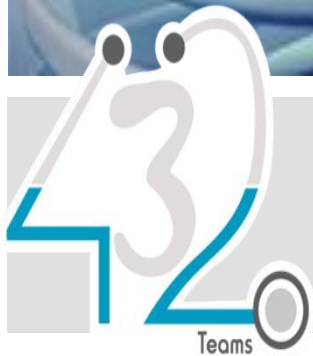


Orthopedics

6

Orthopedic emergencies

(Open fracture, fracture with NV compromise, pelvic fracture)



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Color Code:

Slides

431 team work

Doctor's Notes

Arabic Words

Team Notes

Books' notes

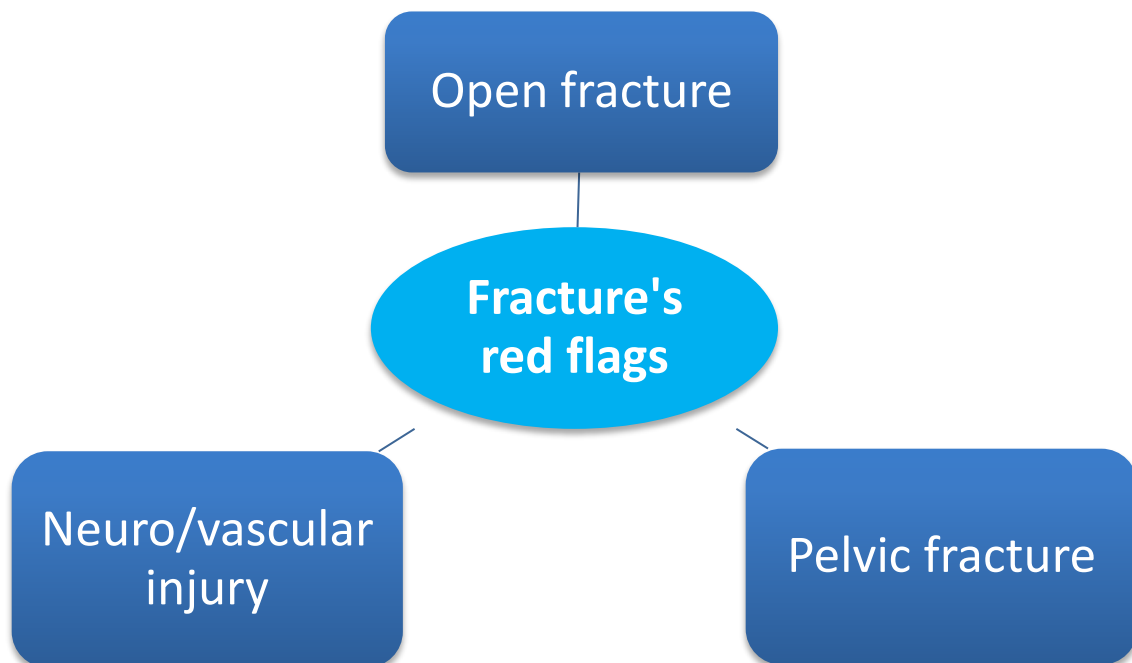
Important

Other Sources

Objectives

- To be able to **identify and diagnose** patients with an open fracture, a fracture with nerve or vascular injury and poly-trauma patients with pelvic injuries
- To be **knowledgeable** about the **pathophysiology and morbidity** associated with these injuries
- To be able to **apply the principles of management** of these injuries at the site of accident and in the emergency room

MIND MAP



1- Open fracture:

Definition

- A fracture that **at some point communicated with the environment**. (Also called compound fracture).
- The bone could be visible within the opening wound at time of presentation or not i.e. all we can see is a small opening wound while the bone got back inside (see the picture).
- Not necessarily bone coming out. E.g. if a nail was inserted into the knee it is an open joint.
- An open joint is managed similarly.
- In joint, it is enough to have an opening without any fracture in the joint even if it was an inside out (nail got inside knee then out).
- Open fracture usually requires higher injury. (It means that the patient sustained a high-energy trauma).
- Not always high energy (e.g. a 90-year-old thin osteoporotic lady with very delicate skin who just got tripped she might easily break her bone and since her skin is not elastic the result will be an open fracture).
- Sometimes it can be missed!!!
- Commonly occurs in bones with minimal soft tissue coverage. (anterior part of Tibia)
- Usually higher energy is required in deep bones. (Femur).



