
In The Name Of God

Dr.R.jokar. MD- orthopaedics surgeon
Knee and sport surgery fellow

دکتر رحمت الله جوکار

- متخصص ارتوپدی و فلوشیپ زانو
- استادیار دانشگاه علوم پزشکی بابل

Definition

These are the fractures in which there is breach in the soft tissue envelope over or near the fracture, such that fracture haematoma communicates with external environment.

WHO facts 2020

- WHO predicts that by the year 2020, the causes of death and loss of health from disability in a row:
- 1. Ischemic heart disease
- 2. Stroke
- 3. Road traffic injuries.

Mechanism of injury

- Open fractures occur as a result of direct high energy trauma either from Road traffic collisions or falls from height.
- These fractures can also occur indirectly, such as a high-energy twisting type of injury.

Epidemiology

- Diaphyseal fractures are more common than metaphyseal fractures.
- Highest rate of diaphyseal fractures are seen in tibia (21.6%) followed by femur(12.1%), radius and ulna(9.3%), and humerus(5.7%)

Location	Total fractures	Open fractures	% open fractures
Upper limb	15,406	503	3.3
Lower limb	13,096	488	3.7
Shoulder girdle	1,448	3	0.2
Pelvis	942	6	0.6
Spine	683	0	0.0
Total	31,575	1,000	3.17

Components of open fracture

- Fracture
- Soft-tissue damage
- Neurovascular compromise
- Contamination.

Fracture Healing may be affected :

*Escape of Haematoma
*Impaired vascularity of soft tissues
*Bone necrosis
*Loss of Bone
*Infection

Infection Has been a very important complication in Open Fractures

- Poor tissue oxygenation and devitalization of the surrounding tissues including the bone provide a perfect medium for infection and bacterial multiplication.

- When left open >2weeks – prone to nosocomial infection such as pseudomonas species and gram negative bacteria.

- This phenomenon of hospital acquired infection emphasizes the importance of a strict protocol for in-hospital management and early wound coverage.

TO ACCURATELY DESCRIBE SIMILAR INJURIES IN ORDER TO PROVIDE A BASIS FOR TREATMENT, TO ESTIMATE PROGNOSIS.

OPEN FRACTURES – GRADING AND CLASSIFICATION

Gustilo and Anderson

Type	Description
I	Skin wound less than 1 cm
	Clean
	Simple fracture pattern
II	Skin wound more than 1 cm
	Soft-tissue damage not extensive
	No flaps or avulsions
	Simple fracture pattern
III	High-energy injury involving extensive soft-tissue damage
	Or multifragmentary fracture, segmental fractures, or bone loss irrespective of the size of skin wound
	Or severe crush injuries
	Or vascular injury requiring repair
	Or severe contamination including farmyard injuries

Gustilo and Anderson

Type	Description
IIIA	Adequate soft-tissue cover of bone despite extensive soft-tissue damage
IIIB	Extensive soft-tissue injury with periosteal stripping and bone exposure
	Major wound contamination
IIIC	Open fracture with arterial injury requiring repair

Type I

Wound size :

small <1cm, clean puncture, a bone spike has protruded

Soft tissue damage:

little, no crushing

Fracture:

not comminuted

Energy of trauma:

low-energy

Type II

Wound size :

more than 1 cm, no skin flap

Soft tissue damage:

Moderate crushing

Fracture:

moderate comminution

Energy of trauma:

low-energy

Type IIIA

Wound size :

Large wound usu> 10cm

Soft tissue damage:

Extensive, contaminated

Fractured bone can be adequately covered by soft tissue

Fracture:

comminuted

Energy of trauma:

high-energy

Type IIIB

Wound size :

Large wound, fracture bone can't be covered by soft tissue (vs Type IIIA)

Soft tissue damage:

