Acute complications of extremity trauma

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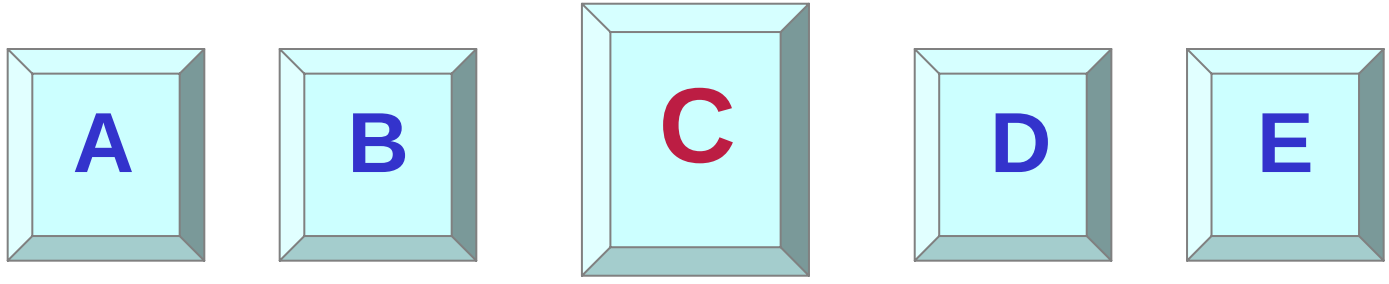
Agenda

- Pitfalls of extremity trauma
- Crush injury
- Compartment syndrome
- Penetrating arterial trauma
- Open fractures
- Amputation

