
EM CASES DIGEST

THE MAGAZINE SERIES FOR ENHANCED EM LEARNING



Vol. 1: MSK & Trauma



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Medicine Cases
216 Balmoral Ave
Toronto, ON, M4V 1J9
www.emergencymedicinecases.com

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OUR THANKS TO...

EDITORS IN CHIEF

Anton Helman

Taryn Lloyd

PRODUCTION EDITOR

Michelle Yee

PRODUCTION MANAGER

Garron Helman

CHAPTER EDITORS

Niran Argintaru

Michael Misch

PODCAST SUMMARY EDITORS

Lucas Chartier

Keerat Grewal

Claire Heslop

Michael Kilian

PODCAST GUEST EXPERTS

Andrew Arcand

Mike Brzozowski

Ivy Cheng

Walter Himmel

Dave MacKinnon

Natalie Mamen

Hossein Mehdian

Sanjay Mehta

Jonathan Pirie

Jennifer Riley

Brian Steinhart

Arun Sayal

Laura Tate

Rahim Valani



University of Toronto, Faculty of Medicine

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Emergency Medicine Institute**

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Joseph and Wolf Lebovic Health Complex



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Anton Helman, MD, CCFP(EM), FCFP

Assistant Professor, University of Toronto

Department of Family & Community Medicine

Staff Physician, North York General Hospital, Department of Emergency Medicine

Education Innovation Lead, Schwartz-Reisman Emergency Medicine Institute

Founder, Editor in Chief and host of Emergency Medicine Cases

FOREWARD

Social media technologies are a game-changer in health professions education.

In the past several years, social media technologies have begun challenging how traditional academic institutions think about education delivery and teaching. Expensive textbooks, classroom-based teaching, and siloed workshops are competing with the growing presence of open-access blogs, podcasts, and global online journal clubs for learner attention. New communities of practices are appearing constantly, connected by the internet.

EM Cases was one of the very first podcasts that I noticed at the forefront of this movement. When it launched in 2010, I was already impressed by the high quality content and attention to detail. I am not surprised to see that it currently garners an amazing 70,000+ downloads per month. Its popularity is a reflection of the how today's busy lifelong learners consume medical knowledge. In a word, it is – opportunistically. With so many digital distractors and an overwhelming amount of medical information to keep abreast of in today's world, education delivery needs to be portable, easily accessible, and digestible in chunks. Thus, podcasts provide an appealing solution for the busy learner, who may wish to listen while driving to work or exercising.

As a blogger, however, I am keenly aware that blogs and podcasts generally provide a rather haphazard delivery of content to learners. I am guilty of that. I publish what is most timely and relevant in the eyes of my editorial team. There is no set curricula framing the periodic release of new materials and generally each blog post is a stand-alone lesson. But can't we, as educators, do better?

EM Cases can. The launch of the EM Cases Digest series is a huge step towards structuring the modern learning experience, using social media technology. This marks the evolution of EM Cases as podcast resource to a premier podcast-enhanced educational curriculum. While many podcast organizations have brief show-notes for their podcasts, none that I know of have created a professionally designed ebook, integrating podcasts into a thoughtfully organized framework of text- and image-based lessons with question-answer sections.

FOREWARD (Continued)

From a pedagogical and instructional design standpoint, this innovative approach makes sense. It optimizes and solidifies learning based on Mayer's cognitive theory of multimedia learning. Incorporating both visual (ebook) and auditory (podcast) elements optimizes working memory and, thus, learning.

Congratulations to Dr. Anton Helman and his EM Cases Digest team, who are at the forefront of reimagining health professions education. I can only imagine the ginormous efforts that went into producing such a product, with an eye towards visual design, education theory, and multimedia integration. The result is an ebook series that is fun, educational, and a joy to read. Thank you for your dedication and pioneering vision for advancing education in emergency medicine.

Your friend and fan,
Michelle

Michelle Lin, MD
Academy Endowed Chair of Emergency Medicine
Professor of Emergency Medicine
University of California, San Francisco;
Editor in Chief
Academic Life in Emergency Medicine blog (<http://aliem.com>)
@M_Lin

Guide to EM Cases Digest

We hope that you will find the EM Cases Digest Series to be an interactive, flexible, and engaging way to enhance your Emergency Medicine learning journey. These magazines are intended to be an adjunct to the EmergencyMedicineCases.com podcasts, as well as to existing Emergency Medicine curriculums and resources. For optimal learning, we suggest EM Cases Digest be used in conjunction with the podcasts for spaced, repetitive learning, and as an interactive workbook, whereby you can explore the links, videos, and original resources (links to original references can all be found on our website). We'd also encourage you to attempt the Q&As actively, revealing expert answers only after formulating your own answers and opinions.



