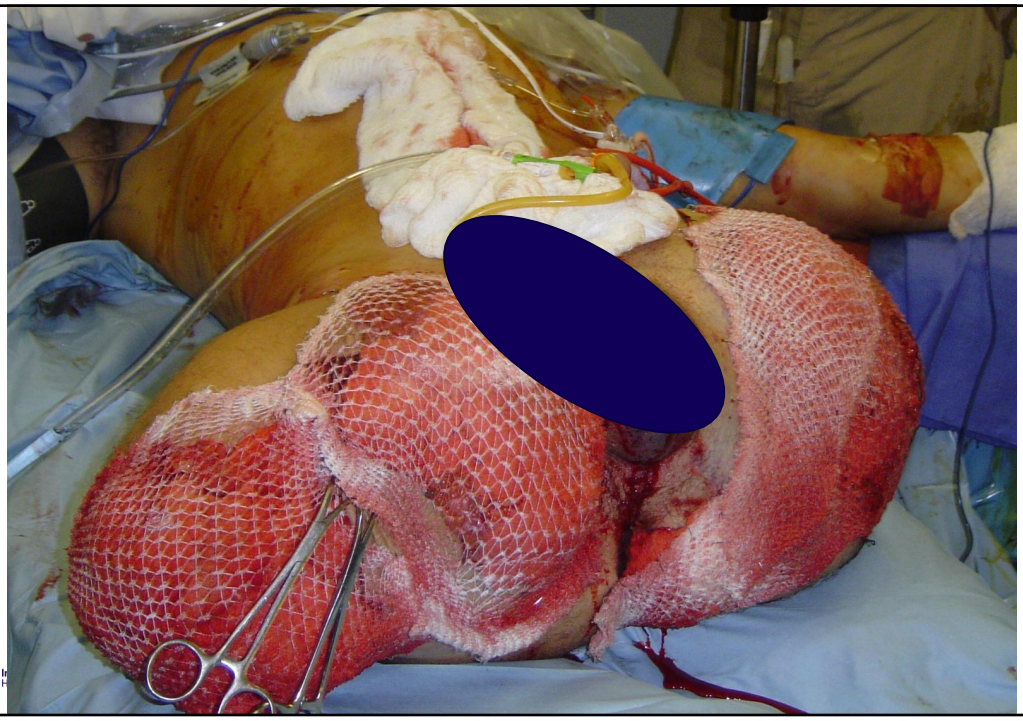

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Subsequent Operations

- Definitive revascularization
- Internal fixation
- Wound closure

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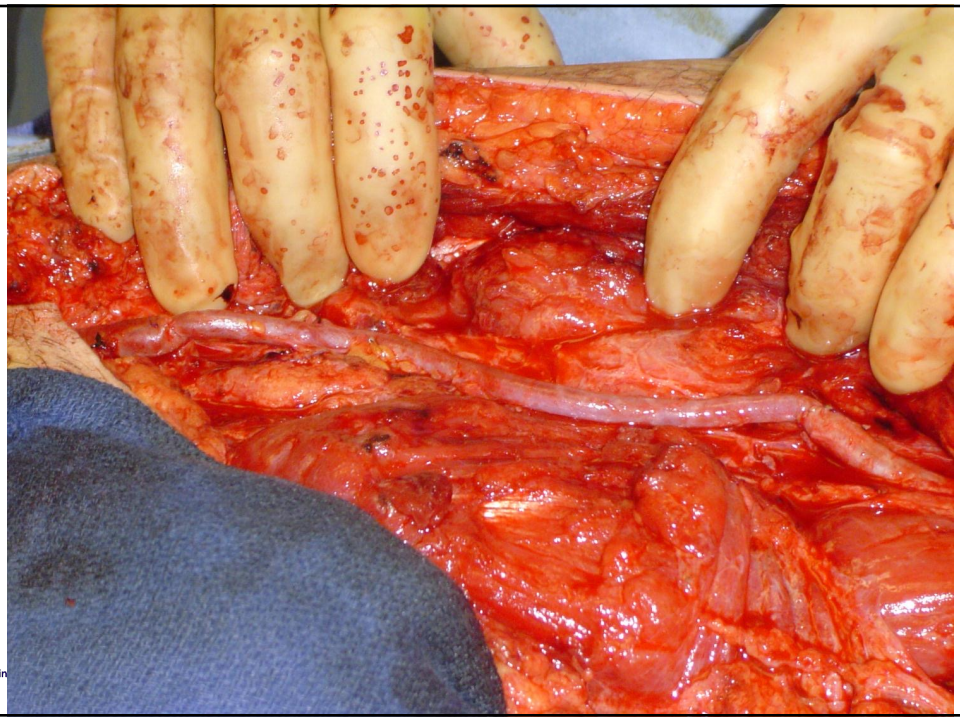