Extremity trauma - pitfalls

- Not always lower priority



- Can easily be missed
- May be quite distracting

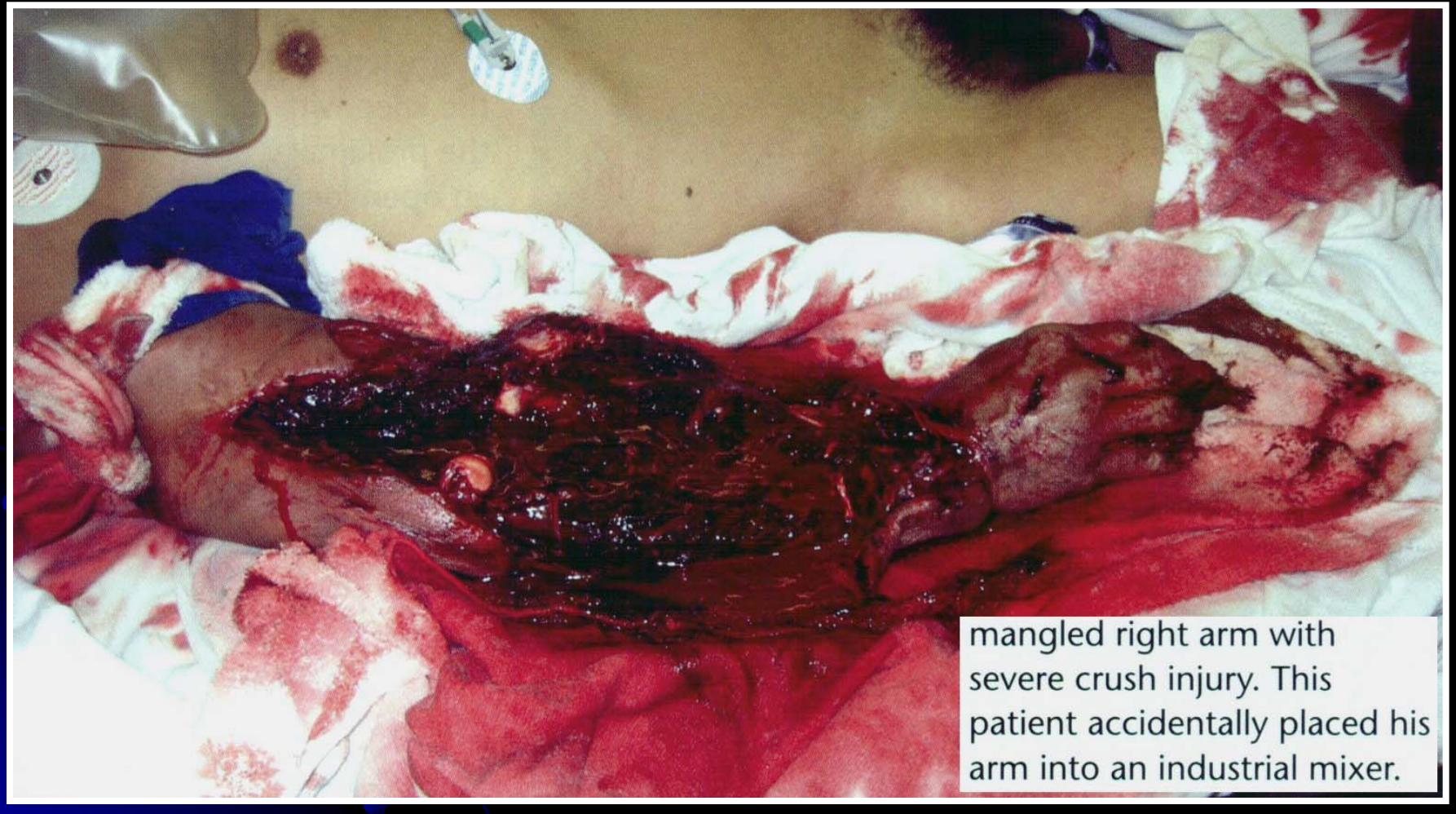
Crush injury

- 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



mangled right arm with severe crush injury. This patient accidentally placed his arm into an industrial mixer.