Pathology:

- It starts with traumatic energy to the soft tissue and bone.
- Leads to inoculation of organisms. (Normal flora of the skin contaminate the exposed bone).
- There will be some necrotic tissue e.g. torn and dead muscle. (The necrotic tissue will act as a source of infection for the organisms).
- Injury to vessels and microvasculature. (Less blood delivered to the tissue >>> decreased O₂ transfusion and nutrient>>> ischemia and lack of immune response).
- Raised compartment pressure will lead to compartment syndrome. (due to swelling)
- Ischemia and lack of immune response.
- As a result of all the above the patient at higher risk to develop an **infection**. (A good environment for bacteria to grow)

Infection in the presence of a fracture:

- Difficult to eradicate.
- Prolonged antibiotics
- Multiple surgeries
- Significant morbidity
- Significant costs (You will take the patient 5-6 times to the OR if you missed it at the first time)

The fracture will not heal thus you will be obliged to cast him for long time > **muscles wasting and joint stiffness**

Important points:

- An open fracture is a usually a “red flag” warning of significant trauma → Detailed assessment of the patient is necessary.
- An open fracture is associated with significant morbidity. Must act quickly. (The sooner you treat the less chance the patient gets into complications).
- A delay in management is proven to increase the likelihood of complications.
- Give urgent priority while triaging (e.g. open fracture is code 1, while closed is 3), provide initial management and consult urgently. The patient should be taken to OR preferably within 6 hours.

Diagnosis:

- Sometimes it's obvious!
- Other times, settle; be observant (the wound is very small, needs high suspicion from the doctor).
- So how to say if this is an open fracture or a skin cut? You have to keep in mind that any wound close to a fracture is potentially an open fracture until proven otherwise!!!
- Whenever a fracture is diagnosed, go back and check the skin. (You do not want to miss it!)
- If you are unsure consider the fracture as open. Over treatment is better than under treatment in this case.

- How do you know if the break in the skin is considered an opening between the outside environment and goes all the way deep down to the bone? **A small wound continuously oozing blood** (even after applying pressure with a gauze it keeps bleeding), especially if you see **fat droplets** within the blood (like oil within the blood, it is diagnostic, but rarely seen), is an open fracture! (it came from the bone marrow)
 - Not always close to the fracture. (E.g. a deep bone as femur get fractured, it has to travel a distance because it is covered in soft tissue such as muscle and breaks through the skin away from the site of fracture). (the deeper the bone the more coverage of soft tissue around the bone the far the opening)
 - Don't probe!! (probe: slender surgical instrument for exploring the depth or direction of a wound)
 - If in doubt, use good light, if there is a break in the dermis or fat is seen, call it an open fracture.
 - Better to overcall than miss it!
- Big wound but no fracture → not an open fracture, managed as soft tissue injury.
 - Fracture + skin abrasion "a superficial damage to the skin, no deeper than the epidermis" → not an open fracture.
 - Fracture + a wound continuously oozing blood → open fracture.

Algorithm:

- Assess and stabilize the patient, ATLS principles.
- Assess the condition of the soft tissue and bone to help grade the open fracture.
- Manage the wound locally. (try straighten the alignment)
- Stabilize the fracture.
- IV antibiotics
- Tetanus status

Assessment:

- A.** If poly trauma case, apply ATLS principles
- B.** If isolated injury, **take brief history** about the following:
1. Mechanism and circumstances of injury. (Form the patient or if not concisions ask the bystanders or the Red Crescent paramedics).
 2. Time since injury. (The management differ between an open fracture since 1 hour than an open fracture since 12 hours).
 3. Past Medical H/Past Surgical H/Allergy/Drugs/Smoking/when was his last meal. (Smoking delays the healing and increase the risk of infection). (Recent last meal requires different type of intubation).
 4. Tetanus vaccination status.

Then **examine the affected region** for:

1. Soft tissue:

- Degree of contamination (clean cut with scissors vs. leg crashed under a bulldozer in a farm)
- Necrotic and devitalized tissue
- Size of wound.
- Coverage loss (the presence of a skin loss that might needs a graft).
- Compartment syndrome (if some compartments are opened some still closed. i.e. the leg has four compartment if two are cut and opened with the accident there still other two who could get swollen and increases in their pressure)



Fig. 23.40 Fasciotomy closure device being used to close a large fasciotomy over a period of 1 week: (a) immediately postfasciotomy; (b) 4 days later; and (c) after healing.

