



7- Open fracture/Fracture with NV compromise/Pelvic fracture

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.

Team members: Meshal Aleiaidi, Mutasim Alhasani, Laila Mathkour

Team leader: Mohammed Baqais, Nora AlSahli

Revised by: Abdulaziz ALMohammed, Dina Aldossary

References: Slides & Notes, team 435 F1, toronto notes , Apely book

★ Definition:

- A fracture that at some point **communicated with the environment**.

The bone could be visible within the opening wound at time of presentation or not **Not necessarily bone coming out** i.e. all we can see is a small opening wound while the bone got back inside (see the pic). The most important thing that we are concern about in these cases are **infection** because the bacteria now have a way to go inside the body.

- An open joint is managed similarly. we consider it as emergency. In an open joint, it is enough to have an opening in the joint capsule without any fracture.



★ Etiology:

- Open fracture **usually** requires higher injury.
- **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**. e.g. **anterior part of Tibia**

Usually higher energy is required in **deep bones**. e.g. Femur, usually with this high energy look for other injuries.

★ Pathology: oozing لما تشوفون هالكلمة خلاص واضحة

Traumatic energy the soft tissue and bone.

- ⇒ Inoculation of organisms. **Normal flora** of the skin contaminates the exposed bone
- ⇒ There will be some **necrotic tissue**.
- ⇒ 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, in compartment syndrome the skin is not affected because it has its own blood supply.
- ⇒ **Ischemia and lack of immune response**. As a result, **the patient at higher risk to develop an infection** because it's a good environment for bacteria to grow. When you already have an infection this is very hard to eradicate and treat and required a lot of antibiotic and multiple surgeries, significant morbidities and very costly.

Common scenario: A patient came with open fracture in femur in a developing region, initial management were done, and patient was taken to OR, fixation and immobilization using a plate were achieved. However, the patient wasn't managed properly with antibiotics. 2 years later, the patient came with chronic osteomyelitis (very complicated to manage at this stage, around 6 to 10 stages of operations are needed).


★ Infection in The Presence of a Fracture:

The most important is to manage the patient with **antibiotic**, when you already have an infection it's:

- Difficult to eradicate.
- **Need** prolonged antibiotics.
- **Require** multiple surgeries.
- **Lead to** significant morbidity.
- **Significant** costs.

- ✓ An open fracture is usually a “red flag” warning of significant trauma so **detailed assessment of the patient is necessary.**
- ✓ An open fracture is associated with significant morbidity → Must act quickly to avoid infections.
- ✓ A delay in management is proven to increase the likelihood of complications like infection. So give urgent priority while triaging, 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, usually **oozing blood**, needs high suspicion from the doctor) **any wound close to a fracture is potentially an open fracture until proven otherwise.** If we have like this picture we are not sure is it open fracture or wound, so we consider it and deal with it as open fracture until proven otherwise. why? because if it open fracture and you didn't recognize it early you may end up with infection.
 - Whenever a fracture is diagnosed, go back and **check the skin.**
 - 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. From where the fat came? from the bone marrow. **The most thing indicative of open fracture is wound near fracture site with oozing blood.**
 - Not always close to the fracture.
 - 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 is not an open fracture, managed as soft tissue injury.
 - ✓ Fracture + skin abrasion "a superficial damage to the skin, no deeper than the epidermis" is not an open fracture.
 - ✓ Fracture + a wound continuously oozing blood is an open fracture.

★ Open Fracture Algorithm:

If you are **in an emergency** and a patient comes to you with an open fracture, this is what you have to do:

1. Assess and **stabilize** the patient, ATLS principles. **Saving life before saving limb**
2. Assess the condition of the soft tissue and bone to help **grade** the open fracture.
3. Manage the **wound** locally.
4. IV **antibiotics.**
5. **Tetanus** status.
6. Stabilize the **fracture.**

1. Assess and stabilize the patient, ATLS principles:

When the patient came to you and he is stable we start to assess him as usual by taking history, perform physical examination. etc. but sometimes the patient is not stable and we don’t have time to take the proper history, so we need to start with ATLS immediately.