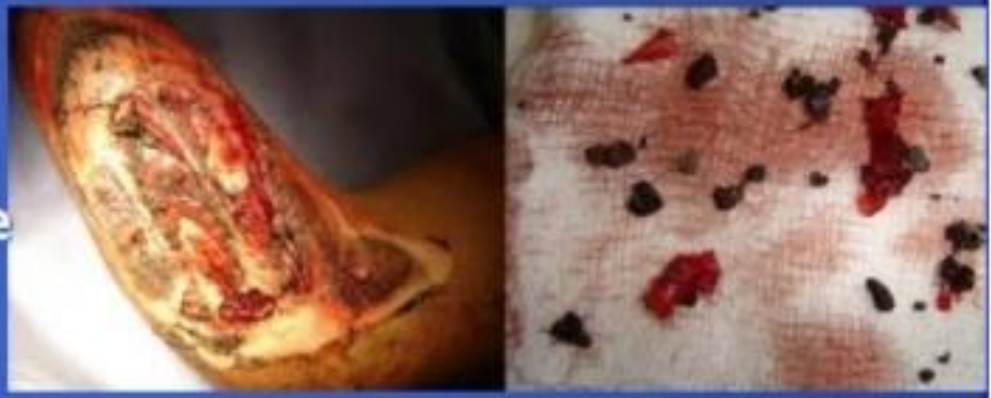
periosteal stripping (intra-op)

Fracture:

Severely comminuted

Energy of trauma:

high-energy



Type IIIC

Wound size :

Large, not adequate coverage of the bone

Soft tissue damage:

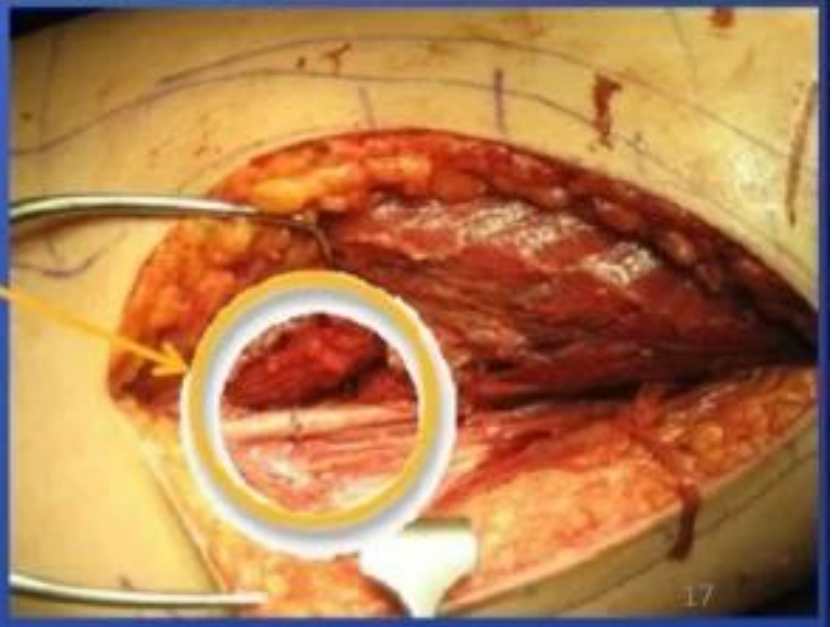
Vascular injury, needs to be repaired

Fracture:

Severely comminuted

Energy of trauma:

high-energy



Goal Of Open fractureTreatment

- Prevent sepsis.
- Heal the fracture.
- Restore function of extremity.

THE TREATMENT OF HIGH ENERGY INJURIES AIM TO PRESERVE LIFE, LIMB AND FUNCTION.

OPEN FRACTURES - MANAGEMENT

Principle of treatment

1. Treat an open fracture as an emergency.
2. Conduct a throughout initial evaluation to diagnose other life threatening injuries.
3. Institute appropriate and adequate antibiotic therapy.
4. Adequately debride and irrigate the wound.
5. Performed delayed closure of the wound within 3 to 7 days.
6. Stabilize the fracture.

7. When indicated, perform cancellous bone grafting early (1 to 6 weeks)
8. Decide on early amputation.
9. Treat compartment syndrome.
10. Rehabilitate the involved extremity.

Decide on early amputation

a) type IIIC injury with posterior tibial nerve loss.

b) Massive soft tissue injury with poor functional results likely.

c) Combined soft-tissue and bone loss, implying prolong hospitalization, when below-knee amputation can be performed.

d) Relative indication: type IIIC injury over 8 hours old.

