COMPOUND FRACTURES AND ITS MANAGEMENT

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INTRODUCTION

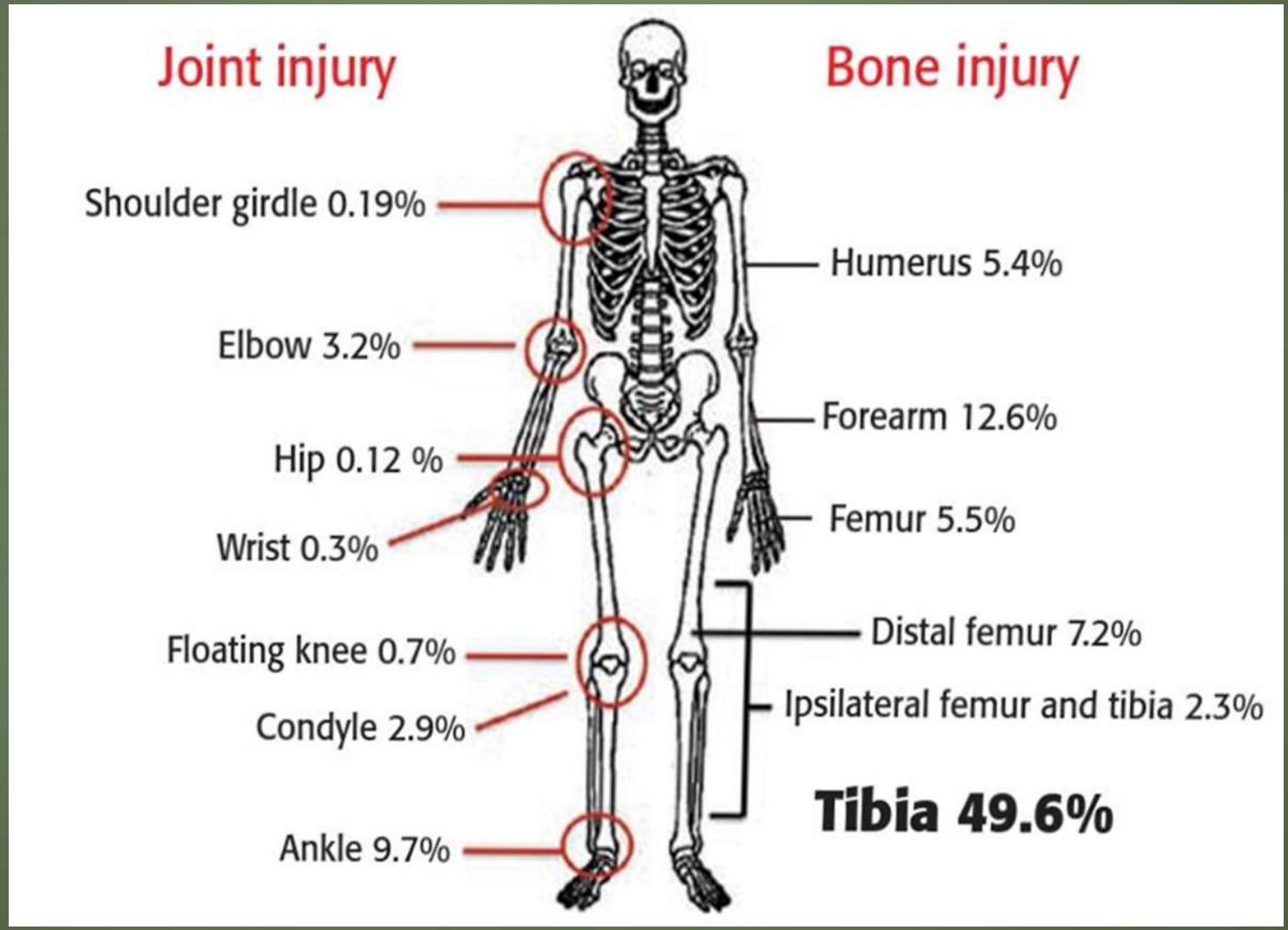
- Defined as an injury where the fracture and fracture hematoma communicate with the external environment through a traumatic defect in the surrounding soft tissues and overlying skin.

- The skin defect may not lie directly over the fracture site and may lie at a distant site. It may communicate with the fracture under degloved skin.

EPIDEMIOLOGY

- 3% of all limb fractures
- 21.3 per 100,000 per year
- Diaphyseal fractures are more common than the metaphyseal fractures
- Tibial diaphyseal fractures are the commonest open long bone fractures followed by femur, radius and ulna, humerus

Distribution of open injuries



MECHANISM OF INJURY

- Direct impacts - high-energy physical forces (trauma), motor vehicle accidents, firearms, and falls from height.
- Indirect mechanisms-twisting (torsional injuries) and falling from a standing position.
- can occur in low-velocity injuries due to the sharp ends of the fractured bone piercing the skin and soft tissues.