Clinical Pearls



Tools & Rules



Key References



Pitfalls



Caution



What would you do?



AH-HA

Ah-Ha's



EXPERT OPINION

Expert Opinion



Your Comments

Here's a little description to help explain all of the graphics in this book:

Clinical Pearls:

The nuggets of wisdom

Pitfalls:

The common regrets

Ah-Ha's:

Wow moments

Tools & Rules:

Clinical decision tools and rules

Caution:

Warning; badness ahead

Expert Opinion:

What our guest experts think when the evidence is unclear

Key References:

EBM game changers

What would you do?:

Reflect on what you would do in your practice

Your Comments:

Go to the linked blog post to leave your comment



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CHAPTER 1: COMMONLY MISSED UNCOMMON ORTHOPEDIC INJURIES

[LISTEN TO THE PODCAST WITH HOSSEIN MEHDIAN AND IVY CHENG HERE](#)



Objectives

1. Develop an awareness and approach to commonly missed uncommon orthopedic injuries
2. Recognize the subtle findings of a Lisfranc injury
3. Learn to appreciate the spectrum of injuries at the perilunate joint
4. Understand how DRUJ injuries alter the management of common wrist injuries that it is associated with
5. Recognize the subtle findings of pelvic apophyseal injuries

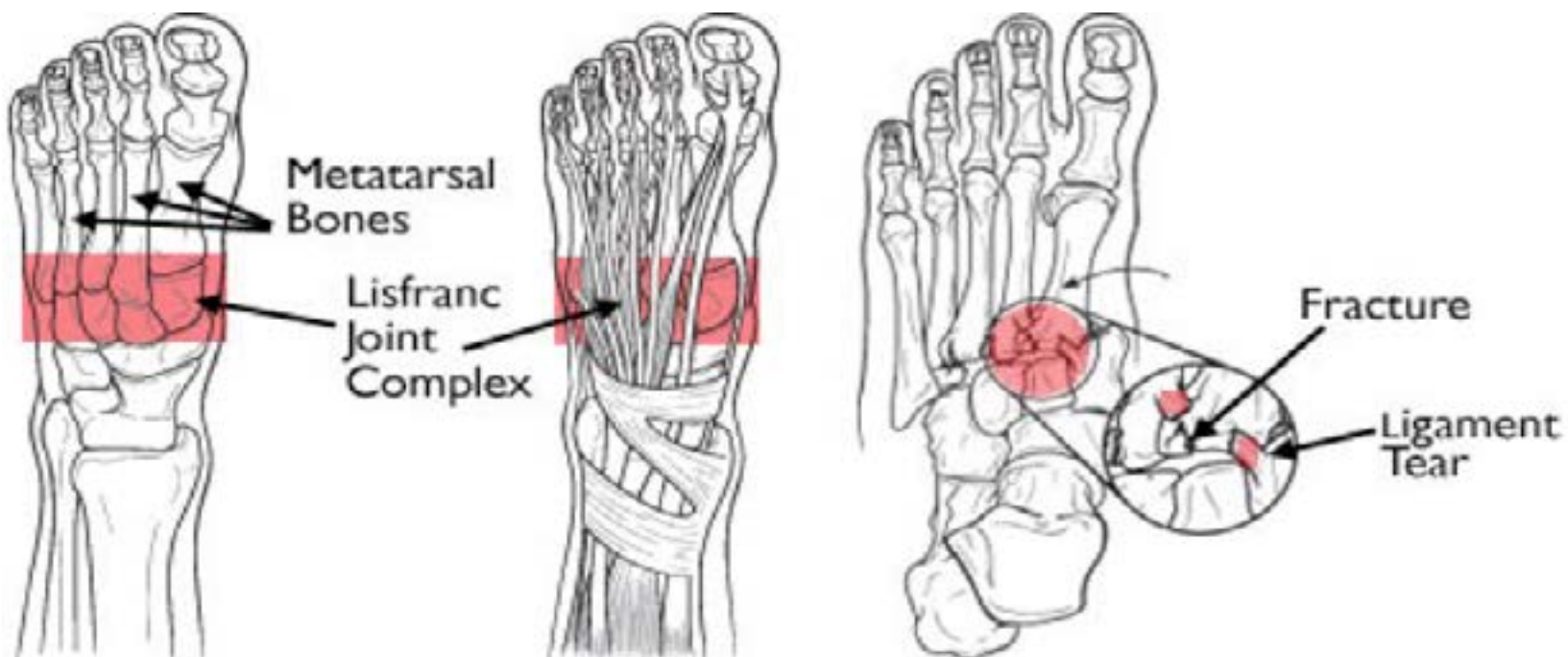
CASE 1: LISFRANC INJURIES

A 43-year-old man was out jogging in a ravine when his right foot slipped into a hole in the ground that he didn't see because it was covered by leaves. He is now in the emergency department because he is barely able to weight bear, and is complaining of pain over his right midfoot. On exam he's impressively swollen and tender over the dorsal midfoot.

You remember hearing about a Lisfranc fracture-dislocation in a patient who had fallen off a horse with his foot caught in the stirrup, and wonder if your patient could have this injury as well.

Q: What is a Lisfranc injury?

A: Lisfranc injuries are a spectrum of injuries, from a simple sprain to complete disruption of the tarso-metatarsal joints in the midfoot. These typically occur at the base of the 2nd metatarsal. Lisfranc injuries are easy to miss because they are relatively uncommon and because the x-ray findings are often subtle or even absent on standard views. Low velocity injuries are typically more commonly missed than high velocity ones. It's these subtle, low velocity injuries, like our case of a man catching his foot in a hole, that we should be on the lookout for.



Anatomy associated with a Lisfranc Injury: Fracture of the 2nd metatarsal or a tear of the tarso-metatarsal ligament

Q: What is the usual mechanism of injury for a Lisfranc fracture?

A: The usual mechanism for a Lisfranc injury is *plantar flexion with external rotation of the ankle*. A classic example is a fall from a horse with the foot caught in the foot stirrup. Other examples include: MVC, foot planted in hole, awkward step off of a curb. In children, a classic history for a Lisfranc injury is the “*bunk bed fracture*,” where a child leaps onto a bunk bed, landing on their toes with an axial load on a plantar flexed ankle.

