



7-open fracture/fracture with nerve compromise/pelvic fracture

Objectives:

1. 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.
2. To be knowledgeable about the pathophysiology and morbidity associated with these injuries.
3. To be able to apply the principles of management of these injuries at the site of accident and in the emergency room.

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References: slides, team 435 F1 , toronto notes ,Apely book

Open Fractures

[toronto notes](#)

[Dr Nabil](#)

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 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.
- ❖ 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 even if it was an inside out (e.g. nail got inside the knee then out).



Etiology:

- ❖ 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**. (e.g. Femur) (usually with this high energy look for other injuries).

Pathology:

- ❖ It starts with traumatic energy the soft tissue and bone
 - ❖ Leads to inoculation of organisms. (Normal flora of the skin contaminates the exposed bone).
- ❖ There will be some necrotic tissue e.g. torn and dead muscle. (the necrotic tissue as well as the hematoma formed with the trauma 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) 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**. (A good environment for bacteria to

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).

grow).

Infection in The Presence of a Fracture:

The most important change to the patient is **antibiotic**

- ❖ 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.
- ❖ 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.
- ❖ 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) **.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!). 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 gets 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 farther the opening) **If you are ensure consider it open.**

- ❖ 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:

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

Assessment:

AMPLE is a [quick history](#)

A: allergy

M: medication

P: past med/surgical

L: last meal

E: event surrounding the injury

A. If polytrauma case, apply ATLS principles.

B. If isolated injury, take brief history about the following:

1. Mechanism and circumstances of injury. (From the patient or if not, concisions ask the bystanders or the Red Crescent paramedics).

2. Time since injury. (The management differs between an open fracture since 1 hour and 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.

5. Then examine the affected region for:

Soft tissue	
❖ Degree of contamination (clean cut or bulldozer in a farm)	❖ Necrotic and devitalized tissue
❖ Size of wound.	❖ Compartment syndrome
❖ Coverage loss (the presence of a skin loss that might need a graft)	
Bone	
❖ Comminution (simple vs. fragmented)	❖ Stripping of bone periosteum that's means the blood supply affected
❖ 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).	

❖ periosteum is important for bone healing and growth because it has blood vessels on its surface, so if a bone is exposed and stripped from everything it is worse than a bone that is still attached to a soft tissue and to periosteum)

open fracture grades (gustilo classification):

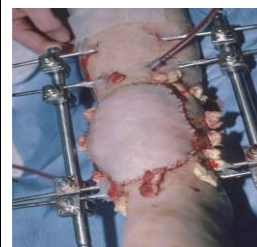
[ORTHO BULLETS](#)

(take full Hx to grade correctly) (IMP)

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. all these conditions have to apply to consider it as grade 1
Grade 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.
Grade 3b	Any open fracture that requires soft tissue coverage procedure
Grade 3c	Any open fracture that requires vascular repair. (patient came with pulseless limb)

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

Management:

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

A- 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) (the doctor said this for the idea only but don't say it in the osce)

❖ 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 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.

❖ No culture swabs in ER. Some studies said it is useless.

❖ Do x-ray

B- 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.
- ❖ Add penicillin or ampicillin or clindamycin (for anaerobes) for clostridium in grade 3 open fractures and all farm and soaked wounds.
- ❖ Grade1: one antibiotic grade 2: two antibiotics grade 3: three antibiotics.

Grade 1: give 1st generation cephalosporin.

Grade 2: give 1st generation cephalosporin +gentamicin.

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

- ❖ grade 3: give clindamycin if patient is allergic to penicillin.

Tetanus prevention: (it depends on the wound type)

Clean wounds criteria	Other wound
<6 hours from injury	Any wound does not apply to type A
Not a farm injury	
No significant devitalized tissue	
Non immersed wound	
Non contaminated wound	

Clean wounds		Other wounds			
Completed vaccination		Not Completed or Unknown	Completed vaccination		Not Completed or Unknown
Booster <10 years	Booster >10 years	Td 0.5 ml IM	Booster<5 years	Booster > 5years	TIG 250U and Td 0.5mlIM
nothing	Td 0.5ml IM* *intramuscular		nothing	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 (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.