CLASSIFICATION

- To know about the extent of injury and the urgency of treatment.
- To evaluate the probable prognosis of the injury.
- To decide the best possible methods of management of the fracture.
- To inform the patient about the total period of hospital stays.
- To decide the type of rehabilitation required after the surgery.

CLASSIFICATION

- Gustilo-Anderson Classification
- A-O classification
- Tscherne Classification
- Ganga score
- Mangled Extremity Severity Score

GUSTILO ANDERSON CLASSIFICATION

Based on :

- Size of the wound
- Amount of soft tissue injury
- Type of fracture
- Presence / absence of neurovascular injury
- Degree of contamination

Type I :

- Clean wound less than 1 cm long.
- Minimal soft tissue damage.
- Fracture usually simple transverse or oblique with minimal comminution, low energy trauma

Type II:

- Wound size between 1-10 cm.
- Moderate soft tissue damage , minimal to moderate crushing component
- simple transverse or oblique fractures with moderate communition

Type III:

- Wound more than 10 cm.
- Extensive soft tissue damage with massive contamination
- High energy fracture pattern with significant involvement of surrounding tissues

Type III A:

- Adequate soft tissue cover, segmental fractures with minimal periosteal stripping

Type III B:

- Inadequate soft tissue cover , periosteal stripping and bone exposure requiring soft tissue flap closure, farmyard injuries

Type III C:

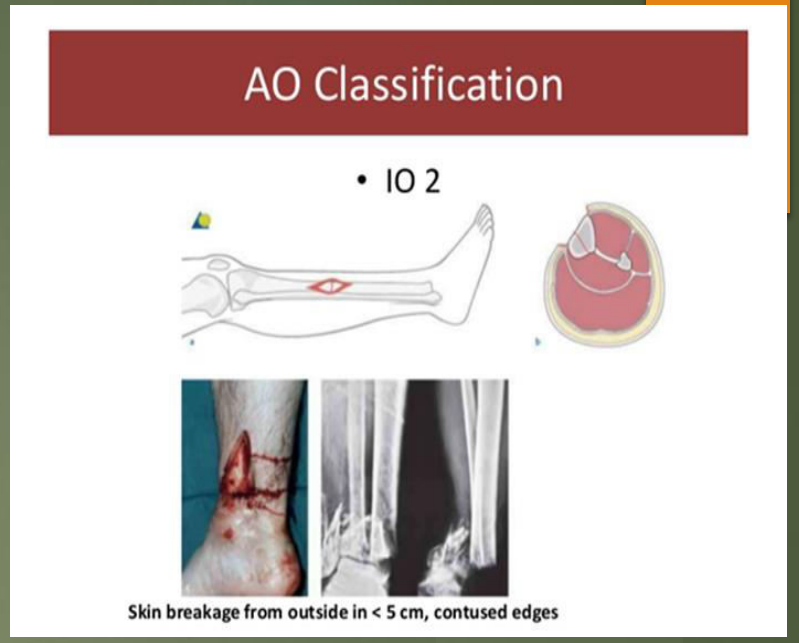
- Any fracture with vascular injury which requires repair.