Q: What findings would you look for on physical exam to suggest a Lisfranc injury?

A: Patients are typically *unable to weight bear*. A key clinical clue is a *hematoma/ecchymosis on the plantar aspect of the foot*. Commonly, there is significant dorsal midfoot swelling and midfoot tenderness.

! Caution!

Be sure to look for signs of compartment syndrome, which may include: paresthesias or hyperesthesia, particularly in the first dorsal webspace.

[For more on compartment syndrome see Episode 28 on Vascular Catastrophes with Anil Chopra and David Carr](#)



Physical exam may reveal ecchymosis on the plantar aspect of the foot. This sign should raise your concern for a Lisfranc injury.

Q: Given your history and physical exam, you obtain 3 x-ray views of the foot (AP, lateral, and standard 45 degree oblique view). What are the x-ray findings of a Lisfranc injury?

A: Commonly, patients have a normal-appearing x-ray. Normally on the AP x-ray, the medial edge of the base of the 2nd metatarsal should line up with the medial edge of the medial cuneiform. On the oblique x-ray, the medial edge of the 3rd and 4th metatarsals should line up with the medial edges of the middle and lateral cuneiforms.

Also, look for *widening* between the bases of the 1st and 2nd or 2nd and 3rd metatarsal bases. Widening >2mm is an indication for urgent surgical intervention.

Look for a fracture or avulsion. Look for a **“fleck sign”**, which is pathognomonic for a Lisfranc injury. This is a small bony fragment avulsed from the second metatarsal base or medial cuneiform.



The pathognomonic Lisfranc “Fleck” sign, an avulsion fracture



Normal alignment of the 2nd metatarsal as seen on AP view



Normal alignment of the 3rd and 4th metatarsals on the oblique view



Caution!

In a significantly displaced fracture or subluxation (>2mm widening at the Lisfranc joint), immediate orthopedics referral in the ED is required for urgent surgical intervention.



Clinical Pearl

- If you suspect a Lisfranc injury, add a 30-degree oblique and consider an ankle nerve block with standing views if the usual views aren't revealing.
- Look for "Fleck sign" and any misalignment of the medial aspect of the 2nd metatarsal and the cuneiform.
- Surgery is indicated if there is >2mm subluxation of the tarso-metatarsal joints.

Q: Great, my x-rays are normal; now what?

A: Given that your patient shows many clinical findings suspicious for a Lisfranc injury, you should consider the following:

1. Obtain a *30-degree oblique x-ray* – this eliminates overlap of metatarsals.
2. Consider *weight-bearing stress views*, following an ankle nerve block.
3. Consider a *CT of the foot* if the x-rays still do not show an injury and you remain suspicious.