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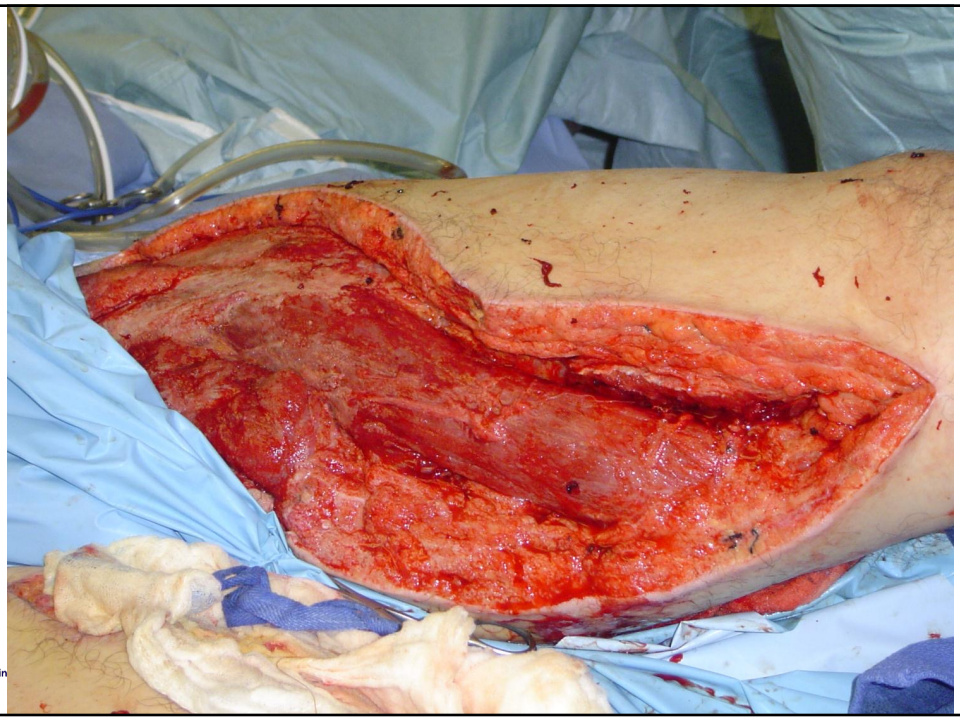

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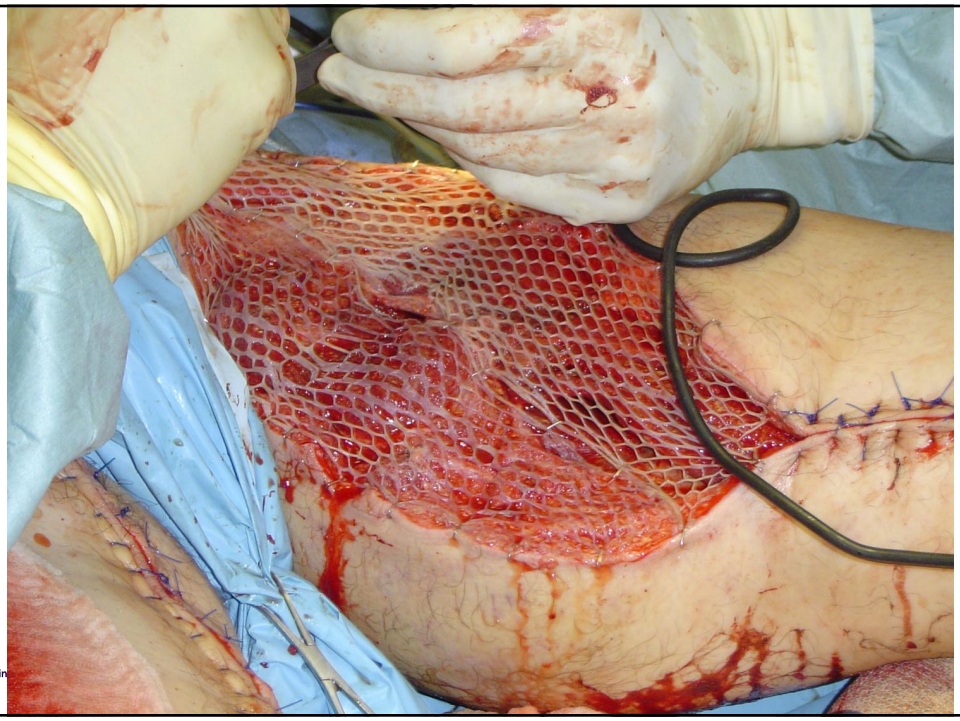