2. Bone:

- Comminution (simple vs. fragmented)
- Stripping of bone periosteum (periosteum important for bone healing and growth because it has blood vessels on it's surface, so if a bone exposed and stripped from everything it is worse than a bone still attached to a soft tissue and to periosteum)
- Away from injury to joint above and below.
- X-rays to joint above and below.

3. Neurovascular status distally:

- On arrival and post reduction and splinting later. (Document everything to avoid any medico-legal issues).

Open fracture grades: (take full Hx to grade correctly) (IMP)

- **Grade 1:** all these conditions have to apply to consider it as grade 1

Less or equal to 1 cm, clean (no dirt, the patient is not swimming at time of injury) non-segmental nor severely comminuted fracture, less than 6 hours since injury.

• **Grade 2:**

>1cm wound and usually less than 10 cm, not extensive soft tissue injury or contamination, non-segmental nor severely comminuted fracture, no bone stripping and with adequate soft tissue coverage (could be 20 cm but clean cut and no extensive soft tissue loss). Same as Grade 1 but the wound is > 1 cm.



• **Grade 3:** anything that does not apply to grade 1 or 2, wound is > 10 cm

- **3A:** Any size with extensive soft tissue contamination or injury but not requiring soft tissue coverage procedure, or with a segmental or severely comminuted fracture, or late presentation more than 6 hours.

- **3B:** Any open fracture that requires soft tissue coverage procedure.

- **3C:** Any open fracture that requires vascular repair. (patient came with uselessness or deformed limb such as wrist drop)

• If combined conditions always take the worse which is 3C (e.g. patient came with an open fracture that needs both soft tissue coverage in addition to vascular repair so we consider it as 3C).

You can't differentiate between 3A and 3B in the ER, we do it in the OR.

Examples on open fracture grading:



It is more than 1 cm and it requires soft tissue coverage. So it is either grade 3B or 3C. how to know? if there is a pulse then it is 3B, if there is No pulse then it is 3C.



it requires soft tissue coverage. So it is either grade 3B or 3C. how to know? if there is a pulse then it is 3B, if there is No pulse then it is 3C.



Differ depending on the scenario:

- If the injury occurred <6 h ago, it is 2
- If the injury occurred >6h ago, it is 3A
- If there is a vascular injury, it is 3C

Obviously: - You can't decide based on the picture alone.

Management:

First, you have to do what we said before from stabilizing to grading.

1- Locally:

- Take a picture! (You don't want to reopen the wound every time another doctor wants to examine it (intern, registrar, consultant, ortho team).
- If dirty, irrigate with normal saline to remove gross contamination (**don't go deep**). do not use water even if it was sterile. (Because osmolality of the water is more so the tissue will lose fluid due to the concentration gradient. Just irrigate, if there is a big piece you can remove it by sterile equipment).
- If bone sticking out, try to reduce gently then immobilize and re-check neurovascular status.
- Cover with sterile wet gauze. **Wet because a dry gauze will stick to the wound and cause more injury when removing it.**
- If bleeding apply direct pressure on wound. **Never use a tourniquet; it will compromise the blood supply.**
- No culture swabs in ER. **Some studies said it is useless.**
- **Do x-ray**

1- Antibiotics: (most imp. in managing open fracture grade 3A)

- First generation Cephalosporin for gram positives (Ex: Cefazolin) in all open fractures.
- Aminoglycoside to cover gram negatives (Ex: Gentamicin) sometimes not required in grade 1 but in general it is safer to give in all grades. **Gram + is most common but you can't guarantee it is only gram +. So if grade 1 and you said I will only cover gram+ or you said I will cover both positive and negative, both answers are correct.**
- **In reality we give both antibiotics to cover both gram positive and negative in grade 1 and 2.**
- Add penicillin or ampicillin or clindamycin (**for anaerobes**) for clostridium in grade 3 open fractures and all farm and soaked wounds.

Grade 1: give 1st generation cephalosporin

Grade 2: give 1st generation cephalosporin + gentamicin

Grade 3: give 1st generation cephalosporin + gentamicin + penicillin or ampicillin

If the patient is allergic to penicillin → give metronidazole.