Q: How do you manage a patient in the emergency department with a suspected or confirmed Lisfranc injury?

A: For an *undisplaced or suspected injury without radiographic findings*, place the patient in a posterior back slab. Patients should be non-weight-bearing, and outpatient follow-up should be arranged with orthopedics. Discharge instructions should include elevation of the leg, and warning signs of compartment syndrome of the foot.

CASE 2: PERILUNATE INJURIES

A 19-year-old woman had been partying in a park with her friends and climbed up a tree showing off to her friends how she could hang upside-down like a bat. She fell out of the tree, landing on both hands, and then rolled onto her back. She complains of pain in her left wrist. On physical examination, she's not tender at the distal radius or the snuffbox, but is tender at the mid-dorsal wrist. There's little, if any swelling. A head-to-toe exam is otherwise normal. You take a quick look at the x-ray of the wrist and it looks normal to you.

Q: What injuries are on your differential diagnosis?

A: Occult Scaphoid fracture – to assess for a suspected scaphoid fracture, there are 3 physical exam maneuvers to assess for:

1. Palpate the scaphoid on the *volar* side of the wrist (palm) with the wrist radially deviated
2. Thumb axial load tenderness – apply axial force to thumb and ask the patient if they experience pain at the location of the scaphoid
3. Snuffbox tenderness

Note that snuffbox tenderness is only one of the three signs of scaphoid fracture.

EM Cases Cross-Link: *For more on Scaphoid Fractures, jump to Chapter 6 in the eBook*

Also consider:

- Scapholunate dissociation
- Lunate dislocation
- Perilunate dislocation
- DRUJ (Distal Radius Ulnar Joint) injury

You decide to go back to re-examine your patient and you confirm that there's no snuffbox tenderness, no axial thumb load tenderness, and no distal radius tenderness. You're worried about this patient because she's complaining of severe pain, so you put her in a wrist splint and have her follow up in your hospital's fracture clinic a week later. You're thinking that it's probably just a badly sprained wrist. When you read the consult note 2 weeks later you find out that the diagnosis is a perilunate dislocation, and the patient went on to require surgery.

Q: What spectrum of injuries encompass perilunate injuries?

A: The spectrum of perilunate injuries that usually result from a FOOSH mechanism range from the least significant scapholunate *dissociation* to the most significant lunate *dislocation*:

- 1. Scapholunate dissociation** – a ligamentous injury with minimal clinical findings and a gap on the AP x-ray of the wrist between the scaphoid and the lunate (The Terry Thomas, David Letterman, or Madonna sign as these celebrities all have visible gaps between their incisor teeth); this is the most common cause of **SLAC** (ScaphoLunate Advanced C**o**llapse).
- 2. Perilunate dislocation** – with advancement of injury, the capitate dislocates from the lunate fossa.
- 3. Lunate dislocation** occurs with further advancement of this injury, which is a volar dislocation of the lunate out of the “seat” of the capitate.