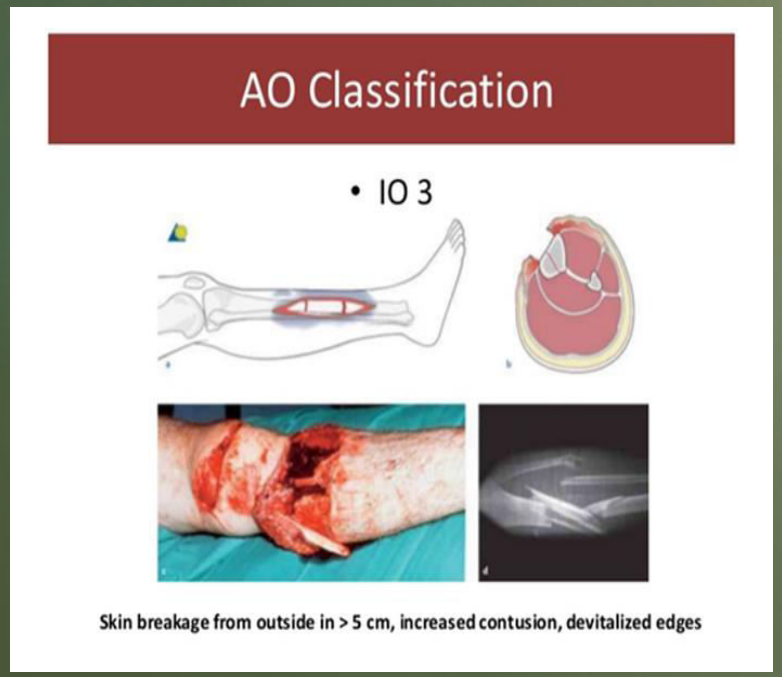
A-O CLASSIFIATION

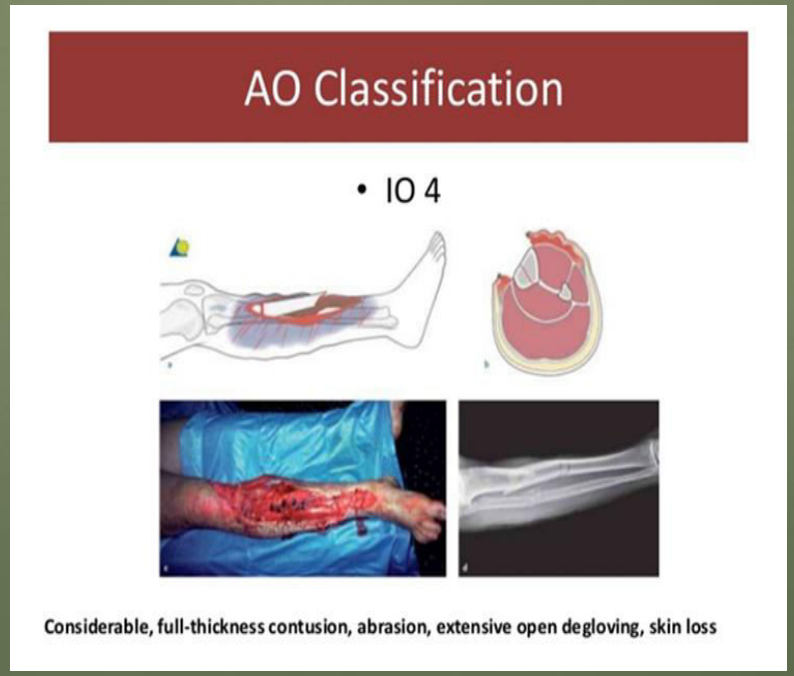
- A-O classification is based on skin lesions, Muscle and tendon injuries and Neurovascular injuries in fractures

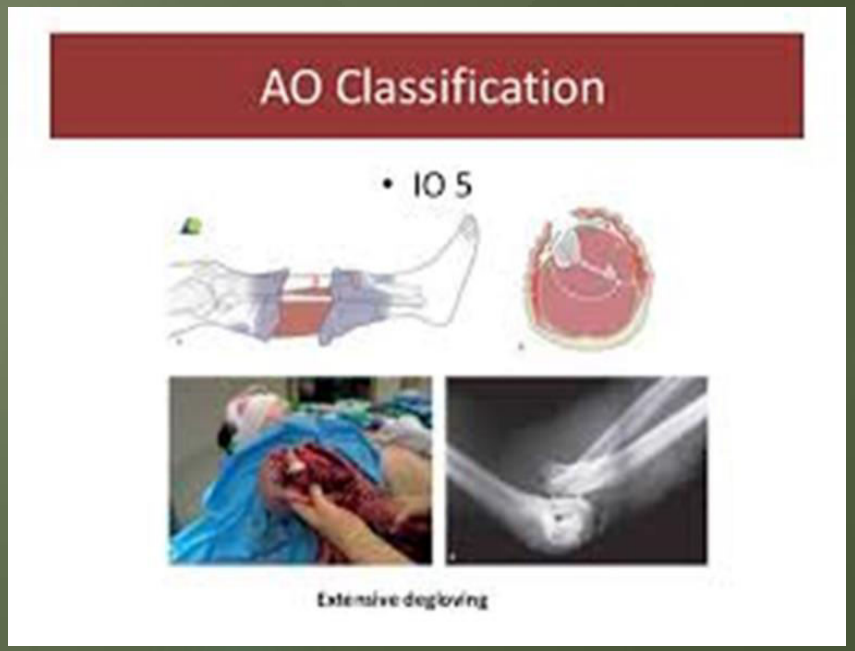
Skin lesions in fracture (Integument Open- IO):

- IO1:Skin open from within out
- IO2: Skin broken from outside in, with contused edges but less than 5cm in length
- IO3: In excess of 5 cm of skin broken, with devitalized edges and local degloving
- IO4: Full thickness contusion, abrasion , skin loss
- IO5: Extensive degloving