2- Tetanus prevention: (it depends on the wound type)

A- Clean wounds criteria:

- <6 hours from injury
- Not a farm injury
- No significant devitalized tissue
- Non immersed wound
- Non contaminated wound

B- Other wounds

Any wound **does not** apply to type A

Clean wounds		Other wounds	
Completed vaccination		Not completed or unknown	
Booster < 10 years	Booster >10 years	Completed vaccination	
nothing	Td 0.5 ml IM	Booster < 5years	Booster > 5 years
		nothing	Td 0.5ml IM
		TIG 250U And Td 0.5ml IM	

Tetanus toxoid (Td) considered as active immunity. While immunoglobulins (TIG) are passive immunity. Called in Arabic الكزاز. Ask about vaccination status. In KSA, most patients will be not completed or unknown.

As soon as patient is stable and ready, alert the OR, and get consent from the patient for surgery.

- Plan: Irrigation (usually we use about 15 L of normal saline), debridement of necrotic tissue (because it is a source of infection) and fracture stabilization.
- The sooner the less risk of further morbidity.

3- In the OR: move to the OR as soon as the patient is stable enough.

- Extend wound if necessary. If it was a small wound, we need to extend until we can reach the bone.
- Thorough irrigation.
- Debride all necrotic tissue.
- Remove bone fragments without soft tissue attachment i.e. floating and not attached to any periosteum or a soft tissue we throw it in the garbage except articular fragments (except the part of bone that have cartilage over it)

- In OR, if there were no necrotic tissue, no contamination & the cut was simple & clean → stabilize the fracture & close the wound (no need to bring the patient to the hospital again).
- But if you find necrotic tissue → do debridement & leave the wound open (no suture yet only gauze & bandage) → recheck again in 48-72 hour for necrotic tissue.
- Usually requires second look or more every 48-72 hours.
- Generally, **do not close open wounds on first look.** (Don't close it surgically, only cover it, and then put external fixation).

4- Fracture management:

Generally, avoid internal fixation (plate and screw). Generally external fixator is used. **Femur and tibia fractures** can usually be treated immediately with IM nail except severe injuries and contamination. (studies showed it is ok to use internal fixation in these cases) Observe for compartment syndrome post-operatively.

- If all principles applied: (in ideal scenario where the patient was transferred immediately to hospital, the management was immediate and proper).
- 2% complication rate in grade 1
10% complication rate in grade 2

Up to 50% complication rate in grade 3



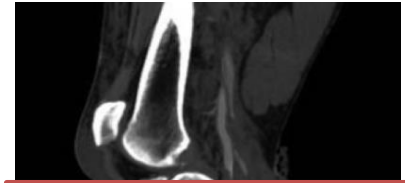
2- Fractures with nerve or vascular injuries

A- Vascular injury:

- Don't miss it!!!!
- **Always perform an accurate assessment at presentation, post manipulation and reduction, post-surgical fixation, serially until condition stabilizes.**
- Serial examination helpful in deciding line of treatment.
- Serial examination helps avoid confusion
- High correlation between vascular injury and nerve injury (e.g. if patient injured the brachial artery suspect a median nerve injury)

Mechanisms

- Penetrating trauma (sharp object)
- High-energy blunt trauma (pedestrian hit by car from side).
- Significant fracture displacement.
- Keep in mind tissue recoil at presentation (it means that it can go back to it's normal place at the time of imaging after injuring the vessel)



CT of knee. Blunt trauma. Fracture of the proximal tibia caused a popliteal artery cut. Common site of vascular injury. (X-ray doesn't show vascular injury)

Vascular injury (by two mechanisms):

- Direct laceration.
- Traction and shearing.



CT angio: Direct laceration by sharp fragments. Penetrating trauma. Gun shot.

Assessment of vascular injury:

- Always check for the following: **Pulse, Color, Capillary refill, Temperature, Compartment pressure**
Check both sides: If vascular injury → one limb is affected.
If shock → both limbs are affected
- Keep high index of suspicion in case of the following:
 - ✓ High energy trauma
 - ✓ Associated nerve injuries
 - ✓ Fractures/ Dislocations around the knee (Dangerous! Measure ABI) > **IMP**

Algorithm:

- Hard signs > Realignment of limb > If persistent > → Vascular intervention
- Hard signs > Realignment of limb > Improved > → Close observation (serial examination) every 2 hours

Why we do realignment? Because Realignment can result in unkinking of vessels, lowering compartment pressure, relaxation of arterial spasm

So, if you did your Vascular exam and you did not find the pulse > best thing to do is realignment of the fracture.

In case of open fracture around the knee > Hard signs > realignment of limb > improved → Do ABI test.