- a. If **polytrauma** case, apply **ATLS** principles.
- b. If **isolated** injury, take brief **history** about the following:
 - Mechanism and circumstances of injury. **What happen? how? is there any other injuries?**
 - Time since injury. **The management differs between an open fracture since 1 hour and an open fracture since 12 hours**
 - Past Medical/Surgical History/Allergy/Drugs/ Smoking.
 - **Tetanus vaccination status**
 - When was his last meal because the patient will go to OR, Recent last meal requires different type of intubation.
 -




AMPLE is a quick history
 A: allergy
 M: medication
 P: past med/surgical
 L: last meal
 E: event surrounding the injury

Then **examine** the affected region for:

Soft tissue	<ul style="list-style-type: none"> - Degree of contamination (clean cut or bulldozer in a farm) - Size of wound - Necrotic and devitalized tissue - Coverage loss (the presence of a skin loss that might need a graft) - Compartment syndrome
Bone	<ul style="list-style-type: none"> - Comminution (simple vs. fragmented) - Stripping of bone periosteum, blood supply is affected → the important of periosteum is blood supply. - Away from injury to joint above and below - X-rays to joint above and below
Neurovascular status distally	On arrival and post reduction and splinting later. Document everything to avoid any medico-legal issues

2. Assess the condition of the soft tissue and bone to help grade the open fracture.

Open fracture grades (Gustilo classification): [ORTHO BULLETS](#)

Grade 1	<p>Less or equal to 1 cm, clean, non-segmental nor severely comminuted fracture, less than 6 hours since injury.</p> <p>What are the difference between segmental and comminuted fracture? Segmental fractures present two fracture lines, both being complete, within the same anatomic location. Comminuted fractures involve multiple fracture lines in the same anatomic location resulting in multiple fragments of bone.</p> <p>If you have same picture but the fracture more than 24 hours what is the grade? 3, any fracture more than 24 hours its 3 even if the fracture is clear.</p>	
Grade 2	<p>> 1 cm 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. Same as Grade 1 but the wound is > 1 cm. In this picture the wound is very big but if you clean it you will find enough soft tissue coverage</p>	
Grade 3	<p>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.</p> <p>3b: Any open fracture that requires soft tissue coverage procedure like skin graft or flab. What are the difference between skin graft and flab?</p>	

A graft is a piece of healthy skin that is removed from one part of the body and used to cover a wound elsewhere and it's does not have its own blood supply. At first, the graft survives because nutrients pass (diffuse) from the wound site into the graft. Soon, blood vessels grow into the graft. The blood vessels supply the graft with nutrients.

A flap is a section of healthy skin that is partially detached and moved to cover a nearby wound. The flap has its own blood supply and usually heal faster than grafts. In the flap you have to take skin, subcutaneous tissue and muscle and it's used in sever soft tissue damage.



3c: Any open fracture that requires vascular repair. (patient came with pulseless limb)

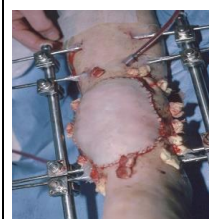


It's very important to take full Hx to grade correctly



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. To make it simple: if all the criteria for grade 1 and 2 are present then it is either grade 1 or 2 depending on the size. If something is missing it is a grade 3a except if it needs coverage (3b) or vascular repair (3b)

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

3. Manage the wound locally: the management are divided to 3 parts, locally, antibiotics and in OR
 First, you have to do what we said before from stabilizing to grading.

Locally:

- Take a picture to documentation or to show it to your colleagues, so you don't need to reopen the wound every time another doctor wants to examine it to avoid contamination.
- If dirty, irrigate with normal saline to remove gross contamination. **Do not use water even if it was sterile.** Because osmolality of the water is more so the tissue will loss 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. We apply direct pressure for 5-10 minutes, if bleeding stops it's a venous which is more common to be injured, if doesn't stop, this is arterial injury.
- No culture swabs in ER. Some studies said it is useless

4. IV antibiotics: Most important in managing open fracture grade 3A.

- I. First generation **Cephalosporin** for gram **positives** (Ex: Cefazolin or clindamycin if allergic) in all open fractures.
- II. Aminoglycoside to cover gram **negatives** (Ex: Gentamicin) sometimes not required in grade 1 but in general it is safer to give in all grades.
- III. Add penicillin or ampicillin or clindamycin (for **anaerobes**) for clostridium in grade 3 open fractures and all farm and soaked wounds. **Metronidazole used also for grade 3**

Grade1: one antibiotic, grade 2: two antibiotics, grade 3: three antibiotics.

Grade 3: give 1st generation cephalosporin + gentamicin + penicillin or ampicillin or give clindamycin if patient is allergic to penicillin.