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Complications

- Wound
- DVT
- Rhabdomyolysis
- Heterotopic ossification

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Heterotopic Ossification

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Mortality

- Civilian 5 – 10%
  - Risks
    - Blood loss, polytrauma, complications
- Military 5%
  - Despite increased severity

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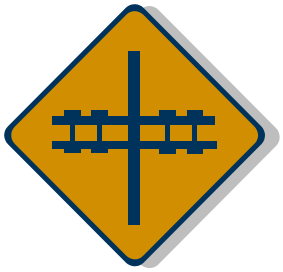
Case Study

- 73 M
- Restrained driver
- Struck by train on patient side
- Passenger dead on scene
- Taken to local hospital
  - Intubated
  - Hemorrhage control
- Transferred to Level 1



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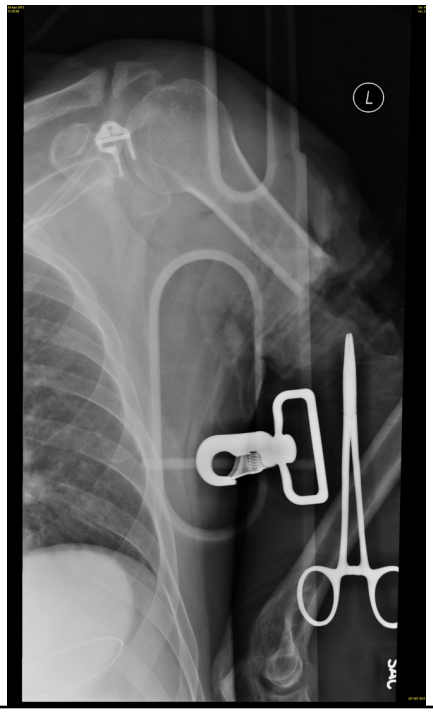