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

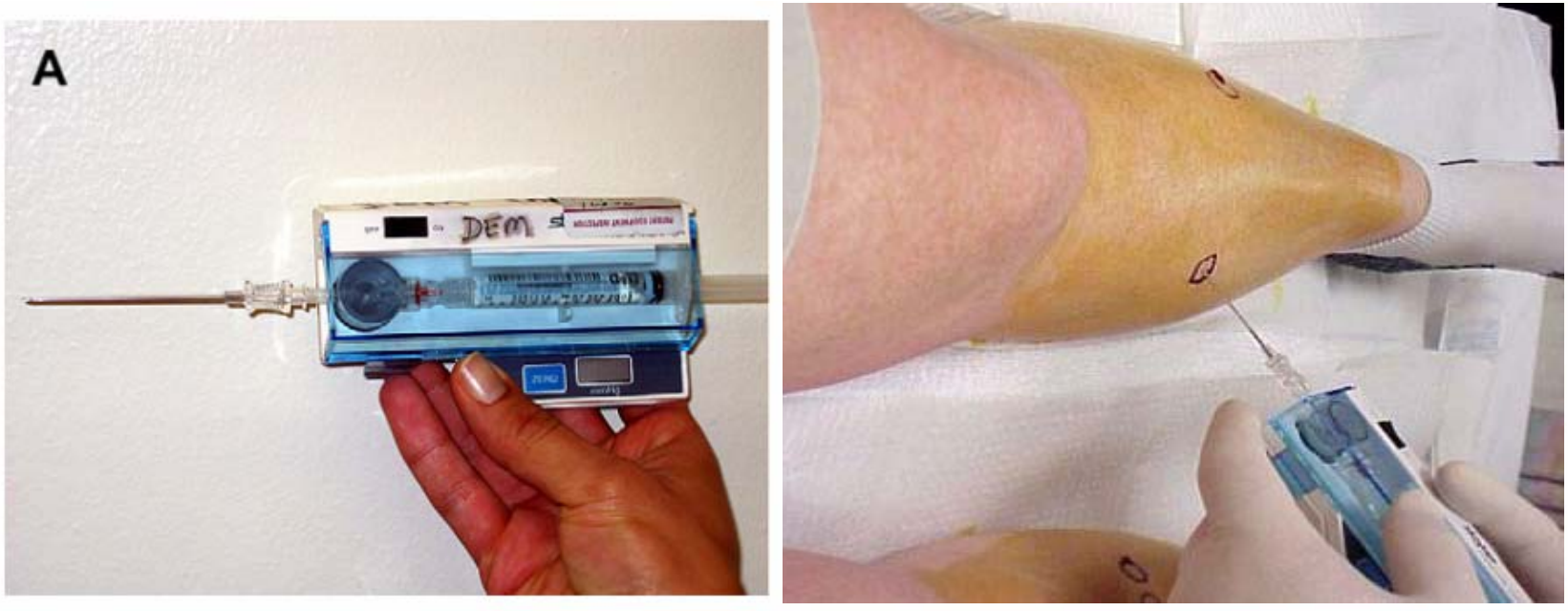
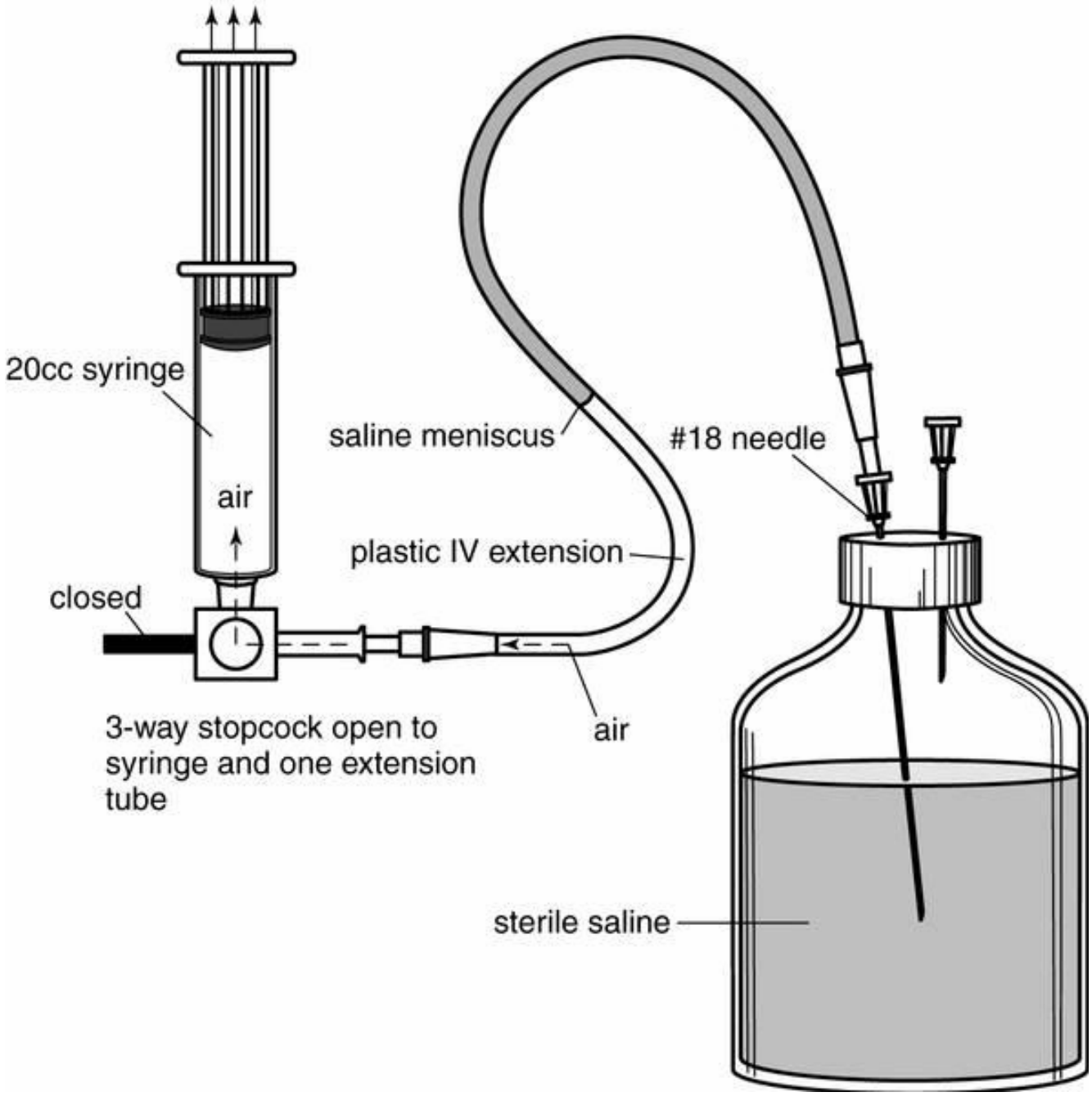


Fig. 1. (*A*) The Stryker device for measurement of intracompartmental pressure. (*B*) The Stryker device being inserted into the calf compartment under local anesthesia.