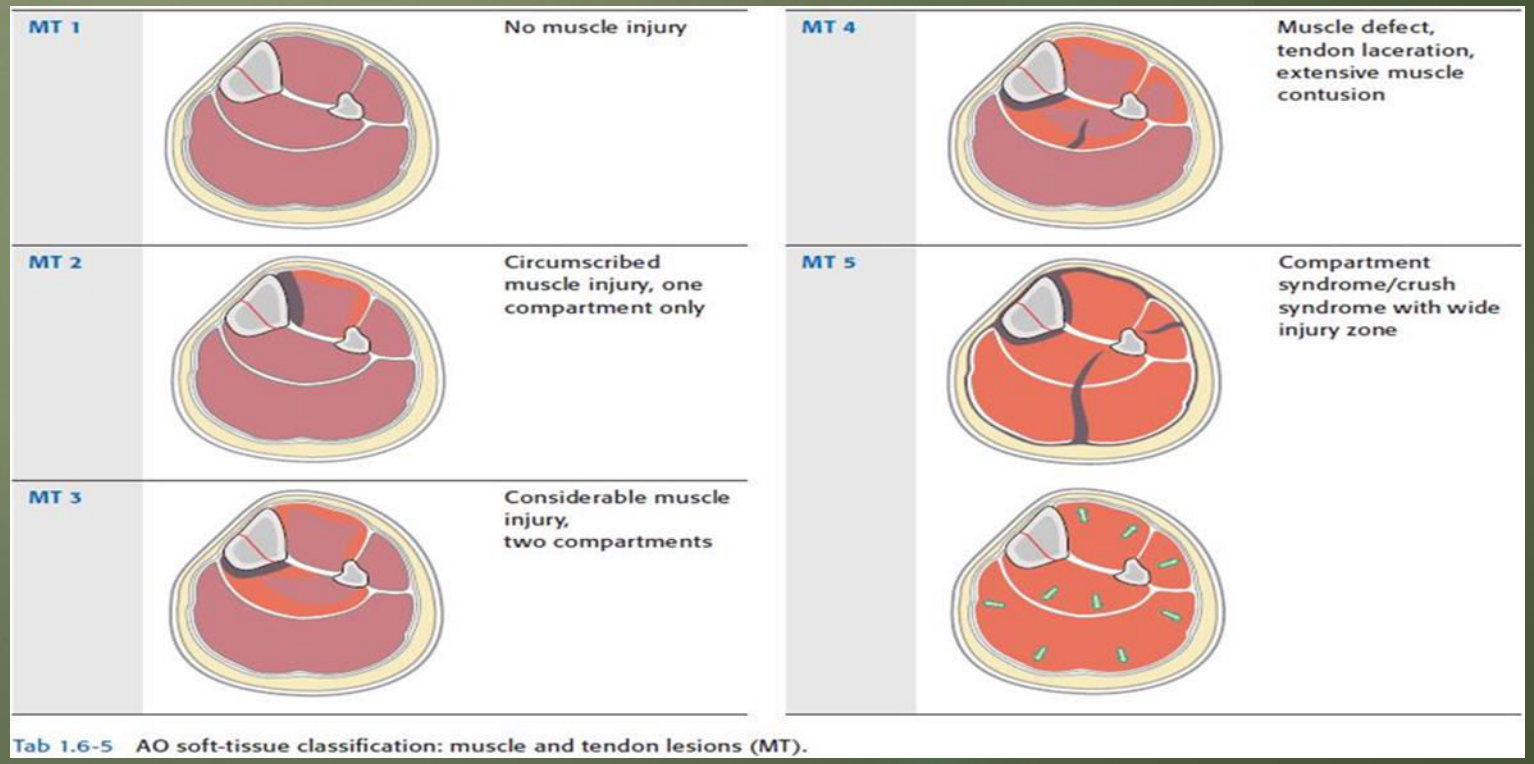






Muscle and tendon injuries in fractures(MT)

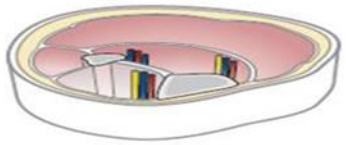
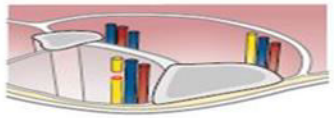
- MT 1: No muscle injury
- MT2: Involving one muscle group only
- MT3: Involving more than 1 group
- MT4: Avulsion or loss of entire muscle group , tendon laceration
- MT5: Compartment Syndrome.



Tab 1.6-5 AO soft-tissue classification: muscle and tendon lesions (MT).