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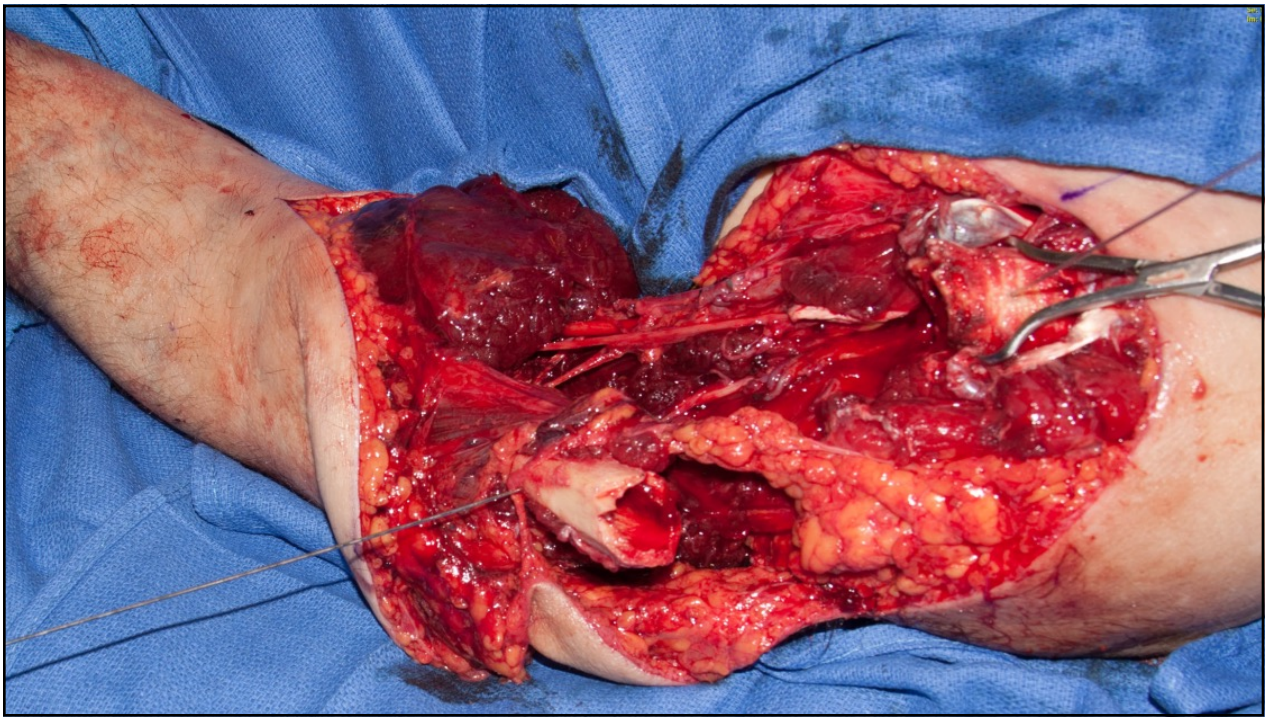

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Multidisciplinary Approach

- Orthopedic Surgery: Tad Mabry, Sanjeev Kakar, Michael Torchia
- Plastic Surgery: Brian Carlsen
- Trauma: Martin Zielinski
- Surgical Critical Care

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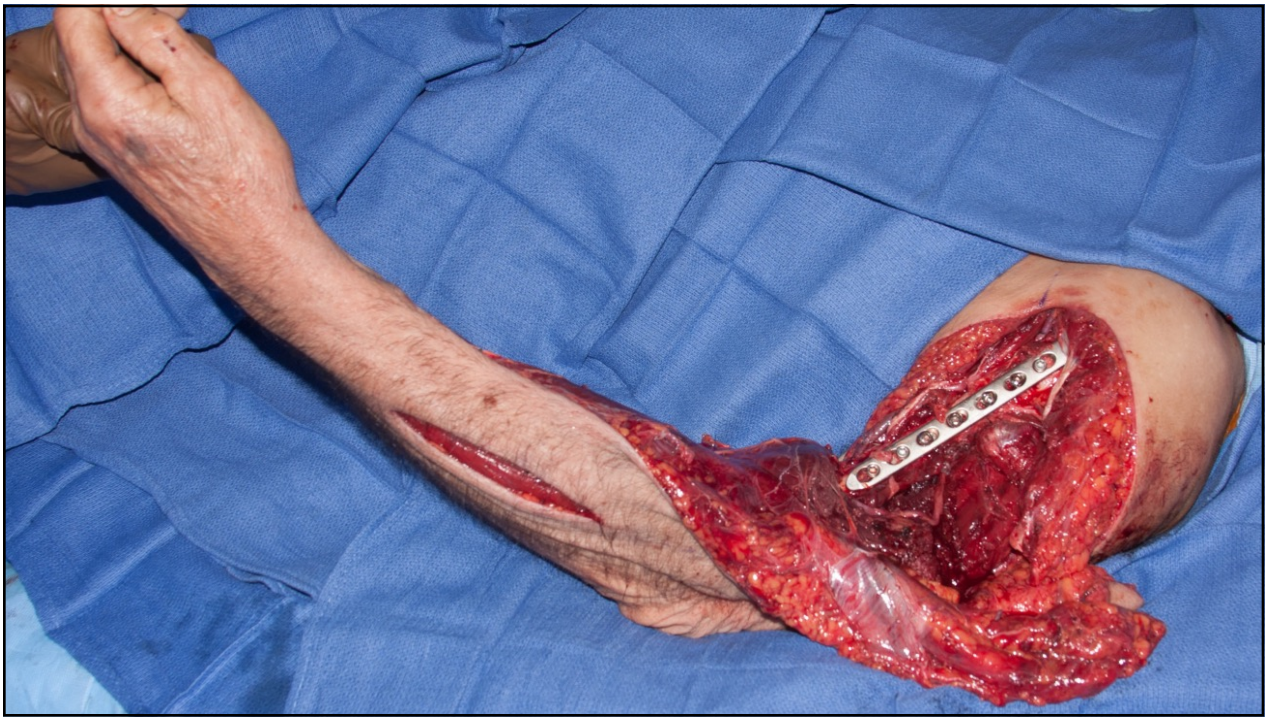