Table 1
Hard and Soft Signs of Vascular Injury Associated With Extremity Trauma
Hard signs
Pulselessness
Pallor
Paresthesia
Pain
Paralysis
Rapidly expanding hematoma
Massive bleeding
Palpable or audible bruit
Soft signs
History of bleeding in transit
Proximity-related injury
Neurologic finding from a nerve adjacent to a named artery
Hematoma over a named artery

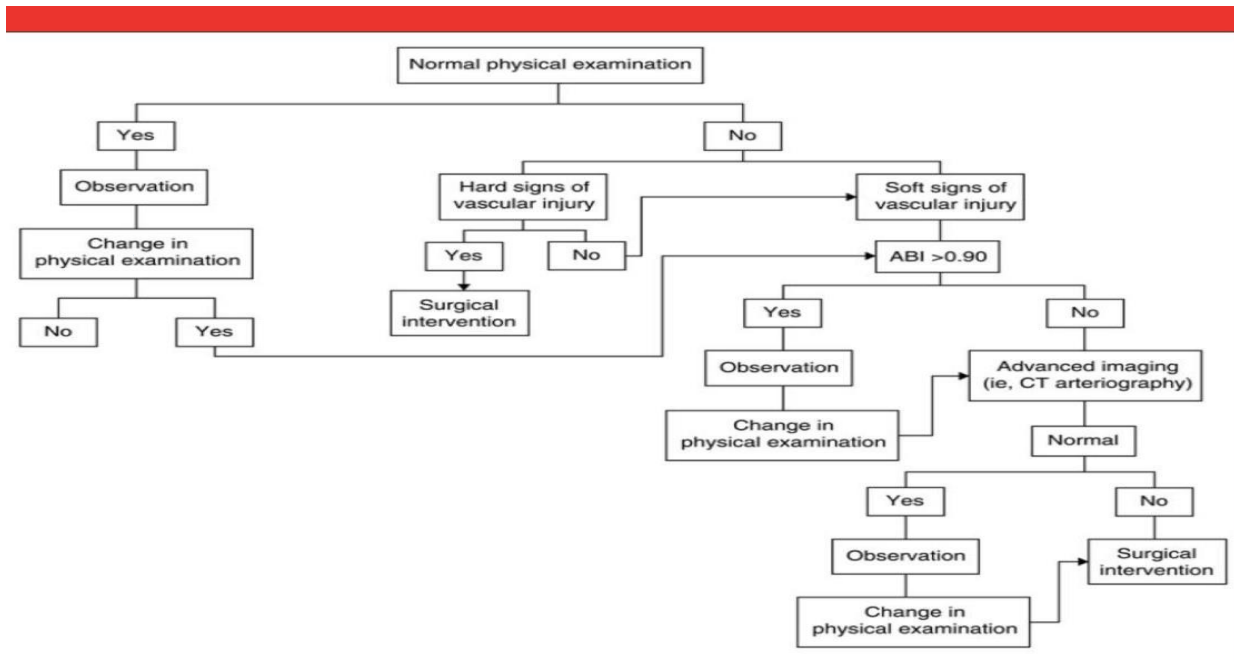
- ABI (the ankle brachial index) is the ratio of the blood pressure in the lower limbs to the blood pressure in the arms. Normal range 1.0-1.2. we do it because the presence of a pulse alone does not exclude vascular injury.
- **< 0.9 associated with vascular pathology**
- Rarely can give false negative result (Ex. Profunda femoris)
- Always used in high risk fractures (knee)
- If positive > Urgent vascular intervention
If vascular status didn't improve (<0.9) after limb realignment → do CT angio.
If there is a slight improvement → do ankle brachial index.

What they will ask for to assess if it became abnormal (i.e. ABI <0.9)? they ask for: Angiography, CT angiography > Gold standard, but it has risks (be careful with patient who have renal failure or pre renal failure)

- Vascular surgeon to arrange with interventional radiologist.