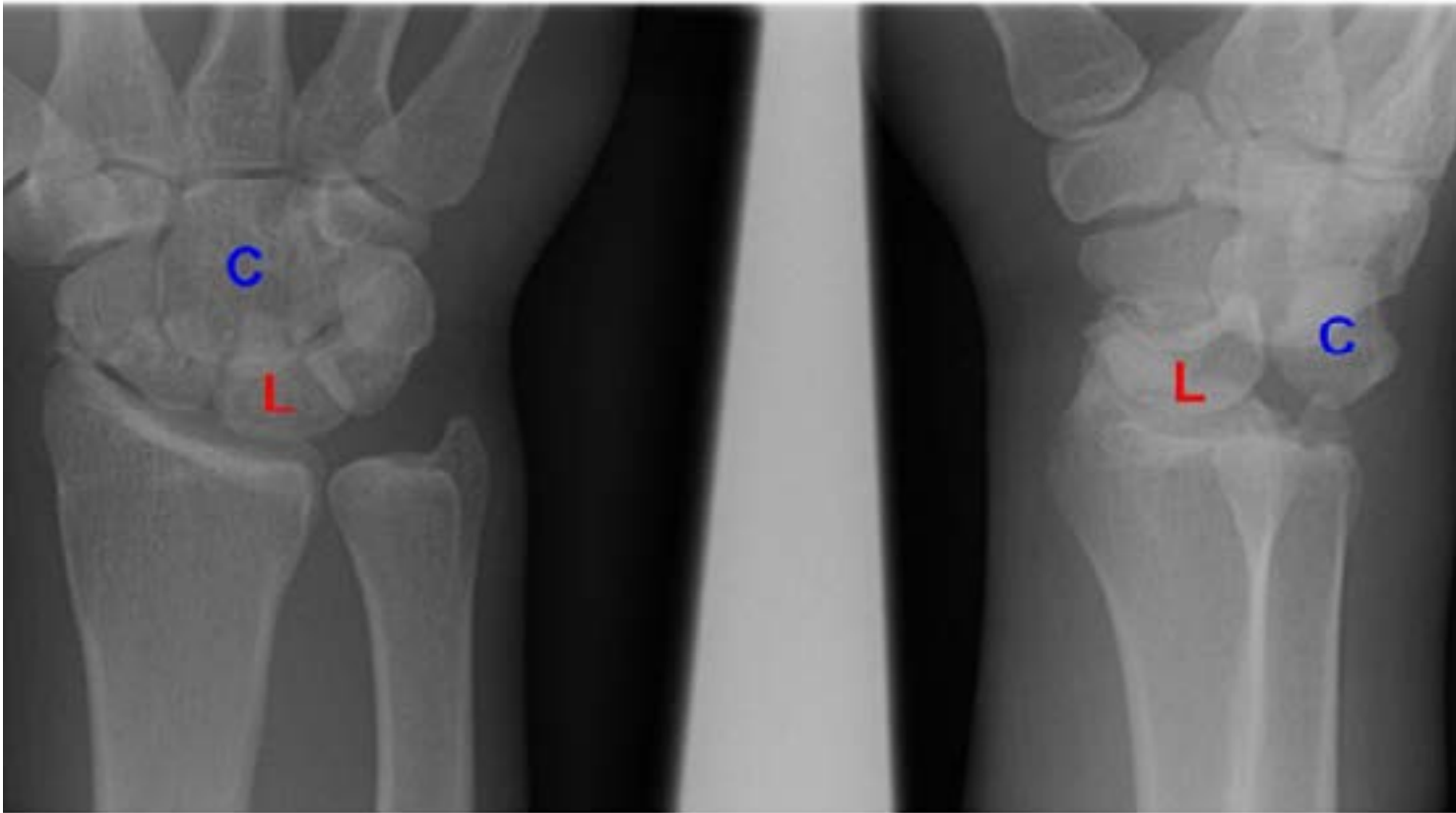
Take some time to review these injuries and look at the images:



Scapholunate dissociation depicting the Terry Thomas sign



Lunate dislocation



Perilunate dislocation

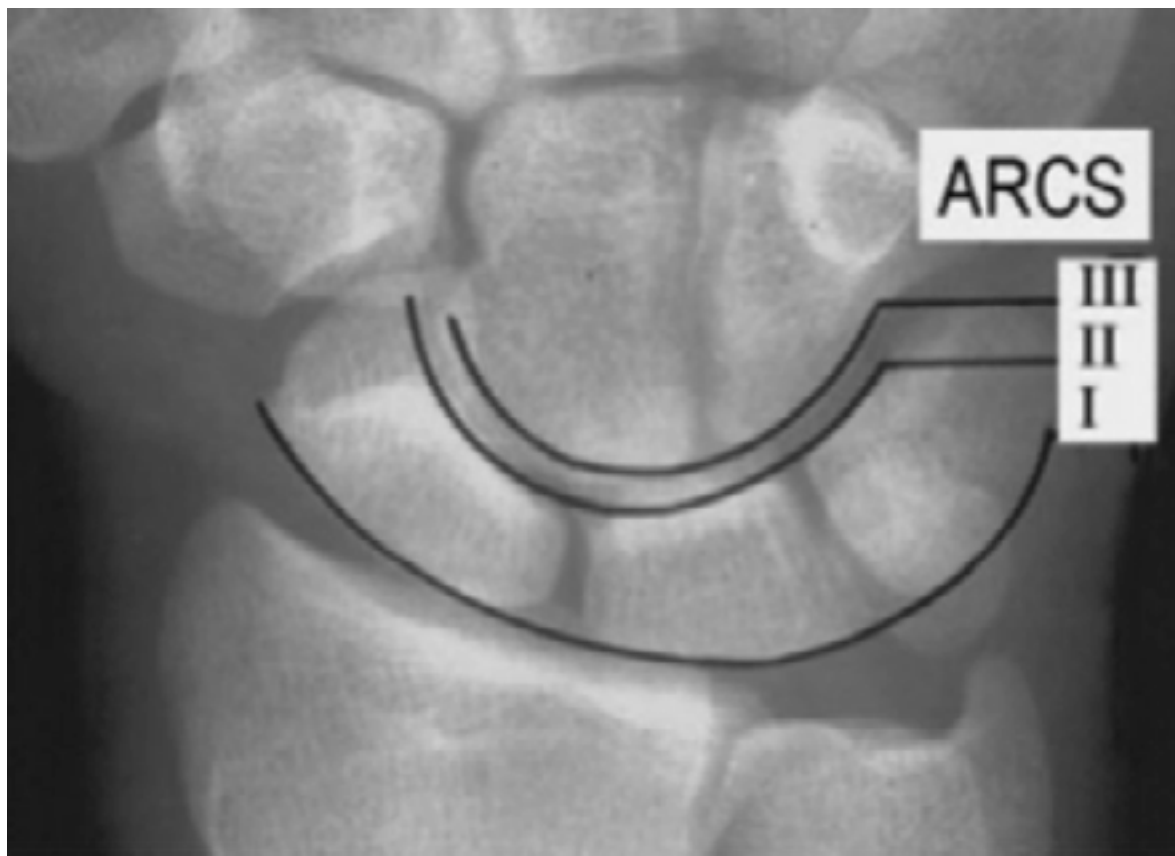
Q: Good thing you decided to send her to the fracture clinic! Why are perilunate dislocations commonly missed?