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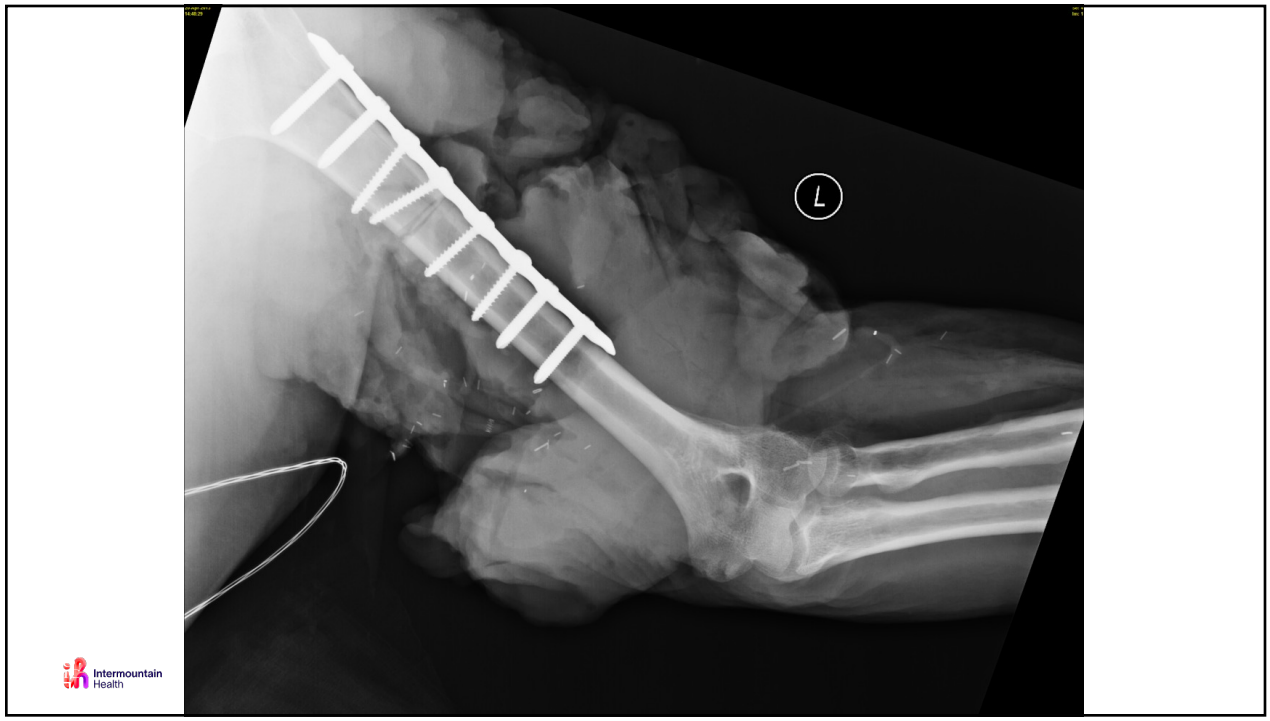