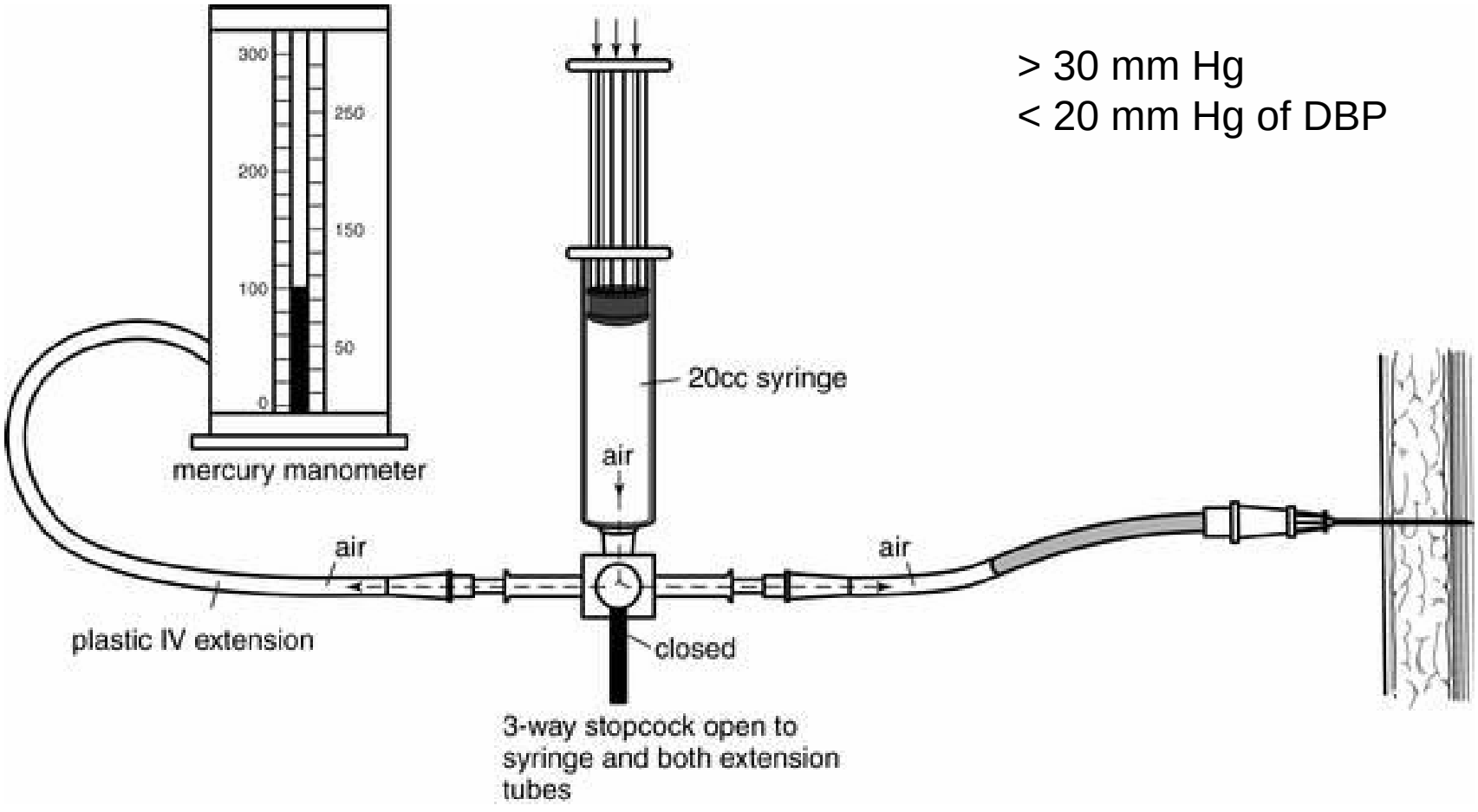
Whiteside's technique

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


20cc syringe
air
closed
saline meniscus
#18 needle
plastic IV extension
air
3-way stopcock open to syringe and one extension tube
sterile saline

> 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,

Penetrating arterial injuries

Penetrating arterial injuries

- "Hard" signs of arterial injury
  - pulsatile or rapidly enlarging hematoma
  - obvious pulsatile arterial bleeding
  - bruit or thrill on palpating the arterial pulse
  - any of the five "Ps" (pain, pallor, pulselessness, paresthesias and paralysis)
  - surgeons prefer to have a preoperative arteriogram before operating

How to detect aterial injury?