Neurovascular injuries in fractures (NV)

- NV1: No neurovascular injury
- NV2: Isolated nerve injury
- NV3: Isolates vascular injury
- NV4: Extensive segmental vascular injury
- NV5:Combined neurovascular injury including subtotal or total amputation.

NV 1		No neurovascular injury	
NV 2		Isolated nerve injury	
NV 3		Localized vascular injury	
NV 4		Extensive segmental vascular injury	
NV 5		Combined neurovascular injury, including subtotal or even total amputation	

Tab 1.6-6 AO soft-tissue classification: nerve and vessel lesions (NV).

TSCHERNE CLASSIFICATION

- This takes into account wound size, level of contamination and fracture mechanism

Grade I:

- Small punctured wound without any contusion
- Negligible bacterial contamination
- Low energy mechanism of fracture

Grade II:

- These fractures are characterized by any type of skin laceration with a circumferential skin or soft tissue contusion and moderate contamination.
- Any severe soft tissue damage without injury to major vessel or peripheral nerve is categorized in this group.

Grade III:

- Extensive soft tissue damage with an additional major vessel injury and/or nerve injury.
- Heavy bacterial contamination

Grade IV:

- Incomplete or complete amputation with variable prognosis based on location and nature of injury

GANGA SCORE

- The basis of the score is that the three components of a limb :
- covering tissues – skin and fascia
- Structural tissues – bone
- functional tissues – muscles, tendons, and nerves

ADVANTAGES

- Assess severity of injury to skin, muscle, bone separately.
- Total score predicts amputation.
- Individual score provides guidelines for reconstruction.
- Scoring includes comorbidities which influences outcome.
- Better intra and inter observer agreement compared to Gustilo classification

- The total score gives a good indication of the outcome measures analyzed:
- Group I-Score of 5 or less.
- Group II- Score between 6 and 10.
- Group III- Score of 11-15.
- Group IV- Score more than 15.
- All the patients in Group IV are having grave injury and eventually lead to amputation

Covering structures: Skin and Fascia	Score
Wounds without skin loss	
Not over the fracture	1
Exposing the fracture	2
Wounds with skin loss	
Not over the fracture	3
Over the fracture	4
Circumferential wound with skin loss	5

Skeletal Structures: bone and joints	
Transverse/oblique fracture/Butterfly fragment < 50% circumference	1
Large butterfly fragment > 50% circumference	2
Comminution/segmental fractures without bone loss	3
Bone loss < 4cm	4
Bone loss > 4cm	5

Functional tissues: musculotendinous (MT) and nerve units	
Partial injury to MT unit	1
Complete but repairable injury to MT units	2
Irreparable injury to MT units/partial loss of a compartment/ complete injury to posterior tibial nerve	3
Loss of one compartment of MT units	4
Loss of two or more compartments/subtotal amputation	5

Co-morbid conditions: add 2 points for each condition present

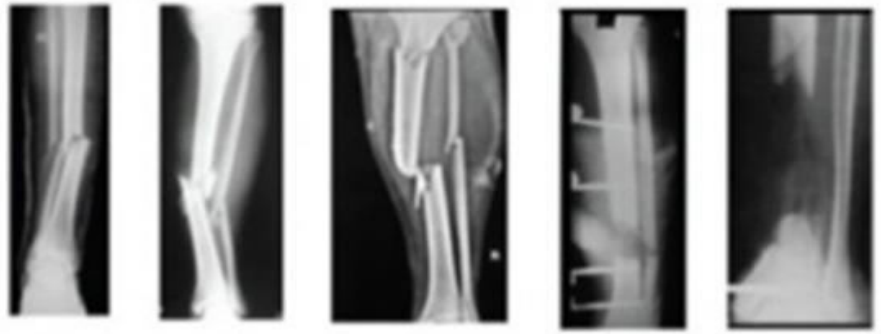
- Injury - debridement interval > 12 hours
- Sewage or organic contamination/farmyard injuries
- Age > 65 years
- Drug-dependent diabetes mellitus/cardiorespiratory diseases leading to increased anaesthetic risk
- Polytrauma involving chest or abdomen with injury severity score > 25/fat embolism
- Hypotension with systolic blood pressure < 90 mmHg at presentation
- Another major injury to the same limb/compartment syndrome

Ganga Hospital Open Injury Severity Score (GHOISS)

a. Covering structure: skin and facia

b. Functional tissues: musculotendinous and nerve units

c. Skeletal structures; bone and joints



MANGLED EXTREMITY SEVERITY SCORE

- Limbs with scores 7-12 points usually require amputation.
- Limbs with scores 3-6 points usually are salvageable.
- Multiply by 2 in ischemic group if ischemia persists for > 6 hours.