DCO – A CURRENT CONCEPT

STOP ONGOING DAMAGE

RELEASE COMPARTMENTS
REDUCE DISLOCATIONS
DEBRIDE OPEN WOUNDS
STABILIZE LONG BONES/ PELVIS

STABILIZE LONG BONES

INITIAL EARLY EXTERNAL FIXATION

STABILIZE PHYSIOLOGY

CONTROL HAEMORRHAGE
FLUID RESUSCITATION
CXR – ICD IF NECESSARY
LATERAL CERVICAL SPINE X RAY
X RAY PELVIS AP
FAST/ DPL

RE EVALUATE
MONITOR
BP, URINE OUTPUT
ABG
REPEAT FAST
IL-6

DEFINITIVE STABILIZATION

STAGED INTRAMEDULLARY FIXATION
MINIMAL INVASIVE PLATE OSTEOSYNTHESIS

Stages of care

1	Initial assessment	ABC's (according to ATLS: airways, breathing, circulation)
		Emergency room management
		Wound dressing and fracture splinting
2	Primary operations	Staged wound debridement
		Fracture stabilization
3	Secondary operations	Skin and soft-tissue reconstruction
		Bone reconstruction
4	Rehabilitation	

Initial assessment

- Important components in assessing traumatized extremity are

1. History and mechanism of injury
2. Neurovascular status
3. Size of skin wound
4. Muscle crush or loss
5. Periosteal stripping or bone loss
6. Fracture pattern, fragmentation
7. Contamination
8. Compartment syndrome.

I. Wound debridement

Irrigation

- Supplements systemic debridement by removing foreign material and decreasing bacterial load.
- Simpulse irrigation system (HPPL-high pressure pulsatile lavage).
- Pressure must be less than 50psi units.

Fracture type	Vol of fluid used for irrigation
Type I	3 L
Type 2	6L
Type 3	9L

Irrigation

- NS normally used for irrigation.
- Antibiotic solution has no advantage than soap for irrigation.
- Surfactant(non sterile soap) same effectiveness, less tissue damage and more economical.

Debridement & Irrigation

- Gustilo et al 1984.
- Adequate debridement is the single most important factor in the attainment of a good result in the treatment of an open fracture
- Systemic debridement
  - **Removal of gross contamination and debris**
  - **From superfical to deep structures**
  - **All necrotic tissue should be excised**
- Use of tourniquet shoud be minimized
- Wound extension for full evaluation of soft tissue injury

Systemic debridement

*SKIN margins excised sparingly

- Muscle viability is determined by the four C's:
  - contractility
  - color
  - Consistency
  - capacity to bleed.
- Evaluation of the bone: Periosteum& any completely free cortical fragments
- When it is difficult to fully determine the viability of all tissues at the time of initial debridement, repeated debridements at 24-48 hour intervals can be employed to eliminate devitalized tissue

"The greatest of all antiseptics is living tissue"

- Sir Alexander Fleming.

Damaged tissue should be excised cleanly with curved scissors.

Excision must be ruthlessly pursued until only viable, bleeding muscle remains.

Timing of debridement and irrigation

- Most guidelines recommend debridement within 6 hrs. If clean, Primary closure.
- Serial debridement may be necessary every 24-48hrs if debridement is delayed until the wound viability is ensured.
- If clean, within 3-4 days delayed Pr. Closure.
- Later Secondary closure (Flaps) or healing by Secondary intentions (scarring).

II.Antiobiotic

Antiobiotics& Infection

- 24-70% of open fractures are contaminated with bacteria
- 14-15% of open fracture complicated with infections in the absence of antitiotic prophylaxis
- Is Wound culture pre-debridement and post-debridement useful?
- Answer is NO!

Antibiotics

- Systemic administration:

Open fractures: Gustilo: type I and II AO: IO 1 and 2	24 hours: first or second-generation cephalosporin
Open fractures: Gustilo: type IIIA–C AO: IO 3–5	5 days amoxicillin/clavulanic acid or ampicillin sulbactam
	or 5 days third-generation cephalosporin
Potential faecal contamination (eg, farmyard injury or open pelvic fracture)	Piperacillin/tazobactam or a carbapenem
	or third-generation cephalo-sporin plus metronidazole

Antibiotics

- Local antibiotics:-In gustilo type III fractures additional use of local aminoglycoside impregnated polymethylmethacrylate(PMMA) beads reduces overall infection rate.

Antibiotic bead pouch technique

Tetanus prophylaxis

- Tetanus Toxoid(TT), dose is 0.5ml i.m. regardless of age.

