Acute complications of extremity trauma

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Agenda

- Pitfalls of extremity trauma
- Crush injury
- Compartment syndrome
- Open fractures

Extremity trauma - pitfalls

- Not always lower priority

- Can easily be missed
- May be quite distracting

Crush injury

- Severity
  - degree of compression
  - duration
- "Crush syndrome"
  - prolonged ischemia
  - muscle necrosis
  - release of cellular components - reperfused

Clinical presentation

- Mangled extremities
- High clinical suspicion
  - coma, intoxicated, drunk

Mangled Extremities

Clinical presentation

- Hypovolemic shock is the most common cause of death in the first 48h of crush syndrome
  - tachycardia, hypotension

Crush injury

- Third space fluid losses
  - hypovolemia and shock
- Release of potassium, calcium
  - life-threatening arrhythmia
- Release of myoglobin
  - myoglobinuria - dark ‘ ‘smoky’ ’ colored urine
  - renal failure
- Release of lactic acid
  - systemic acidosis

Crush injury - tests

- Urinalysis：OB and sediments
- CPK：30,000~100,000 U
- Myoglobin
- BUN, Cr
- K
- Compartment pressure

Crush injury - Pre-hospital

- The ABCs
- IV crystalloids
- Splinting
- Supplemental O2
  - despite normal SpO2

Crush injury - ED treatment

- Secure ABC, keep vital signs
  - avoid succinylcholine
- Volume
  - monitor CVP, urine output
- Rhabdomyolysis
  - correct hyperkalemia, acidosis
  - always sodium bicarbonate (?)
  - consider dialysis

Compartment syndrome

- Chronic
  - distance runners
  - anterolateral compartment of the leg
- Acute
  - surgical emergency
  - 70% due to fractures (esp. tibia #)

Compartment

- Compartment
  - there are over 40 compartments in the body - abdomen, thorax, eye, and cranial vault, ...
- Extremity compartment
  - an anatomic space confined by unyielding (inflexible) fascia and bone
  - containing compressible structures - muscle, nerves, and blood vessels

Mid-tibia fracture + cast

Compartment pressure

- Inadequate perfusion is assumed to occur once compartment pressure is within 20 mm Hg of diastolic blood pressure, or within 30 mm Hg of mean arterial pressure

Ischemic time

- Warm ischemia (at body temperature) for muscles & nerves
  - If < 4 hr：Reversible
  - If > 6 hr：Partially reversible
  - If > 8 hr：Irreversible necrosis, necrosis, scarring and contractures eventually result in a deformed, insensate, nonfunctional limb

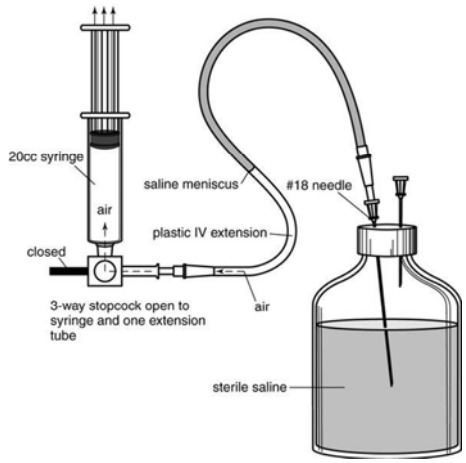
Compartment pressure

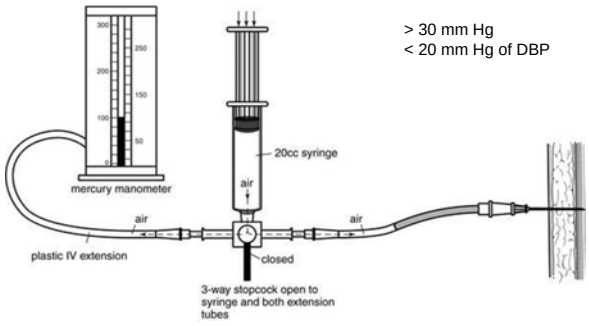
Fig. 1. (*A*) The Stryker device for measurement of intracompartmental pressure. (*B*) The Stryker device being inserted into the calf compartment under local anesthesia.