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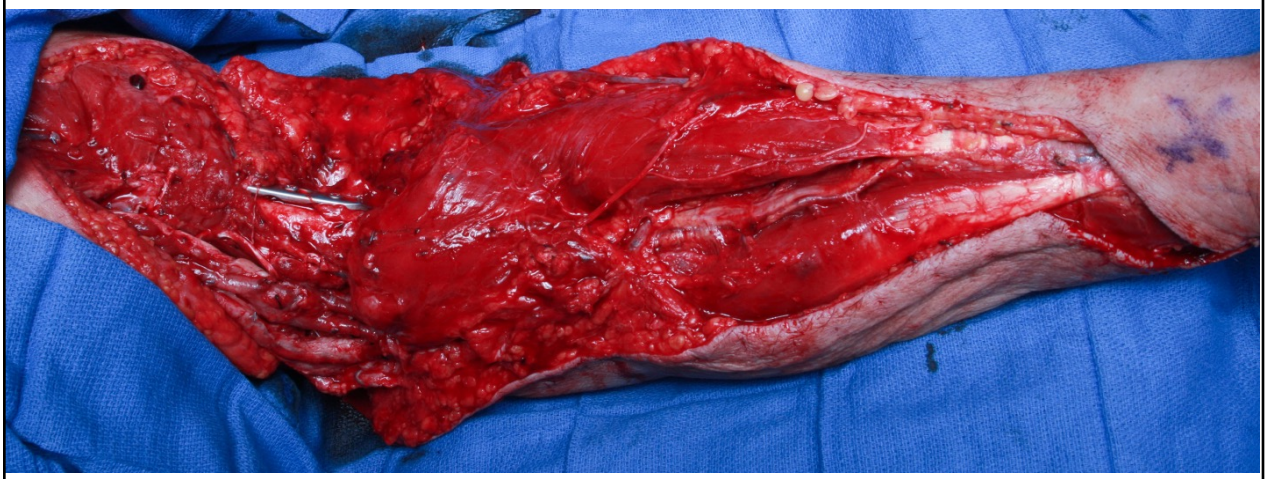

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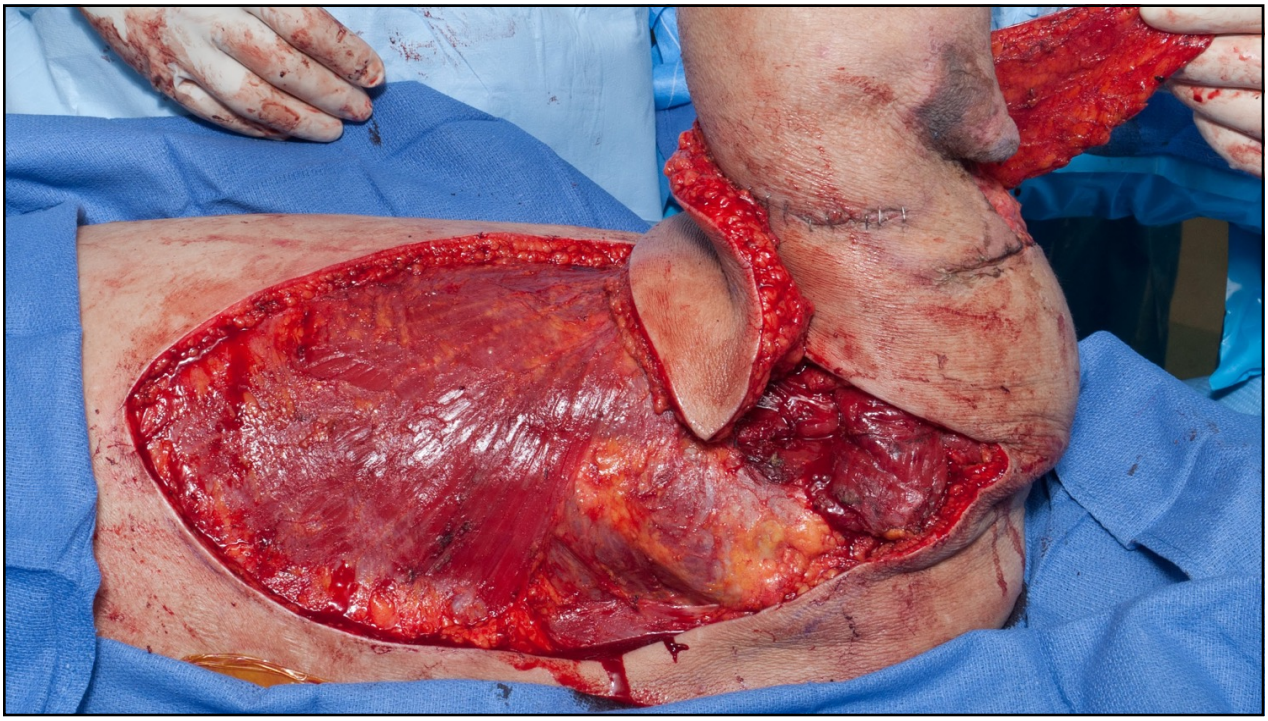