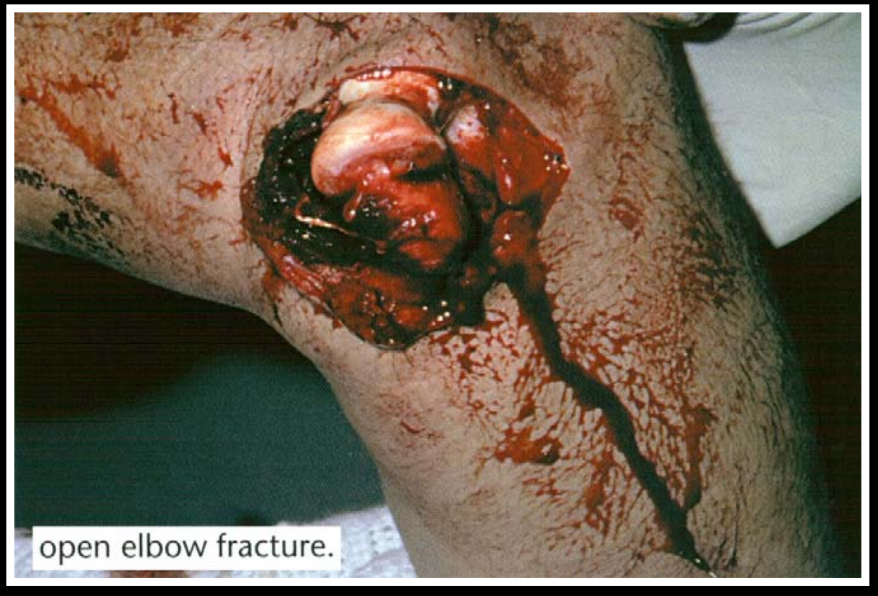
- API or ABI less than **0.9**
  - **API** (arterial pressure index): Comparison of the systolic arterial pressure in the injured limb compared with the uninjured limb
  - **ABI** (ankle brachial index): comparison of the injured limb to the uninjured arm or leg
- Duplex ultrasound is useful
- CT angiogram
- Angiography

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


open fracture of the mid tibia.


open elbow fracture.

What is Gustilo Classification
Of open fractures ?

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

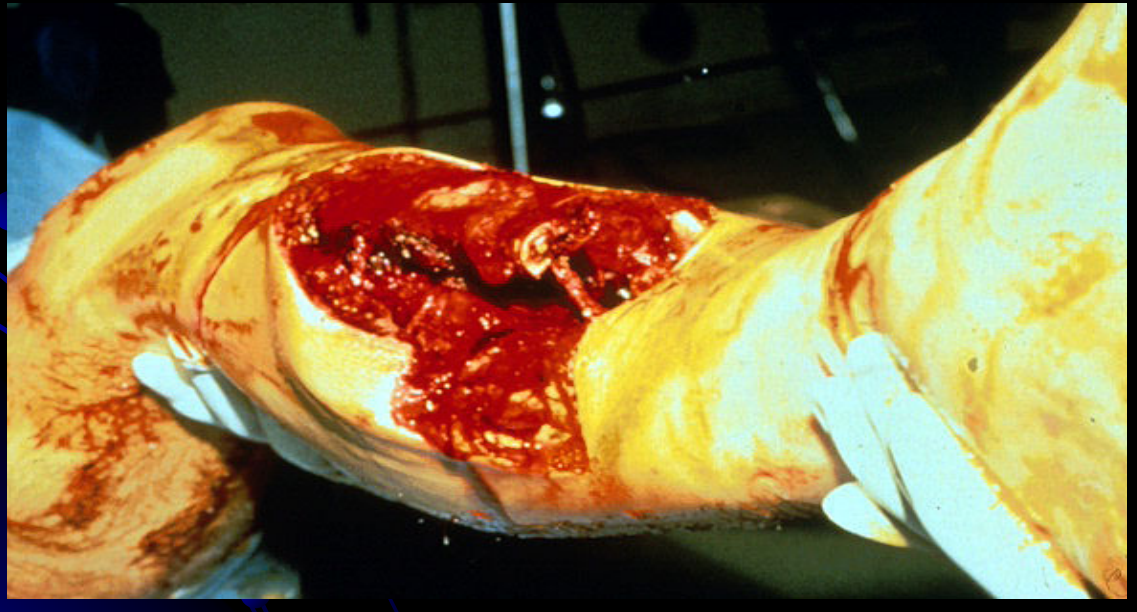
- Includes:
  - High velocity trauma
  - Gunshot injuries
  - Farmyard injuries
  - Fractures requiring vascular repair