Management:

- Once vascular injury is confirmed (patient with fracture and without pulses you did ABI, you did realignment still abnormal)
- Coordination between: Vascular +Orthopedic +General (surgeons)
- **The aim is to save limb by perfusion then protect it.**
- Emergently re-establish perfusion and protect repair with skeletal stabilization.
- Orthopedic surgeon should go first and act quickly to stabilize the fracture. the principle is that fixing the artery should be first, but what if after fixing the artery the bone moves (since it is unstable) and damage the artery again? So most of the time the orthopedics surgeon will act quickly to stabilize the fracture by general fixator. Then we do the vascular repair.
- Warm ischemia time dictates treatment (warm means the hand still attached to the body) cold ischemia is when the amputated part was in a bag ice. In cold ischemia can wait longer because the metabolic rate decreased in this amputated part.
- Most times, a quick external fixator is applied, followed by vascular repair
- Avoid prolonging warm ischemia to do
- **Prolonged warm ischemia >6 hours you have to do Prophylactic fasciotomy.** (due to **reperfusion reaction** i.e. after repairing the vessel the reperfusion will cause edema in the muscle leading to increased pressure>>> compartment syndrome)
- Grade 3C open fractures have the worst outcome
- Amputation may be necessary in severe cases



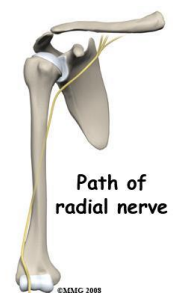
Nerve injuries

The most common type of nerve injury in bone fracture is Neuropraxia

- Cause of medico-legal concern
- Accurate assessment and documentation at presentation, post reduction, post-surgery is essential
- Remember to examine for motor and sensation prior to sedation.
- Closed fractures with nerve injuries usually does not require surgery: why? → Usually good outcome >80% → Usually managed conservatively in the early stages → Recovery may take more than 6 months (most of the time it will recover spontaneously)

Intact nerve before reduction, absent after reduction:

- Controversial management.
- Usually observe (because most of the time it's neuropraxia)
- It is acceptable if you say I will redisplace the fracture after you discovered that after the reduction there were absence of nerve intact. But it has been proven that it is not always useful. Just observe.



Path of radial nerve

Radial nerve palsy



Radial nerve run in the spiral groove

Management:

A- Closed Fracture requiring surgery with nerve injury:

(what dictate the need of surgery is the fracture not the nerve injury)

- Limited exploration (do not perform another incision specially for fixing the nerve itself, we do surgery for fixation of bone only if the nerve is in our way we fixed if not we don't do another incision).

B- Open fracture with nerve injury:

Explore, tag nerve ends for later repair. (We do suture like a tube between the two ends of the nerve ends)

Follow up

Clinically:

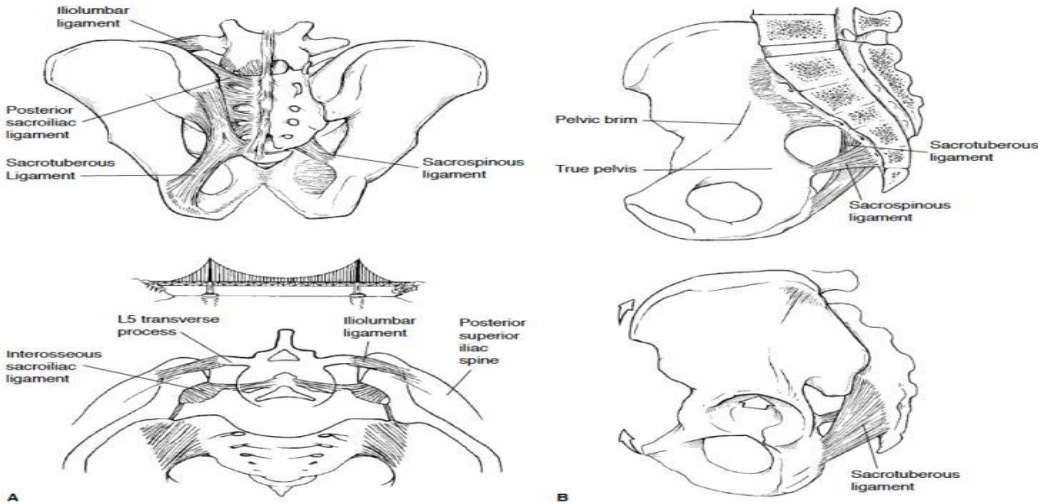
- Electrodiagnostic assessment start at 6 weeks then serially every 6 weeks (6 weeks because if done before 6 weeks it is useless and it cannot be read)
- If no improvement: Nerve exploration: neurolysis / repair / grafting
- Tendon transfers to preserve function (done when the nerve grafting is not expected to succeed or already failed. E.g. we take one of the plantar flexor tendons in case of foot drop).
- In other words, some tendons are transferred in order to restore more normal movement to a foot and ankle that has lost function.