Type	Definition	Points
A	**Skeletal/soft tissue injury**	
	• Low energy (stab;simple fracture; "civilian" GSW)	1
	• Medium energy (open or multiple fractures; dislocation)	2
	• High energy (close-range shotgun or "military" GSW; crush injury)	3
	• Very high energy (above and gross contamination; soft tissue avulsion)	4
B	**Limb ischemia** (*Score doubled for ischemia >6 hours)	
	• Pulse reduced or absent but perfusion normal	1*
	• Pulseless; paraesthesia; diminished capillary refill	2*
	• Cool; paralysed; insensate; numb.	3*
C	**Shock**	
	• Systolic BP always >90 mm Hg	0
	• Hypotensive transiently	1
	• Persistent hypotension	2
D	**Age (years)**	
	• <30	0
	• 30–50	1
	• >50	2

CLINICAL FEATURES

Signs and Symptoms :

- Deformity of an arm or leg
- Pain in the injured area that gets worse when the area is moved or pressure is applied
- An inability to bear weight on the affected foot, ankle, or leg
- Limb length discrepancy
- Bone protruding from the skin
- Crepitus

Signs of hypovolemic shock:

- Decrease in blood pressure
- Rapid respiration
- Rapid heart rate
- Cool, clammy skin
- Decreased level of consciousness

Signs and symptoms of Fat embolism:

- cerebral : drowsy, restless and disoriented
- Pulmonary : tachypnoea, tachycardia, petechial rash(in front of neck, anterior axillary fold, chest, conjunctiva)
- Sputum and urine may reveal presence of fat globules

Signs and symptoms of ARDS:

- Shortness of breath and rapid breathing
- Low blood pressure
- Confusion and extreme tiredness
- cyanosis

Signs of vascular injury

Hard Signs

- Absent or significant difference in pulsations compared to normal side.
- Severe hemorrhage from the wound.
- Expanding and pulsatile hematoma.
- Bruit or thrill.

Associated Signs

- Associated numbness and neurological deficit.
- Difference in skin temperature distal to injury.
- Absence of venous filling.
- Absence of pulse- oximeter reading
- No capillary blanching

MANAGEMENT

GOALS OF TREATMENT:

- 1.To convert the contaminated wound into a clean wound.
- 2.To convert the open fracture into a closed one
- 3.To establish a union in a good position.
- 4.To prevent pyogenic and clostridial infections.

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:

- Patient assessment and resuscitation: ABC"s
- History and mechanism of injury
- Rule out cervical injuries, chest, abdominal injuries, head injuries in polytrauma patients.
- Vascular status – clinically by capillary filling time, filling of veins, peripheral pulses, temperature of the limb
- Neurological status by sensory deficits and motor power examination
- Wound- size ,site , location , depth , if it is transverse/longitudinal/irregular, skin around the wound, photographic documentation
- Muscle crush or loss
- Periosteal stripping or bone loss
- Fracture pattern , fragmentation
- Contamination of wound

TORNIQUET

USE OF TORNIQUET

- Inflatable torniquet to be used
- Helps in reducing unexpected profuse hemorrhage

INTERMITTENT DEFLATION

- Results in capillary fashion
- Gives good indication of skin viability

CONSTANT INFLATION OF TOURNIQUET

- Leads to anoxia
- Interfers with the viability of muscle during debridement

EMERGENCY ROOM MANAGEMENT

Control active bleeding by applying direct pressure:

- Uncontrollable bleeding from a wound can be controlled with the help of tourniquet and patient should then be taken to operating room as quickly as possible.
- Establishing and documenting intact vascularity in all fractured limbs.
- Blind clamping of blood vessels must be avoided because it may compress nerves – which may cause irreversible neurovascular damage

Wound care:

- It consists of washing the wound under strict aseptic conditions and covering it with sterile dressing.

Stabilize:

- Temporary stabilization of fracture with splints which decreases the pain, further injury from bone ends, and disruption of clots.

IV antibiotics:

- Should be given in all patients as soon as possible(within 3 hrs) and continued until first debridement.
- Cephalexin is a good broad spectrum antibiotic. In serious compound fractures, a combination of 3rd gen cephalosporins and aminoglycosides are preferred.