A: Swelling and deformity are often absent on exam. The x-ray findings can be very subtle.

Q: The carpal bones are plentiful and difficult to remember and assess on x-ray. What should you be looking for on the AP x-ray for perilunate injuries in general?

A:

1. On the AP x-ray of the wrist, think of carpal bones as flagstones that should have equal distances of 1-2mm between them. Any narrowing/overlap or widening between carpal bones should make you suspicious of a serious perilunate ligamentous injury. If you can't "drive a car around all the bones" then you should suspect a perilunate injury.
2. There are typically 3 smooth Gilula lines, which form arcs between the rows of carpal bones. These lines should be smooth. If there are any steps or disruption of these lines, you need to consider a perilunate ligamentous injury.



Gilula lines on a normal AP x-ray of the wrist – any disruption in these lines should raise your suspicion for a ligamentous injury

.....

Q: What is the main, classic x-ray finding of a scapholunate dissociation?

A: A gap between the scaphoid and lunate on the AP x-ray of the wrist of $>3\text{mm}$ is a scapholunate *dissociation* until proven otherwise. This x-ray finding has been described as *The Terry Thomas sign* or *The David Letterman sign* as well as *The Madonna sign* as all 3 of these famous celebrities have a visible gap between their two front teeth.



Terry Thomas or David Letterman or Madonna sign – a gap between the scaphoid and lunate on the AP view of the wrist indicating a scapholunate dissociation

Q: What are the main x-ray findings for a perilunate dislocation and lunate dislocation on x-rays of the wrist?

A: On the AP x-ray of the wrist, there is crowding of the carpal bones such that the normal 1-2mm of space in between the carpal bones is lost in both *perilunate* and *lunate* dislocations. Sometimes a *triangular appearing lunate* will be found in a *lunate dislocation*.

On the lateral x-ray, there should be normal “*stacking of cups*”. The radius, capitate, and base of metacarpals all look like cups and should stack on top of each other in a straight line. Assess the *radio-lunate-capitate* line, a vertical line through the radius, which should normally bisect the capitate. If there is not normal stacking, consider a perilunate dislocation. With further displacement of the lunate out of the seat of the capitate, the lunate appears like a “*spilled tea cup*” and then is classified as a complete *lunate dislocation*.



“Stacking of cups” alignment of radius, capitate, lunate and 2nd metacarpal on normal lateral x-ray of the wrist.



The “spilled tea cup” appearance of a lunate dislocation.

Q: Why is it so important to diagnose perilunate dislocations early on? What are the consequences of missing a perilunate dislocation?

A: There can be long-term functional disability and pain. There is a significant risk of median nerve palsy, pressure necrosis, compartment syndrome and long-term wrist dysfunction related to osteoarthritis, carpal tunnel syndrome and joint stiffness.



Clinical Pearl:

A FOOSH injury + acute carpal tunnel syndrome = perilunate dislocation until proven otherwise

Q: A few shifts later, after reading up on perilunate dislocations, you diagnose one. You're feeling pretty good about picking up the diagnosis, but you have never reduced one before. How do you perform a closed reduction of a perilunate dislocation in the ED?