Common sites of nerve injury: >(very IMP)

- Shoulder fracture / dislocation > Axillary nerve
- Distal humeral shaft fracture > Radial nerve
- Elbow fracture / dislocation > Median>> Radial>> Ulnar
- Hip fracture / dislocation > Sciatic nerve
- Knee fracture / dislocation > Peroneal nerve

3- Pelvic Trauma in the poly trauma patient

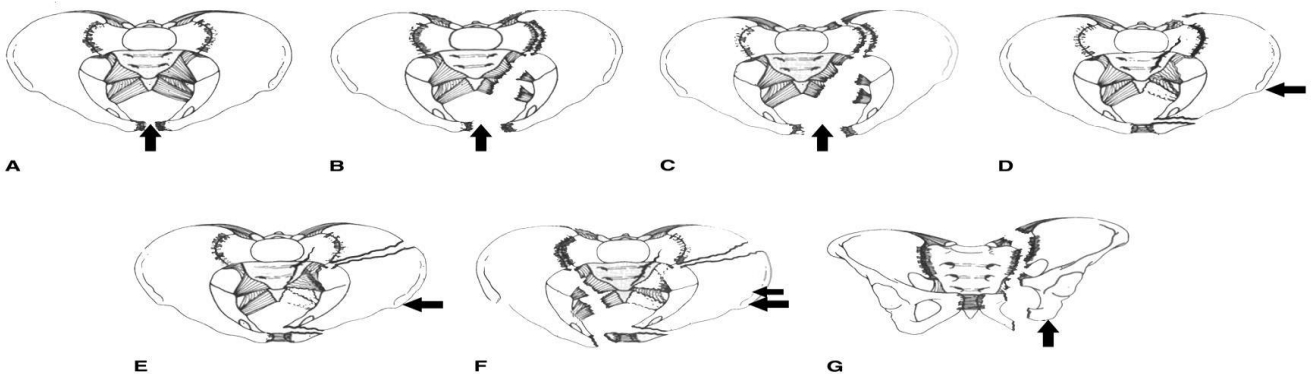
Pelvis anatomy



What make the pelvis stable?
Ligaments

Pathology

- How the fracture causes instability to the patient pelvis? We have three mechanisms:
 - 1- Fall on one leg causing vertical shears pelvic fracture (figure G). extremely unstable.



- 2- Lateral compression, e.g. car accident (figure D, E,F).
- 3- Anterior force causing open book. (A, B,C).

- More survival with open book then lateral compression and least is the vertical.

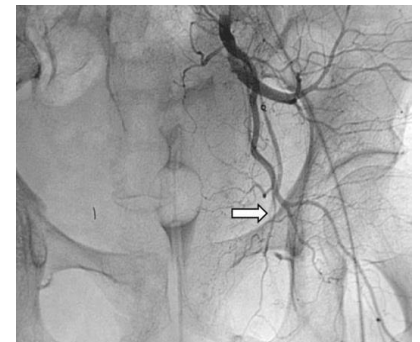
Figure A: Anterior force causing a little opening in the sacro-iliac joint. **Figure B:** Anterior force causing a little opening in the sacro-iliac joint and instability. **Figure C:** more force caused open book pelvis. In this kind of injury, the left and right halves of the pelvis are separated at front and rear, the front opening more than the rear, i.e. like opening a book. **Figure D, E,F :** lateral compression. **Figure G:** vertical shears pelvic fracture

- Pelvic fractures / instability may cause life threatening bleeding. The bleeding will be from the internal iliac artery and it will be retroperitoneal that's why it cannot be seen in US (FAST).
- So a patient comes after a high energy trauma we give him blood his blood pressure will increase then after a while it will go down, so what to do? Give him fluid again the patient will respond then the pressure will go down again this will tell you it is a matter of volume problem not cardiac or something else. So where is the fluid we are giving is going??? You have to suspect an **internal bleeding**.
- Diagnosing pelvic instability can save lives

Pelvic fractures are classified into stable, horizontal instability & vertical instability.

Diagnosis:

- History: High vs. Low energy trauma
- Mechanism of injury: Anterior vs. Lateral vs. Axial force
- Pelvic skin contusion, bruising
- Short extremity (in vertical shears)
- Careful neurologic assessment.
- **Primary survey: part of "C" circulation**
- Assess stability by gentle compression on the ASIS.
- Traction on the leg and assess pelvic instability (traction on leg while your hand at the iliac crest if it moves then it is a vertical shear fracture).