Grade IIIa

- Grade III with
  - Sufficient tissue to allow bony cover

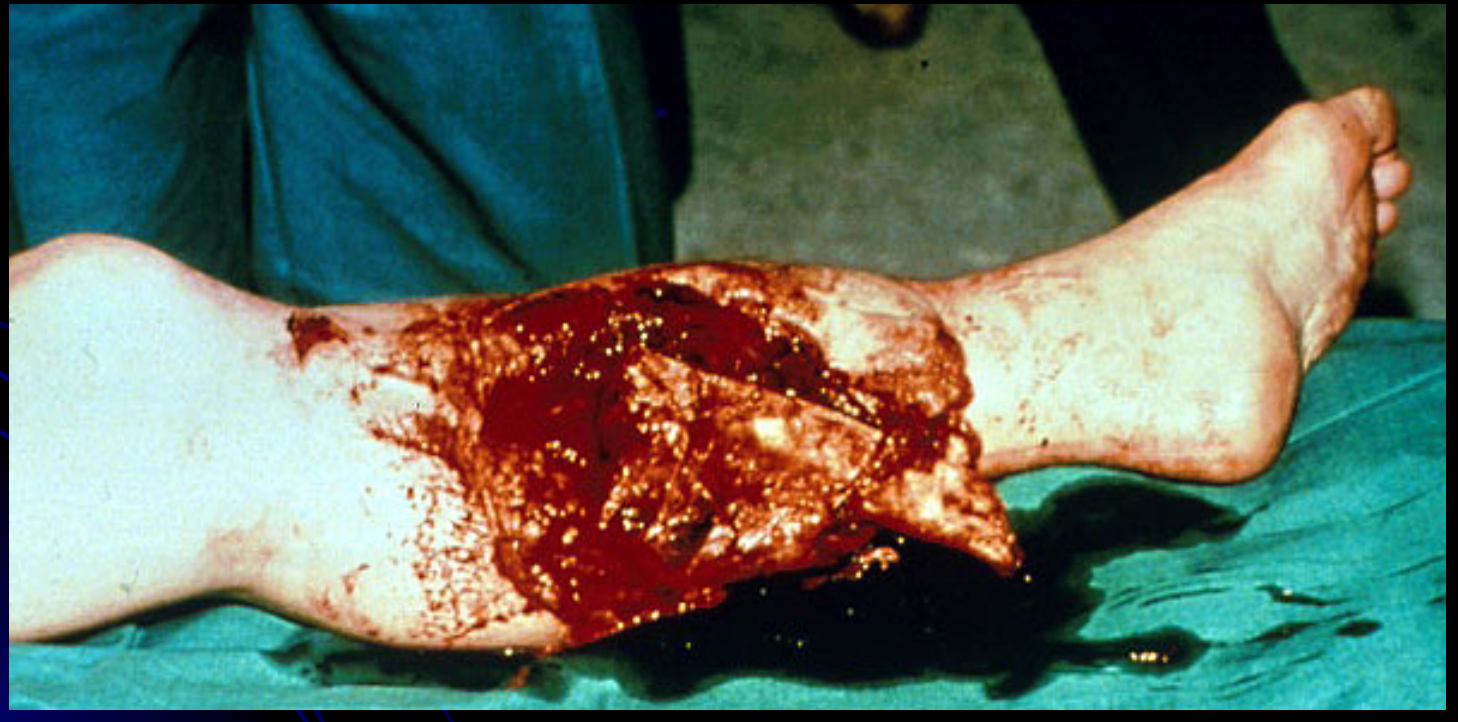
Grade IIIb

- 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

Amputation

Amputation

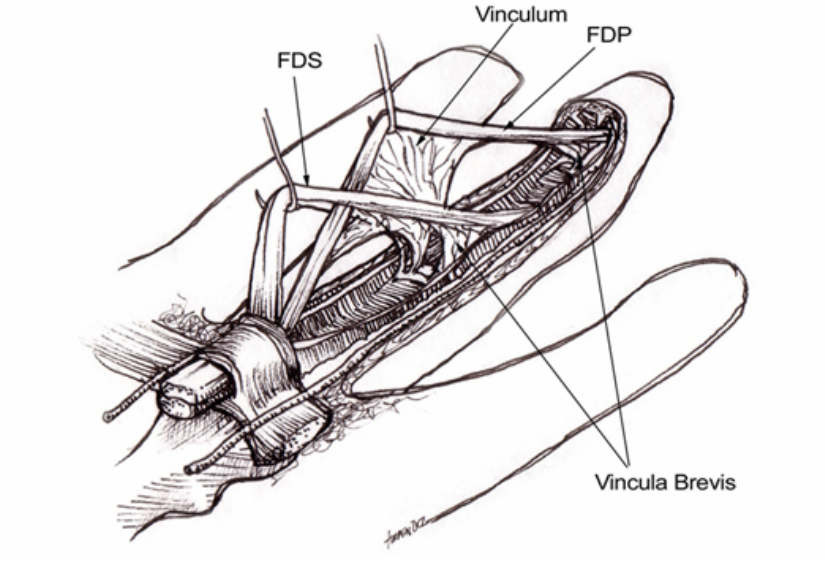
- Often a source of litigation
- Often a source of patient dissatisfaction
- Few qualified surgeons
- Few qualified centers

Amputation

- Only < 1/3 suitable for replantation
  - sharp incision wounds
  - not severely crushed
  - little or no devitalized parts

Replantation of fingers

- Digits amputated distal to the insertion of the flexor superficialis tendon
- Pediatric have much better prognosis and should be considered regardless of the level



Contraindications to replantation

- Warm ischemic time > **6 hr**
- Cold ischemic time > **12 hr**
- Crushed or avulsed parts in which multiple tendons have ruptured
- Multiple levels of amputation
- Significant vascular disease or diabetes
- Self-inflicted amputations
- Hemodynamically unstable

Amputation - ED management

- Visually striking, distract attention
- Serious bleeding seldom occur
  - direct compression of the bleeding vessel rather than clamping