A: Closed reduction of a perilunate dislocation is a simple procedure that can and should be done by the ED physician in the ED. The elbow is flexed to 90 degrees while the hand is placed in finger traps. Ten-15 lbs of longitudinal traction is applied for 10 minutes. With a dorsal dislocation, the wrist is initially extended and traction is applied. The wrist is then flexed with volar pressure applied to the lunate. A palpable clunk may be perceived.

Post-reduction, these patients should be placed in a volar slab, in neutral position to avoid median nerve damage.

If adequate anatomical reduction is achieved, these patients require close orthopedics follow-up in 1-2 days for possible operative management.

CASE 3: THE “DRUJ” INJURY

A 52-year-old man runs for the bus, trips and lands onto an outstretched hand. He comes in complaining of right wrist pain. On physical examination, he is tender and swollen on both the distal radius as well as the ulnar styloid. The x-ray of his wrist shows an undisplaced distal radius fracture. He's placed in a volar below-elbow plaster wrist splint and given follow-up in your local fracture clinic in 2 weeks.

Q: Do you think this course of action is reasonable? What other diagnoses might you consider and look for on x-ray?

A: One common way of missing orthopedic injuries occurs when we find one injury, and instead of continuing to look for another injury, we stop prematurely and miss a second significant injury. This is known as *search satisficing*, which reflects the universal tendency to call off a search once something is found. Co-morbidities, second foreign bodies, other fractures, and co-ingestants in poisoning may all be missed.

A second key principle in orthopedics is to look above and below the joint obviously affected for additional injuries. Using this cognitive forcing strategy will help you pick up that second, more subtle orthopedic injury that may have serious consequences for your patient.

EM Cases Cross-link: [To listen to more on Cognitive Decision Making and Bias, check out Podcast Episode 11 here](#)

All patients who have suffered from a distal radius fracture should be assessed for a *DRUJ injury*, especially if they have ulnar styloid tenderness without an ulnar styloid fracture present on the x-ray. A **DRUJ injury** is a **D**istal **R**adius **U**lnar **J**oint Injury.



Caution!

After a FOOSH, either in isolation or associated with a wrist fracture, pain that is predominantly over the distal ulna is a DRUJ injury until proven otherwise.

When the splint was removed after 2 weeks, the patient had significant pain and tenderness not only on the distal radius but also across the entire wrist. The original x-rays were reviewed and on the lateral, you could see that the ulna was displaced dorsally relative to the radius, and a DRUJ injury was diagnosed.

Q: What are physical exam findings in a DRUJ dislocation?

A: Be suspicious of a DRUJ *dislocation* if:

1. The ulnar styloid is more or less prominent on the affected wrist
2. You may feel crepitus and/or blocking on pronation or supination of the wrist.
3. You may feel the **“piano key” sign**, which is the ability to ballot the ulnar styloid.
4. Look for the **ulnar fovea sign**, which is point tenderness over the ulnar capsule, palmar to the extensor carpi ulnaris tendon.