C- 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 **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).

D- 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 Nerve or 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. pt presented with only numbness then he started to lose feeling, or he started to improve → the two cases have different management approach

❖ Serial examination helps avoid confusion because sometimes the arterial injury is delayed so u have to check frequency. for example in vascular injuries sometimes if you have fracture around the knee (proximal tibia) high energy dashboard injury directed to the tibia → when the patient initially presents he had perfect pulses in his foot then next day you find the leg necrotic and black what happened? sometimes the injury in the artery does not occur immediately (when the intima gets injured with time blood starts to flow slowly into the arterial wall → dissect → occlude → acute limb ischemia (SO SERIAL Examination every 2-4 hours depending on risk)

❖ High correlation between vascular injury and nerve injury (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)
- ❖ Traction and shearing. (vascular)

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:

1- High energy trauma

2- Associated nerve injuries

3- Fractures/ Dislocations around the knee (Dangerous! Measure ABI) > **IMP** 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:

❖ 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.

❖ **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.

Table 1

Hard and Soft Signs of Vascular Injury Associated With Extremity Trauma

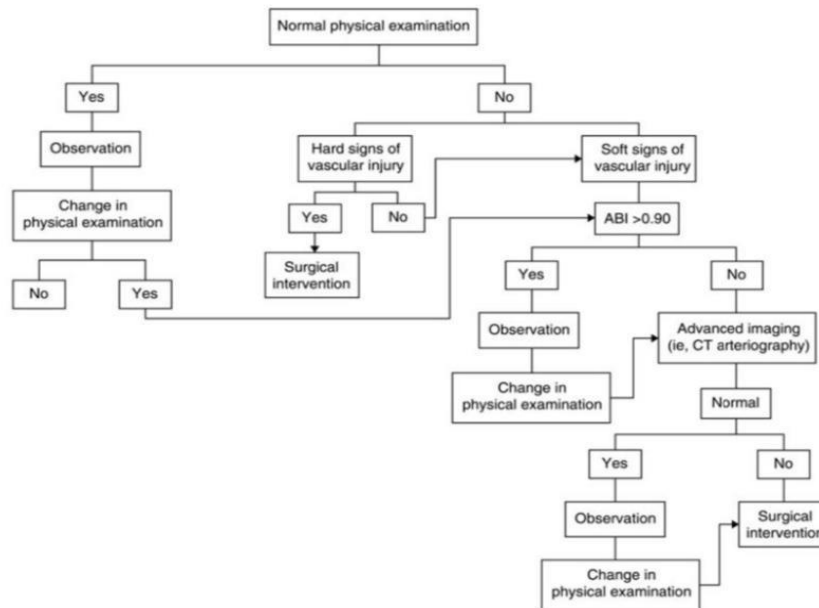
Hard signs

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

❖ **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
- ❖ 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 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 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

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)
- ❖ It is acceptable if you say I will re-displace the fracture after you discovered that after the reduction the nerve wasn't intact. But it has been proven that it is not always useful. Just observe.

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 it 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: 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). [if there's no improvement after one year we do tendon transfers](#)
- ❖ 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