5. Tetanus status

Tetanus prevention is depending on the wound type:

a. Clean wounds criteria:

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

b. Other wound criteria:

- Any wound does not apply to type A

Clean wounds			Other wounds		
Completed vaccination		Not Completed or Unknown	Completed vaccination		Not Completed or Unknown
Booster <10 y	Booster >10 y		Booster <5 y	Booster > 5 y	
nothing	Td 0.5 ml IM	Td 0.5 ml IM	nothing	Td 0.5 ml IM	TIG 250 U and Td 0.5 ml IM

Tetanus toxoid (Td) considered as **active** immunity. While immunoglobulins (TIG: Tetanus immune globulin) are **passive** immunity. 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, **debridement of necrotic tissue** because it is a source of infection and fracture stabilization.
- ✓ The sooner the less risk of further morbidity.

In the OR:

- 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**, because it's dead bone i.e. floating 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 (make sure) → stabilize the fracture & close the wound 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

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 an ideal scenario)

- 2% complication rate in grade 1
- 10% complication rate in grade 2
- Up to 50% complication rate in grade 3**

Fractures with 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 because sometimes the arterial injury is delayed so you have to check frequently. Sometimes you did the examination and everything were normal. in this situation you need high index of suspicion.
- High correlation between vascular injury and nerve injury (proximity) e.g. if patient injured the brachial artery suspect a median nerve injury

★ Mechanism:

- 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 its normal place at the time of imaging after injuring the vessel)
- Direct laceration (vascular) usually from blunt injury
- Traction and shearing. (vascular)



All arteries and veins contain three layers. The innermost layer is called the tunica intima. The muscular middle layer is called the tunica media, and the outermost layer is called the tunica adventitia. The most layer to be affected if intima.

★ Assessment of Vascular Injury: IMPORTANT

Always check for:

- 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:

1. High energy trauma.
2. Associated nerve injuries.
3. Fractures/ Dislocations around the knee (Dangerous! Measure ABI) because of popliteal artery vascular injury sometimes occurs with intimal tear. In an intimal tear the intima of the vessel is injured but the blood flows normally early on. Later the blood pushes the tear and occludes the vessel in a valve like mechanism.

★ Algorithm:

Is there is any hard signs → Realignment of limb: (hard sign means dangerous or alarming sign)

- If persistent → Vascular intervention
- If Improved → Close observation with serial examination every 2 h.

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.

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. Angiography, CT angiography is a gold standard, but it has risks, so be careful with patient who have renal failure or pre renal failure. Needs vascular surgeon to arrange with interventional radiologist

#الصورة مهمة#

Table 1

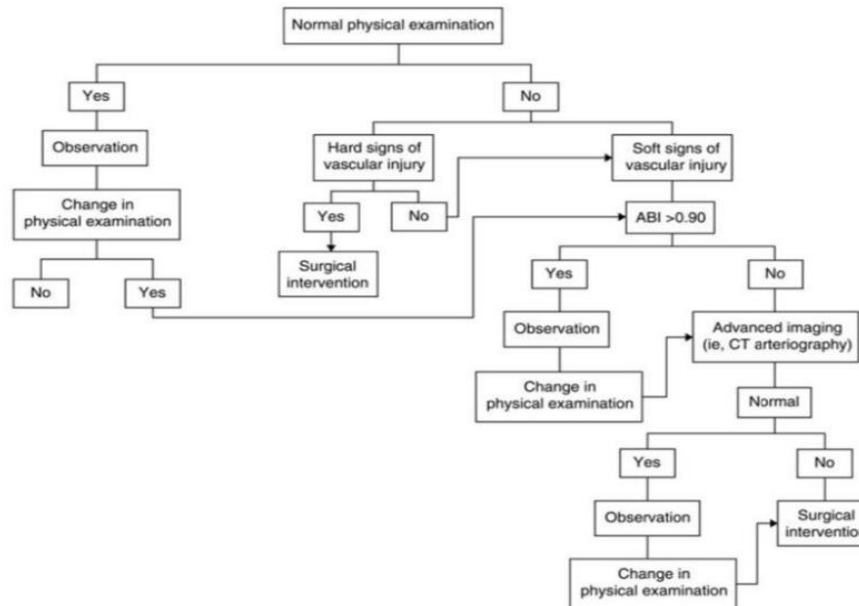
Hard and Soft Signs of Vascular Injury Associated With Extremity Trauma

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



★ Management:

- Once vascular injury is confirmed → Coordination between: Vascular + Orthopedic + General surgeons.
- Aim: Emergently re-establish perfusion and protect repair with skeletal stabilization.