- Immunoglobulin:-

  75IU <5yrs of age

  125IU 5-10yrs

  250IU >10yrs.

Stabilization of fracture

Stabilization of the fracture

NON-OPERATIVE

- Splintage
- POP slab for temporarily fixation of fracture
  - Goal:
  - Pain relief
  - Facilitate nursing care

Primary surgery

Timing :

- Surgical emergency
- Operating within 6-8hrs of injury – contaminated wounds not treated within this time will have sustained bacterial multiplication to result in early infection.

Primary surgery

Fracture stabilization:

- As soon as primary wound care is completed, treatment should proceed to fracture reduction and fixation.
- Surgeon should rescrub and regown.
- Different set of instruments than those used for debridement is necessary.

Fixation Options ??

External Fixation Vs Internal Fixation

Relative Indications for External Fixation in Open Fractures

1) Severe contamination any site,

2) Periarticular fractures
   - Definitive
     - Distal radius
     - Elbow dislocation
   - Relative
     - Knee
     - Ankle
     - Elbow
     - Wrist
     - Pelvis

External fixation

- Advantages of Ext Fixation:-
- Can be applied relatively easily and quickly,
- It provides relatively stable fracture fixation,
- There is no further damage done if applied correctly,
- It avoids implantation of hardware in open wound.

Ext Fixator

- **Disadvantages:**
- Major problems with external fixation are related to pin tract infection, malalignent , delayed union, poor patients compliance.

- Tubular fixactors may not be the choice of fixation but Ring fixators may be an option in open diaphyseal fractures.

Relative Indications for Internal Fixation in Open Fractures

1) Periarticular fractures
   - Distal/proximal tibia
   - Distal/proximal femur
   - Distal/proximal humerus
   - Proximal ulnar radius
   - Selected distal radius/ulna
   - Acetabulum/pelvis

2) Diaphyseal fractures
   - Femur
   - Tibia
   - Humerus
   - Radius/ulna

Plates

- Open diaphyseal fractures of the radius and ulna as well as the humerus are best managed with plate fixation.

- The plate fixation of lower extremity diaphyseal fractures is generally not recommended due to higher rate of infections.

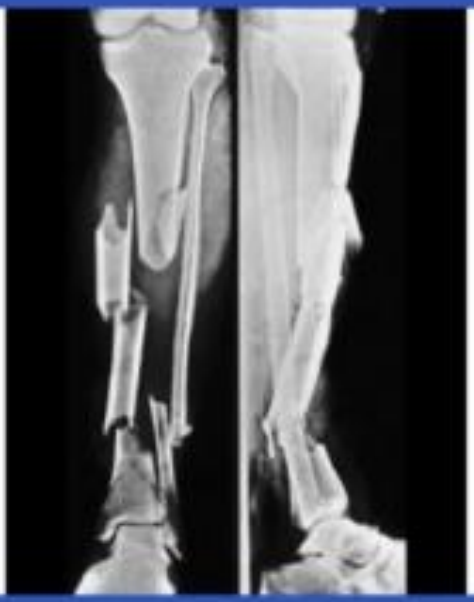
Intramedullary nailing

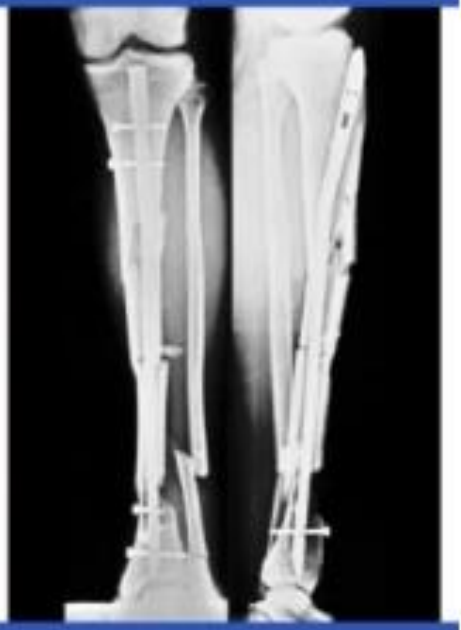
- Locked intramedullary nailing has been established as the treatment of choice for most diaphyseal fractures in lower extremity.