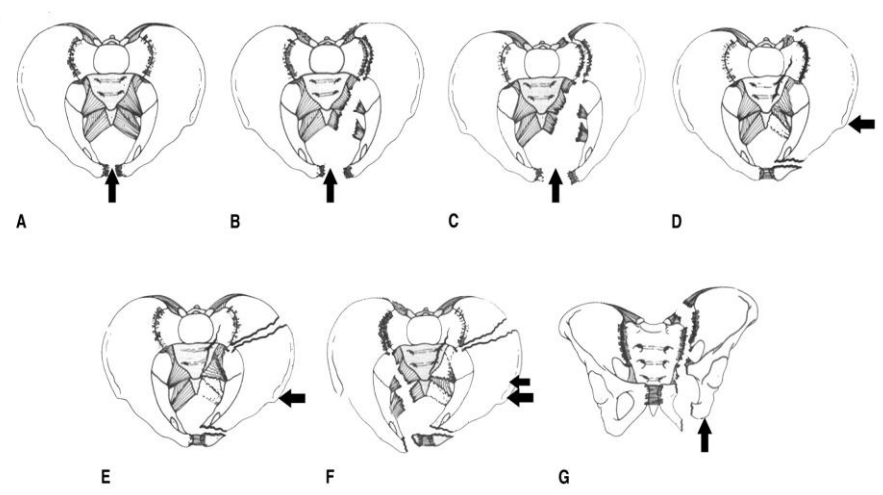
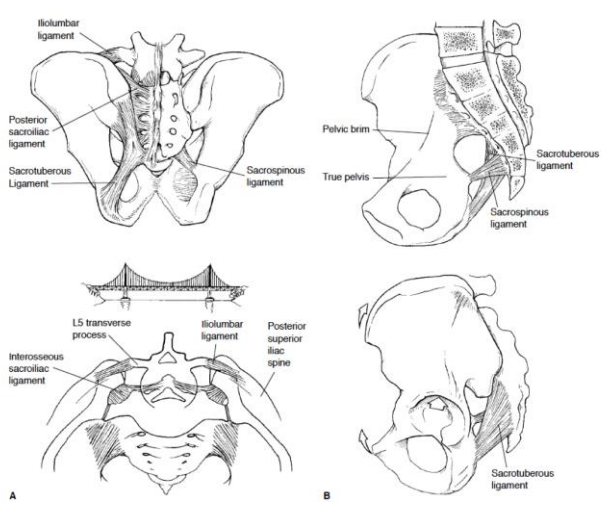
Common sites of nerve injury: >(very IMP)

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

Pelvic Trauma in the polytrauma patient

[dr Nabil](#)

[toronto notes](#)



What makes the pelvis stable? Ligaments

■How the fracture causes instability to the patient's pelvis?

We have three mechanisms:

- Fall on one leg causing vertical shears pelvic fracture (figure G). extremely unstable.
- Lateral compression, e.g. car accident (figure D, E, F).
- 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 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:

❖ 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 hollow viscous > it an OPEN FRACTURE

If unstable or painful: (mostly fractured)

Management:

❖ **Apply sheet around hips and close the pelvis gently** (around the trochanter used in case of compression fracture)

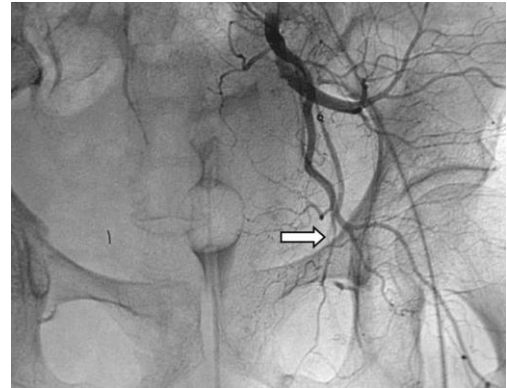
❖ This results in decreased intra-pelvic volume leading to tamponading the bleeding (by increasing the pressure around the vessel the blood pressure will rise).

❖ **Traction on the leg to stabilize vertical instability.**

❖ This minimizes ongoing vascular injury and bleeding.

❖ **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.

Complications:

Extra from the book (Apely) not in the slides

- ❖ Thromboembolism: A careful watch should be kept for signs of deep vein thrombosis or pulmonary embolism. Prophylactic anticoagulants are advocated in some hospitals.
- ❖ Sciatic nerve injury: It is essential to test for sciatic nerve function both before and after treating the pelvic fracture. If the nerve is injured it is usually a neuropraxia and one can afford to wait several weeks for signs of recovery. Occasionally, though, nerve exploration is necessary.
- ❖ Urogenital problems: Urethral injuries sometimes result in stricture, incontinence or impotence and may require further treatment.
- ❖ Persistent sacroiliac pain: Unstable pelvic fractures are often associated with partial or complete sacroiliac joint disruption, and this can lead to persistent pain at the back of the pelvis. Occasionally arthrodesis of the sacroiliac joint is needed.

[MCQs & SAQs](#)