Tetanus prophylaxis:

- Tetanus Toxoid(TT): dose is 0.5ml I.M.
- Immunoglobulin: 75IU - <5yrs of age
  125IU - 5-10yrs
  250IU. - >10yrs

Analgesics

INVESTIGATIONS

- Plain radiographs of Anteroposterior and lateral views with inclusion of joints above and below the fracture
- Radiological gas shadows-Clostridium perfringens.
- Major open injuries often has deep wound contamination.
- Pre- debridement culture
- Angiography
- CT scan: helpful in intra articular fractures of the ankle and knee joint

<u>Biochemical markers</u>:

- Serum lactate
- Interleukin -6
- C-reactive protein

PRIMARY MANAGEMENT

Objectives of initial surgical management

- 1.Preservation of life and limb
- 2.Wound debridement
- 3.Definitive injury assessment
- 4.Fracture stabilization

WOUND DEBRIDEMENT

- Adequate debridement is the 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 superficial to deep structures
- All necrotic tissue should be excised
- Use of tourniquet should be minimised.
- Wound extension for full evaluation of soft tissue injury

PRINCIPLES OF DEBRIDEMENT

- Must be performed by experienced team.
- Performed as early as possible.
- Orthoplastic approach.

Steps:

- pre debridement photographs.
- Use of tourniquet.
- Superficial debridement.
- Deep debridement.
- Bone.
- Completion.

TIMING OF DEBRIDEMENT AND LAVAGE

- Most guidelines recommend debridement within 6 hrs.
- With delay risk of infection increases.
- Serial debridement may be necessary every 24-48 hours if debridement is delayed until the wound viability is ensured

Skin and fascia

- Wounds must be longitudinally extended to provide adequate visualization of deeper structures.
- Margins must be trimmed to bleeding dermis to create a clean edge.
- Gentle handling of the skin and prevention of degloving are essential.
- All avascular fascia must be excised.

Muscles

- All muscles in the compartment must be evaluated for viability (4C-color, consistency ,contractility ,capacity to bleed) and debrided .

- In type 1,2 and 3a – all non viable and in doubt muscle can be debrided.
- In 3b and 3c –removal of entire muscle compartment may be needed.
- Tendons , unless injured beyond the repair should be preserved.
- In open wounds tendons are subjected to desiccation and hence it should be covered with soft tissues/with moist dressings.

Bone

- Bone ends and medullary cavity must be carefully examined for impregnated paint , mud and organic material.
- All fragments without soft tissue attachments must be excised.

VESSELS

- Exploration not to be done routinely
- Indicated in cases of ischemia
- Major vascular injuries requiring repair are usually indicated prior to surgery
- Unexpectedly vascular injury may be encountered during debridement
- Repair can be achieved by reverse saphenous vein graft, prosthetic graft temporary shunts , bone shortening and repair

LAVAGE

- Adequate quantity of fluid with low pressure pulsatile lavage is preferable .
- Used before and after debridement.
- Supplements systemic debridement by removing foreign material and decreasing bacterial load.
- Normal saline is most commonly used irrigant, it can be applied by bulb syringe, pouring, and low pressure lavage.

Recommended irrigation volume:

- Grade1 fractures - 3liters normal saline
- Grade2 fractures - 6liters normal saline
- Grade3 fractures - more than 9 liters

FACTORS INCREASING THE RISKOF INFECTION

Local factors:

- organic, farm yard, or sewage contamination
- Poor debridement with retention of foreign debris and nonviable tissues.
- Inadequate skeletal stabilization.
- Presence of dead space.
- Debridement later than 24 hrs.

Systemic factors:

- presence of shock and ARDS.
- Comorbid factors like age above 65 yrs, metabolic disorders like DM, h/o smoking.
- Compartment syndrome and hypo vascular tissues.
- Prolonged hospital stay and exposure to resistant organism.
- Poor nutrition.

COMPLETION OF DEBRIDEMENT

- Deflate tourniquet and evaluate viability of all retained structures.
- Assess loss of tissues and document with photograph for future reference and planning.
- Decide on method and timing of wound closure or soft tissue coverage and bone stabilization.
- Document sequence of reconstruction.
- In very severe tissue loss Vacuum assisted closure may be used as a bridging procedure till the patient is fit for flap cover

IRRIGATION ADDITIVES

- Additives are generally 3 types:

1.<u>Antiseptics</u>:

- Povidone-iodine
- Chlorhexidine
- Hydrogen peroxide

2.<u>Antibiotics:</u>

- Bacitracin
- Polymyxin
- Neomycin

3.<u>Surfactants</u>:

- Castile soap
- Green soap
- Benzalkonium chloride

ANTIBIOTICS

- **Gustilo and Anderson type I and II**:-

  First-generation cephalosporins

- **Gustilo and Anderson type III**:-

  First-generation cephalosporins(or third generation cephalosporins)plus aminoglycoside

- **Fecal or potential clostridial contamination**:-

  Consider addition of penicillin to above regimen

Local antibiotics:-

- In Gustilo type III fractures additional use of local aminoglycoside impregnated Polymethylmethacrylate(PMMA) beads reduces overall infection rate.