- The technique has particular value for open fractures as Intramedullary nails can be inserted with no further disruption of the already injured soft-tissue envelope and preserves the remaining extra osseous blood supply to cortical bone.

IM nailing

- Data showing that solid intramedullary nails inserted without reaming have a lower risk of infection.
- On the other hand reamed intramedullary nails can reliably maintain fracture reduction with regards to angulation, rotation, displacement, and length.
- Prospective randomised trails that compared reamed with unreamed interlocked IM nails did not show any significant difference concerning outcome and risk of complication.





Early wound cover surgery

Primary Closure

If it is to be done, the following criteria must be met:-

1. The original wound must have been fairly clean, and not have occurred in a highly contaminated environment.
2. All necrotic tissue and foreign material have been debrided.
3. Circulation to the limb is essentially normal.
4. Nerve supply to the limb is intact.
5. The patient's general condition is satisfactory and allows careful postoperative assessment.
6. The wound can be closed without tension.
7. Closure will not create a dead space.
8. The patient does not have multisystem injuries.

Delayed primary closure

- Closure before the 5th day is termed delayed primary closure.
- As long as closure is achieved before the fifth day, wound strengths at 14 days are comparable with those in wounds closed on the first day.
- Leaving the wound open minimizes the risk of anaerobic infection, and the delay allows the host to mount local wound defensive mechanisms that permit safer closure than is possible on the first day.

- Current standard of care for all open fracture wounds is to be left open initially.
- Delayed closure is accomplished within 2-7days
- VAC assisted wound closure is presently recommended for temporary management of open fracture wounds.

VAC

- The wound bed is exposed to mechanically induced negative pressure in a closed system .
- The system removes fluid from extravascular space, reduces edema, improves micro circulation and enhances the proliferation of preparative granulation tissue.
- Polyurethane foam dressing is placed in wound and ensures an even distribution of negative pressure.

VAC

WHY OPEN FRACTURES CAN BE DANGEROUS

OPEN FRACTURES:-

COMPLICATIONS

Complications

- Hypovolemic shock
- Compartment syndrome
- Fat embolism
- ARDS
- Neurovascular injuries
- Infection

Hypovolemic shock - management

- Two large-bore IV lines should be started.
- Once IV access is obtained, initial fluid resuscitation is performed with an isotonic crystalloid, such as Ringer lactate solution or normal saline.
- An initial bolus of 1-2 L is given in an adult (20 mL/kg in a pediatric patient), and the patient's response is assessed.