  - tourniquet rarely necessary, kept on less than 3 hours if used

Amputation - ED management

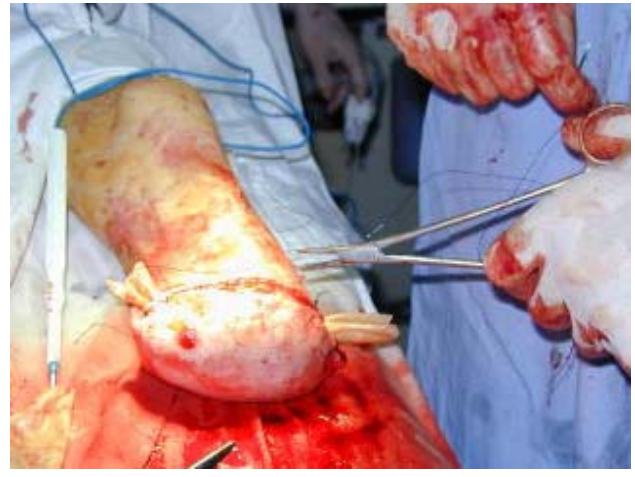
- Severed part wrapped in a sterile saline-soaked gauze and placed in a thin plastic bag that is then placed in a container of ice
- Ideal temperature = 4°C, avoid freezing
- Prophylactic antibiotics

Amputation - ED management

- Also preserve unsuitable part - a potential source of skin and bone for stump revision
- Partial amputation
  - cooling is controversial
  - avoid cooling if there is evidence of perfusion

Amputation - prognosis

- Replanted limbs and digits
  - psychologically desirable
  - limited function
- Replanted parts
  - sensory deficits
  - limited range of motion and strength
  - prolonged rehabilitation
- Consider functional prosthesis
  - completion of the amputation
  - revision of the stump



Take home message

- Elevated compartment pressure
  - 〔DBP - CP〕< 20 mm Hg
  - 〔MAP - CP〕< 30 mm Hg
- Replantation of amputee
  - Warm ischemic time: < 6hr
  - Cold ischemic time: <12 hr
- Golden time to debridement of open fractures
  - Low energy, clean wound: < 24 hr
  - High energy, dirty wound: < 6 hr

The End