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 orthopedic surgeon will act quickly to stabilize the fracture by general fixator. Then we do the vascular repair. **In short: we fix the fracture first then the artery because fixing of fracture will move the artery again.**

- Warm ischemia time dictates treatment. Warm means the hand still attached to the body, cold ischemia is when the amputated part was in an ice bag. In cold ischemia it can wait longer because the metabolic rate is decreased in this amputated part.
- Most times, a quick external fixator is applied, followed by vascular repair.
- Avoid prolonging warm ischemia to do repair.
- **Prolonged warm ischemia > 6 hours you have to do Prophylactic fasciotomy.** due to reperfusion injury 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.

Fractures with Nerve Injury

- 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.

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

★ Management:

A. 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**

B. Intact nerve before reduction, absent after reduction:

- Controversial management.
- Usually observe because most of the time it's neuropraxia.

C. Closed Fracture requiring surgery with nerve injury: **what dictates the need for surgery is the fracture not the nerve injury**

- Limited exploration. do not perform another incision especially 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.

D. 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

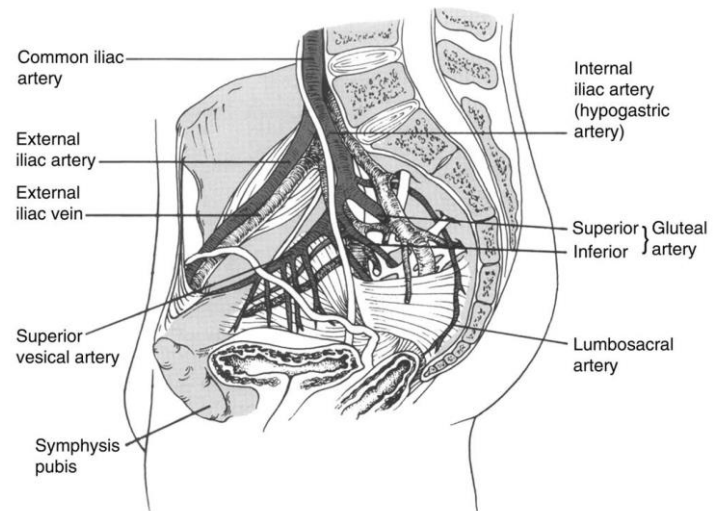
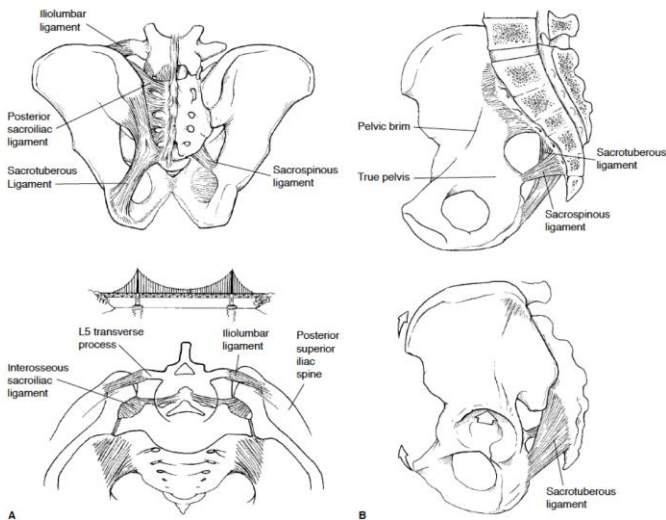
Clinically:

- 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:
 - A. Nerve exploration: neurolysis, repair, grafting
 - B. Tendon transfers to preserve function. **It's 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. patient needs to get used to it.

#Common sites of nerve injury: imp

1. Shoulder fracture, dislocation → Axillary nerve
2. Distal humeral shaft fracture → Radial nerve
3. Elbow fracture, dislocation → Median → radial → ulnar
4. Hip fracture, dislocation → Sciatic nerve
5. Knee fracture, dislocation → Peroneal nerve

Pelvic Trauma in the polytrauma patient [dr Nabil](#) [toronto notes](#)



★ Pelvic anatomy:

What makes the pelvis stable? The bony pelvis is held together with the support of the 3 vertebropelvic ligaments.

What are the ligaments?