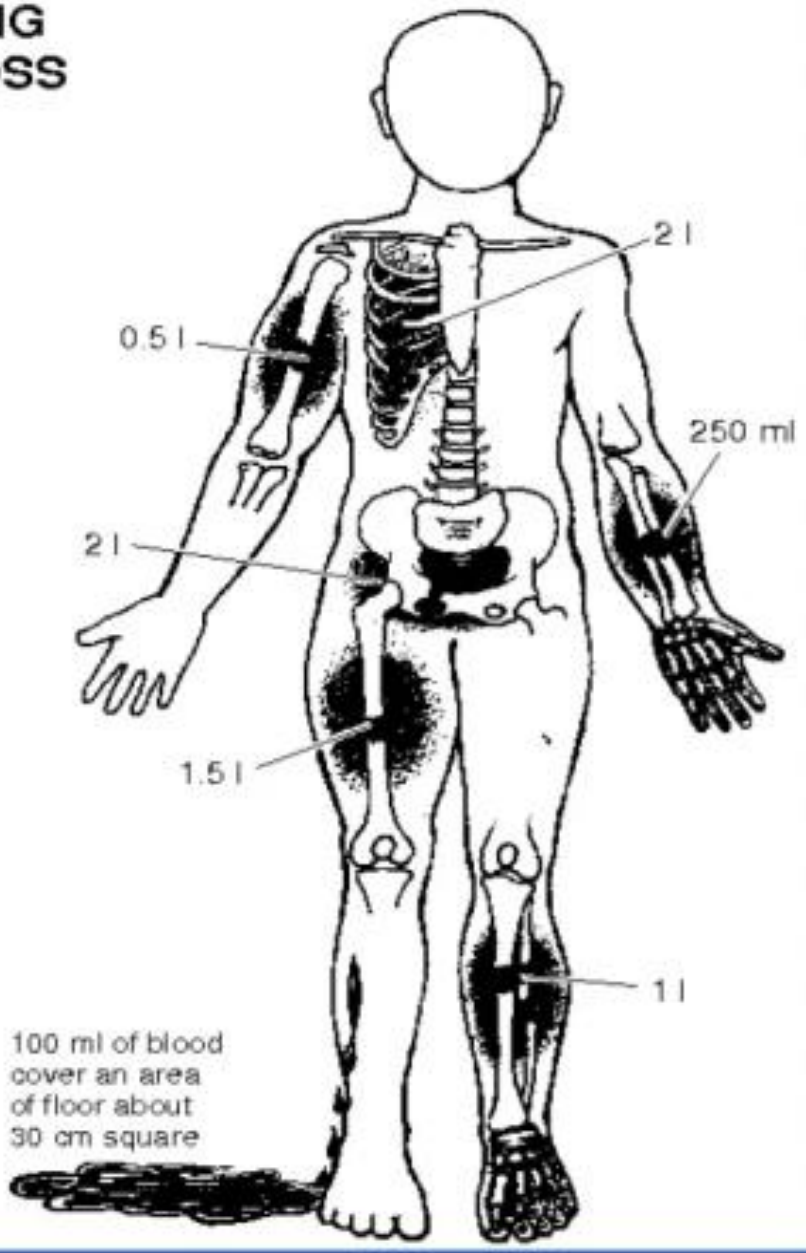
Hypovolemic shock

- Type of fluid:-
- Colloid – albumin, dextran, plasma.
- Crystalloid – NS, D5, RL.
- Blood – uncrossed 'O' –ve.

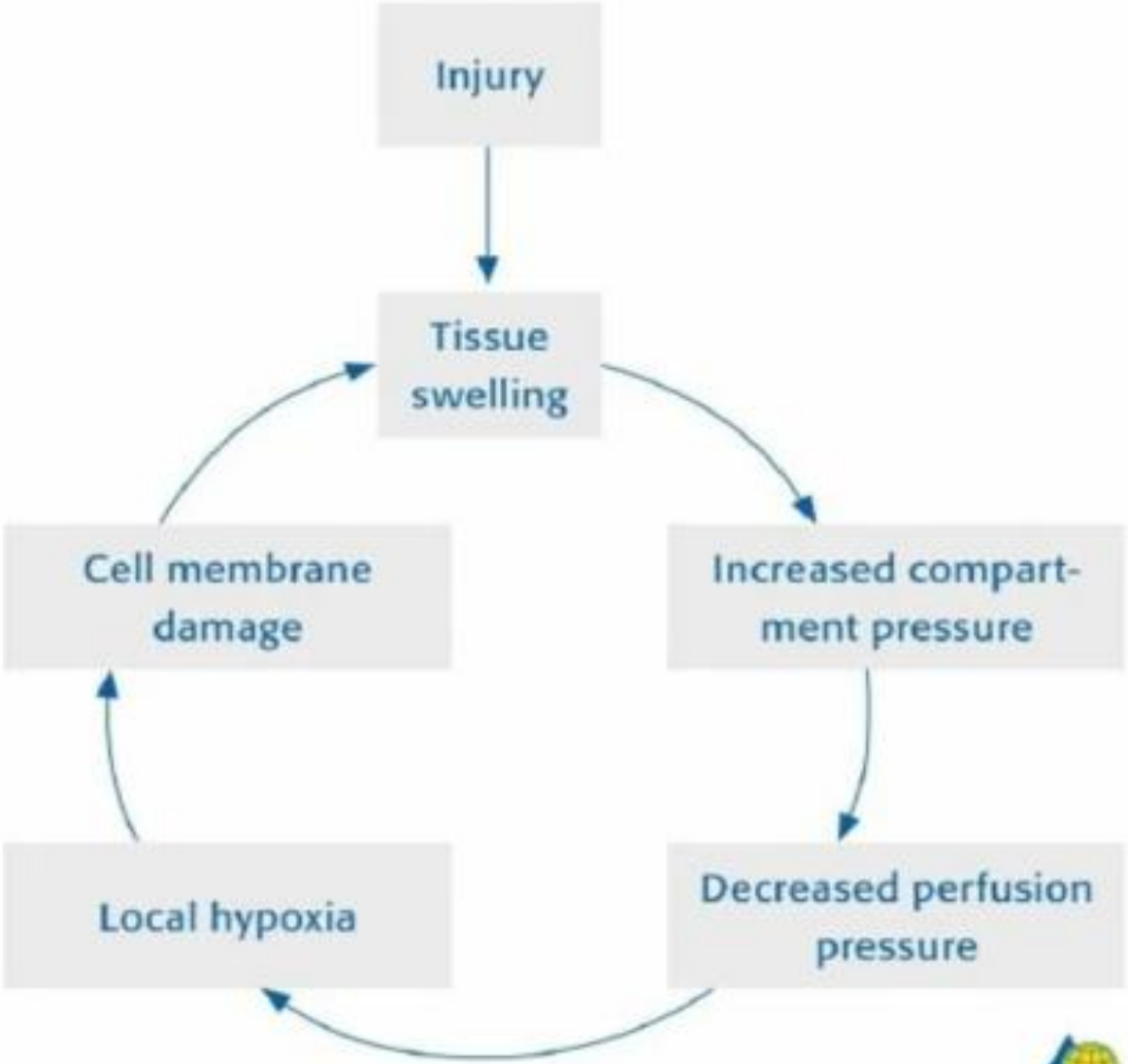
- Basic Rule:-
- 3:1 rule when using crystalloids.Eg. If blood loss is 100cc the patient should receive 300cc of normal saline or Ringer lactate.
- 1:1 rule for colloids.