FRACTURE STABILIZATION

- Restoration of normal length of bone leads to reduction of dead space in which blood can accumulate
- Improves venous and lymphatic return
- Stabilise soft tissue planes and thus facilitates early healing
- Permits early mobilization of joints and thereby helps in rehabilitation

- GRADE I,II &III A – Immediate IM Nailing
- GRADE III B – External fixation
- GRADE III C – External fixation conversion to IM Nailing after wound healing

METHODS

Extra osseous-

- In low grade open fractures with splints, plasters, weight bearing casts etc.

Internal fixation-

- Usually appropriate if wound is clean and soft tissue coverage is available
- Fracture involving the joints or physes

External fixation-

- In high grade open fractures
- In dirty wounds
- Extensive soft tissue injuries
- Fracture shaft of humerus, tibia and fibula

EXTERNAL FIXATION

Advantages :-

- Can be applied relatively easily and quickly
- Allows easy evaluation of skin and soft tissues
- It provides relatively stable fracture fixation
- There is no further damage done if applied correctly
- It avoids implantation of hardware in open wound
- Ability to convert into internal fixation.

Disadvantages:

- Pintract infection, malalignment , delayed union, poor patients compliance.
- Tubular fixators may not be the choice of fixation, but Ring fixators may be an option in open diaphyseal fractures

INTERNAL FIXATION

PLATES :

- Open diaphyseal fractures of the radius and ulna as well as the humerus are best managed with plate fixation.
- Intra articular and metaphyseal fractures
- The plate fixation of lower extremity diaphyseal fractures is generally not recommended due to higher rate of infections.
- Plate fixation is the preferred form of skeletal stabilization in metaphyseal and articular fractures of both the femur and tibia

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.
- Tibial diaphyseal fractures are ideally stabilized with interlocking nails, as they provide both longitudinal and rotational stability

WOUND CLOSURE

Timing of Wound Closure

- Primary closure: Wound closed by direct skin suturing during the index procedure.
- Immediate cover: Soft tissue cover performed within 48 hours.
- Early cover: Soft tissue cover performed within 1 week.
- Delayed cover: Soft tissue cover performed within 3 weeks.
- Staged reconstruction: Soft tissue reconstruction done after 3 weeks.

PRIMARY CLOSURE

- The original wound must have been fairly clean, and not have occurred in a highly contaminated environment
- All necrotic tissue and foreign material have been debrided
- Circulation to the limb is essentially normal
- Nerve supply to the limb should be intact.
- Wound can be closed with out tension
- Closure will not create a dead space
- Patient does not have multisystem injuries

DELAYED PRIMARY CLOSURE

- Closure before the 5th day is termed as 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
- Vacuum assisted wound closure is presently recommended for temporary management of open fracture wounds.

VACUUM ASSISTED CLOSURE

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

Wounds without skin loss:

- Tension free primary closure after thorough debridement.

Wounds with skin loss:

- Healing by secondary intention , delayed primary closure , split skin grafts , free flaps.

BONE GRAFTING

Indication:

- Bone loss
- High velocity trauma
- Severe comminution

Timing :

- Type 1 - immediate
- Type 2 & 3 - 6-12 weeks

LIMB SALVAGE AND AMPUTATION

- Limb is nonviable as evidenced by
  - Irreparable vascular injury
  - Warm ischemia time >8hrs
  - Severe crush injury with minimal remaining viable tissue.
- Severely damaged limb may constitute a threat to patient life especially in patients with severe debilitating illness.
- Mangled extremity severity score of >7 accurately predict the amputation.
- Score doubles for ischemia >6hrs.
- Ganga hospital open injury severity score 17 and above.

COMPLICATIONS

- Infection
- Chronic osteomyelitis
- Gas gangrene
- Tetanus
- Hypovolaemic shock
- Miscellaneous – Implant failure , reflex sympathetic dystrophy

REHABILITATION

- Joint mobilization
- Muscle exercise
  - During immobilization
  - After removal of immobilization
- Functional use of the limb

SUMMARY

- Treat open fractures as emergencies
- Perform a thorough initial evaluation to diagnose life and limb threatening injuries
- Begin appropriate antibiotic therapy in the emergency department or in the operating and continue treatment for 2-3 days only
- Immediately debride the wound of contaminated and devitalized tissue, copiously irrigate and perform repeat debridement within 24-72hrs
- Stabilize the fracture
- Wound closure
- Perform early autogenous cancellous bone grafting
- Rehabilitation

THANK YOU