If unstable or painful: (mostly fractured)

- **Apply sheet around hips and close the pelvis gently** (around the trochanter used in case of compression fracture)
- This results in decreased intra-pelvic volume leading to tamponading the bleeding (by increasing the pressure around the vessel the blood pressure will rise).
- **Traction on the leg to stabilize vertical instability.**
- This minimizes ongoing vasculature injury and bleeding.

Rectal exam:

- Bone fragments (a pelvic bone fragment got inside the rectum and it could be sharp so be careful)
- High riding prostate (a sign of pelvic fracture)
- Bleeding

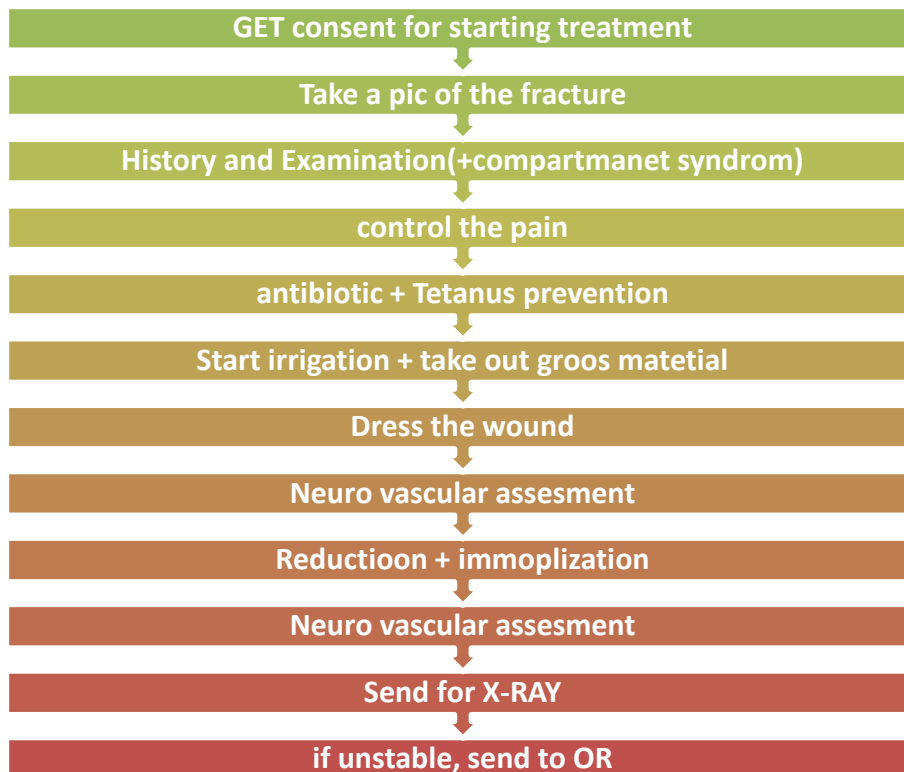
If the fractured bone penetrates the bowel or vagina or any halo viscous > it's an **OPEN FRACTURE**

Management (IMP)

- Stabilize pelvis with binder (IMP)
- If vertically unstable apply traction
- IV resuscitation
- Look for other injuries
- Check response
- If partial response, may require angiography for embolization of bleeders
- May require external fixator and/or pelvic clamp (the patient going to OR for other issue like abdominal laparotomy or something we do external fixation)
- Early diagnosis: Aggressive resuscitation
Coordinated team effort
Save lives.



Management of open fractures (Summary)



MCQs

Q1: you were in the ER one day and there is a patient with open fracture, by history and examination you found this: < 1cm clean wound without segmental fracture, he had the fracture 9 hours ago. Grade the fracture?

Q2: Patient had an open fracture while swimming in a lake. He went to the ER before after 2 hours of the fracture. What is the best dose of Tetanus vaccine for him (note: he doesn't know if he had Tetanus vaccine before)?

Q3: Patient with open fracture in the arm and you examine him and found that the distal pulse is absent; after you reduce the fracture it reappeared but weak and the other signs of vascular injury are normal. What is the best thing to do next?

Q4: Patient with open fracture in the arm and you examine him and found that the distal pulse is weak and the other signs of vascular injury are normal? What is the best thing to do next?

Q5: What is the most important thing in the management of an open fracture grade 3A?

Answers:

Q1: GRADE 3

Q2: TIG 250U AND TD 0.5 ML IM

Q3: do serial examination.

Q4: ABI

Q5: to start antibiotics as early as possible.

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