Whiteside's technique

1. a mercury manometer,
2. two plastic intravenous extension tubes,
3. two 18-gauge needles,
4. a 20-mL syringe,
5. a three-way stopcock,
6. a bottle of bacteriostatic normal saline,
7. a pair of disposable gloves and
8. a dressing set

Materials Required





> 30 mm Hg
< 20 mm Hg of DBP

As the plunger is depressed, the saline meniscus will be altered from a convex configuration to a flat configuration when the air pressure in the system equals the interstitial pressure in the patient's examined tissue

Compartment syndrome: causes

- Fracture of a long bone, including open fractures
- Compressive dressings and casts
- IV / IO fluid infiltration
- Snakebite
- Burns
- Nephrotic syndrome
- Anticoagulants, platelet inhibitors

Compartment syndrome: Detection

- The five "Ps"
  - pain - the only reliable sign
  - pallor
  - pulselessness
  - paresthesias
  - paralysis

Compartment syndrome: Pain

- Among the five "Ps" , pain is the only reliable sign
  - burning quality
  - delayed onset
  - increasing severity
  - pain on a passive stretch of the compartment (dorsiflexing the foot)

Compartment syndrome

- Signs that are not reliable
  - arterial pulse
  - tense ‘ ‘woody’ ’ feeling on palpation
  - fracture blisters
  - SpO2
  - Near-infrared spectroscopy (NIRS)
    - false positive: shock, severe anemia, hypoxia, hematoma...

How to suspect?

- Mechanisms and location
- Hemodynamic status of patient
- Look for rhabdomyolysis, myoglobinuria, renal failure, and hyperkalemia

Management

- Fasciotomy
  - Should be performed < 6 hr (warm ischemia)
- Correct renal failure and hyperkalemia
- Mannitol and HBO
- an insensate “dead” limb do not benefit from fasciotomy and experience increased complications,

Open fractures

Definition

- Etiology:
  - Penetration by gunshots, stab wounds, FB impalement
  - Penetration from within by sharp fragments of bone fractured during blunt trauma
- Any wound in the vicinity of a fracture should be considered an open fracture until proven otherwise by exploration of the wound or by radiography

Gustilo & Anderson classification

- Consider
  - Prescence of neurovascular injury
  - Degree of contamination (farmyard injuries are grade III injuries)
  - Energy transfer (degree of comminution and periosteal stripping)
  - Wound dimensions

Gustilo-Anderson Classification		
I	Low energy, wound < 1 cm (so-called puncture wounds)	
II	Wound > 1 cm with moderate soft tissue damage	
III	High energy wound > 1 cm with extensive soft tissue damage, segmental fractures, farmyard injuries / highly contaminated environment, high-velocity gunshot injuries	
	IIIA	Adequate soft tissue coverage
	IIIB	Inadequate soft tissue coverage, periosteal stripping
	IIIC	Associated with arterial injury requiring repair

Grade I

- Wound: < 1cm
- Contamination: clean puncture
- Soft Tissue: little damage/ no crush
- Fracture: simple transverse/ oblique with minimal comminution

Grade II

- Wound: > 1cm
- Contamination: moderate
- Soft Tissue: moderate
- Fracture: moderate comminution

Grade III

- Wound: extensive skin loss
- Contamination: high degree
- Soft Tissue: extensive soft tissue damage
- Fracture: highly comminuted

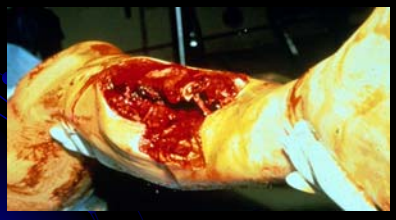
- Includes:
  - High velocity trauma
  - Gunshot injuries
  - Farmyard injuries
  - Fractures requiring vascular repair

Grade IIIa

- Grade III with
  - Sufficient tissue to allow bony cover

Grade IIIb

- Grade III with
  - Extensive soft-tissue damage with periosteal stripping and bone exposure
  - Inadequate soft tissue for bony cover



Grade IIIc

- Any open fracture with vascular injury that requires repair (for survival of the limb)

Infection & Amputation Rates

Gustilo Grade	Infection Rate	Amputation Rate
I	0 – 2%	-
II	2 – 7%	-
IIIa	7%	2.5%
IIIb	10 – 50%	5.6%
IIIc	25 – 50%	25%

Golden time

- ☑ Arterial repair
  - within **6 hr** window of warm ischemia
- ☑ Surgical debridement
  - Old: within **6 hr** - prevent subsequent osteomyelitis
  - New: within **24 hr** - antibiotics in ED

Early debridement

- ☑ Old age
- ☑ High-energy mechanisms
- ☑ Severe soft tissue injury
- ☑ Severe contamination
- ☑ Poor vascular supply
  - DM, ESRD, PAOD...

Open fractures - treatment

- ☑ Prevent tetanus
  - TT
  - TIG
- ☑ Broad spectrum antibiotics
  - 1st-G cephalosporin + AG
  - Ertapenem

Take home message

- Elevated compartment pressure
  - 〔DBP - CP〕< 20 mm Hg
  - 〔MAP - CP〕< 30 mm Hg
- Golden time to debridement of open fractures
  - Low energy, clean wound: < 24 hr
  - High energy, dirty wound: < 6 hr

The End