1. **Iliolumbar ligament:** from tip of transverse process of L5 to posterior aspect of inner lip of iliac crest; strengthens the lumbo-sacral joint.
2. **Sacrotuberous ligament:** from sacrum to tuberosity of the ischium.
3. **Sacrospinous ligament:** from ischial spine to lateral margins of the sacrum

These ligaments, amongst others, provide critical, structural support and connection of various tissues in and around the pelvis.

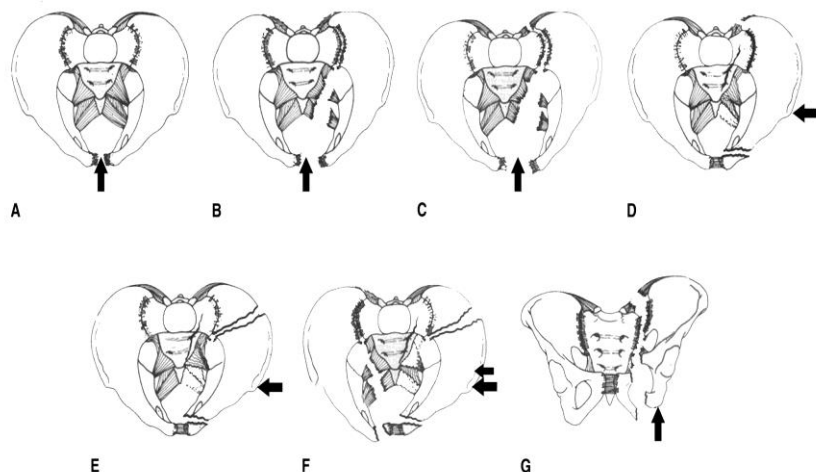
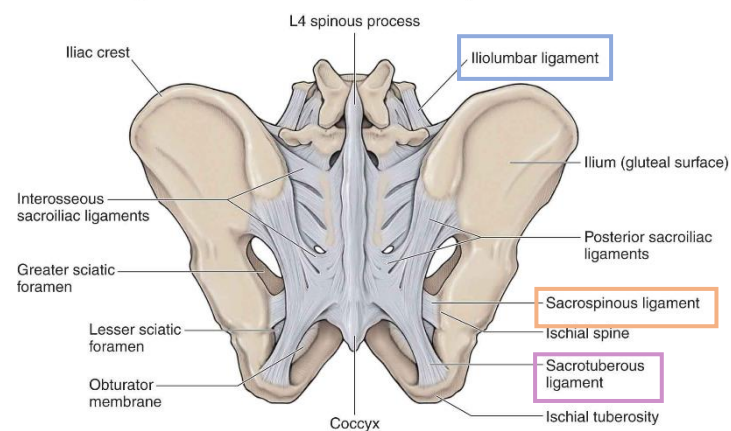
★ Pathology:

How the fracture causes instability to the patient's pelvis? We have three mechanisms:

1. Fall on one leg causing vertical shears pelvic fracture (figure G). extremely unstable.
2. Anterior force causing open book. (A, B, C).
3. Lateral compression, e.g. car accident (figure D, E, F).

There is more survival with open book then lateral compression and least is the vertical.

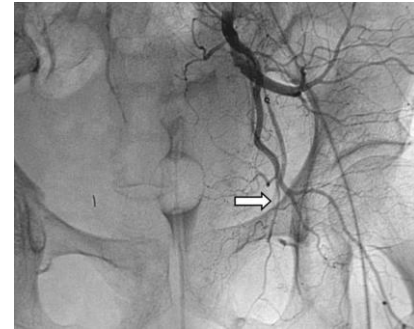
- ⇒ Figure A: Anterior force causing a little opening in the sacro-iliac joint.
- ⇒ Figure B: Anterior force causing a little opening in the sacro-iliac joint and instability.
- ⇒ Figure C: more force caused open book pelvis. In this kind of injury, the left and right halves of the pelvis are separated 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 venous plexus of internal iliac vein 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.

★ 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).
- **Rectal exam:** it's very important to perform it to check if there is any:
 - 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.
- Blood at the meatus, Labial or scrotal ecchymosis, Vaginal exam.
- ✓ **If the fractured bone penetrates the bowel or vagina or any hollow viscous → it an OPEN FRACTURE**



★ Management:

- Stabilize pelvis with binder.
- 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.
- Early diagnosis: Aggressive resuscitation, Coordinated team effort, Save lives.
- 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



★ Complications:

Thromboembolism, Sciatic nerve injury, Urogenital problems, Persistent sacroiliac pain.