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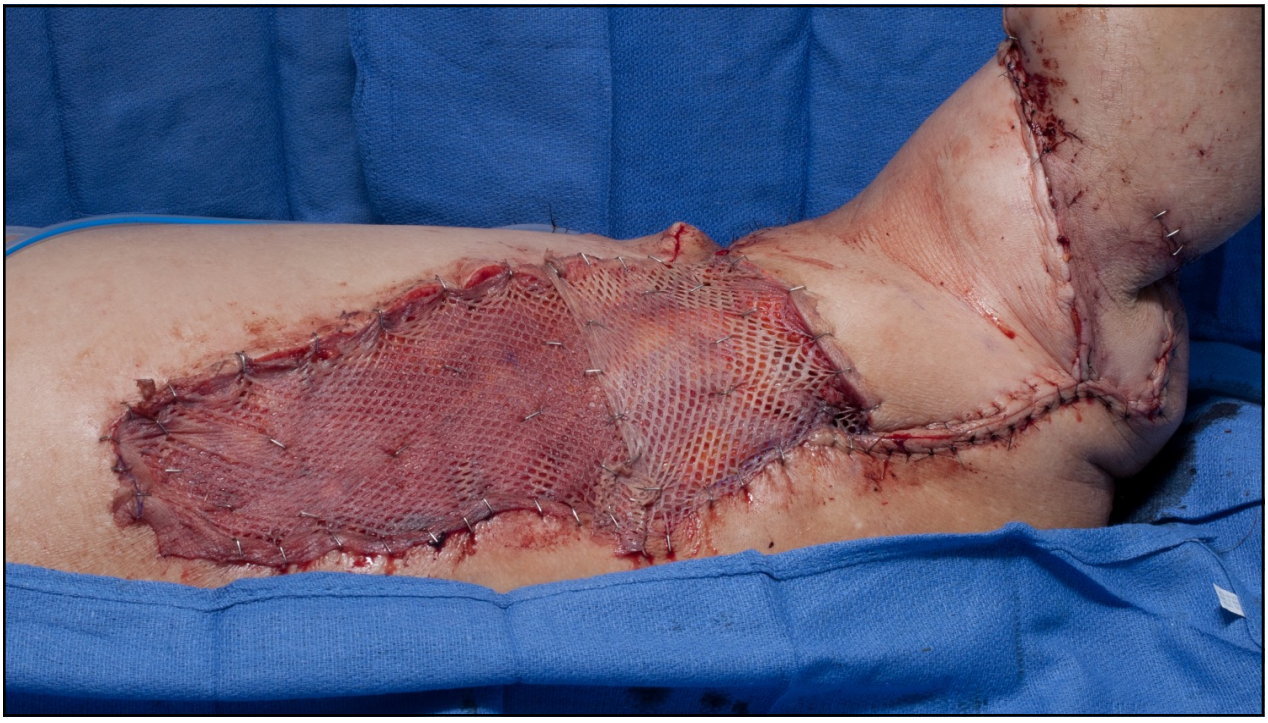

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Was It Worth It?

- Pressors 4 days
- Extubated after 6 days
- 25 L IVF
- Acute kidney injury
- Delirium
- NSTEMI day 4
- Minimal function
- Mild persistent neuropathic pain
- **Pt. is extremely happy he didn't lose his arm**

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Modern Prosthetics

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Summary – Mangled Extremities

- Difficult problem
- Critical decisions begin at scene
- Life over limb
- Salvage is possible
- Modern prosthetics are highly advanced

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Thank You!

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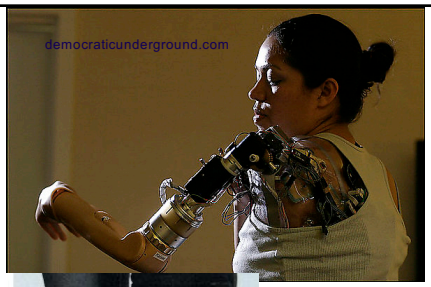

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