ESTIMATING BLOOD LOSS

the volume of your fist is about 500 ml



Compartment syndrome



Compartment syndrome

- Classically 5 "Ps" associated with compartment syndrome:—
  1) Pain out of proportion to what is expected
  2) Paresthesia
  3) Pallor
  4) Paralysis
  5) Palpable pulse absent.

Compartment syndrome

- Treatment - Fasciotomy

Fat embolism

- Definition - Occlusion of small vessels by fat globules.
- Types:-

  1. cerebral – drowsy, restless and disoriented.

  2.pulmonary – tachypnea, tachycardia, petechial rash(in front of neck, ant axillary fold, chest and conjunctiva)

Fat embolism

- Diagnosis:–
- signs of retinal artery emboli(striate hemorrhages and exudate) may be present.
- Sputum and urine may reveal presence of fat globules.
- X-ray of chest shows patchy pulmonary infarcts.

Fat embolism

- Treatment:-
- Respiratory support
- Heparinization
- Intravenous low-molecular weight dextran and corticosteriods.

ARDS

- Is caused by release of inflammatory mediators which cause disruption of pulmonary vasculature.
- Signs and symptoms– Tachypnea, low BP, Cyanosis.
- Treatment – 100% oxygen inhalation.

Vascular injury

- Absent peripheral pulses in an injured limb should be considered to be due to vascular damage unless proved otherwise.
- Classical signs of arterial injury:-

  (a) absent pulses

  (b) active hemorrhage

  (c) expanding hematoma, and

  (d) bruit or thrill.

Vascular injury

- Investigations:-

  Colour doppler study

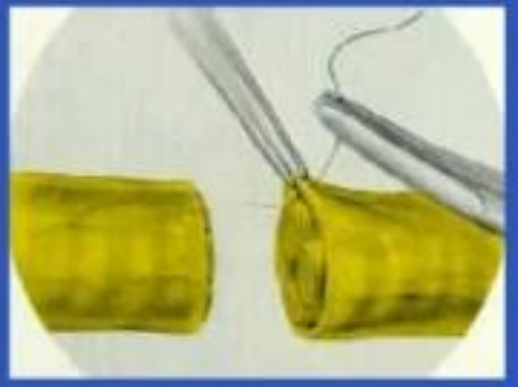
  Arteriography.
- Treatment:-

  Arterial reconstruction

  Bypass grafts.
- Timing:- loss of total blood supply to the limb for > 8 hours nearly always results in amputation.

Nerve injury

- Nerve repair should be done within **3 weeks** of injury for better results



Take Home Messages

Success of open fracture management depends on strict adherence to principles of good surgical debridement, antibiotic therapy, fracture stabilization, early soft tissue reconstruction and timely bone grafting.


Thank you for your
concentration and
patience hearing..