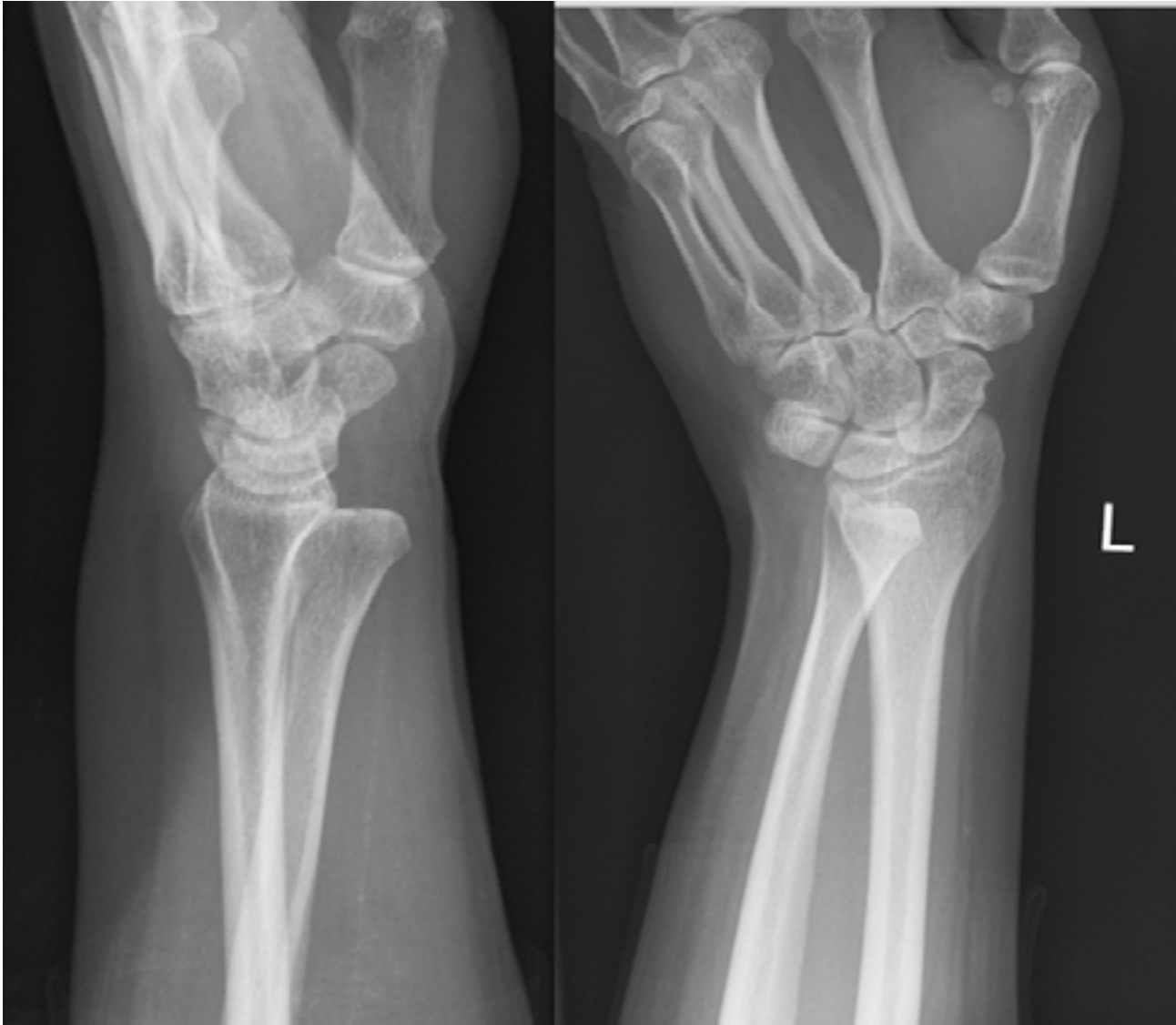
The ulnar fovea sign, tenderness over the area demonstrated here, is the most reliable clinical finding. The patient will have point tenderness over the ulnar capsule, just palmar to the extensor carpi ulnaris tendon

Q: Not all DRUJ injuries are created equal. What injuries encompass the spectrum of DRUJ injuries?

A: DRUJ injuries range from a simple sprain to a complete dislocation of the joint. DRUJ injuries are commonly associated with a FOOSH injury, with or without distal radius fractures. DRUJ injuries can also occur with other carpal injuries.

Q: The x-ray findings of DRUJ injuries are often subtle or absent. However, with a full dislocation of the DRUJ, the x-ray usually is abnormal. What are x-ray findings of a DRUJ dislocation?

A: On the AP x-ray of the wrist, look for widening of the joint >2mm. On the lateral x-ray, look for displacement or subluxation of the distal ulna compared to the distal radius. The majority of DRUJ dislocations are dorsal.



DRUJ Dislocation



DRUJ Immobilization:

Immobilize with an above-elbow splint with the patient's forearm supinated and the wrist in slight extension.

Q: Missing a DRUJ dislocation can result in significant long-term pain and disability. It is best to reduce a DRUJ dislocation in the ED to avoid this. How are subluxed or dislocated DRUJs reduced and immobilized?

A: The majority of DRUJ subluxations or dislocations are dorsally displaced. In these cases, supination and pressure over the ulnar head typically reduces this injury. Obtain a post-reduction x-ray and place the patient in an above-elbow splint in supination similar to the way you would immobilize a patient with a Smith's fracture.



- In patients with a FOOSH who also have ulnar sided wrist pain (especially if the patient has a distal radius fracture), consider a DRUJ subluxation or dislocation.
- On exam, check for a prominent ulnar styloid compared to the contralateral wrist, look for the piano key sign, look for a block and feel for crepitus in pronation and supination. Finally, don't forget the ulnar fovea sign!
- Often the x-ray views are not revealing, and you will need to go on to CT.
- Dorsal dislocations need to be reduced in the ED simply by supinating the forearm. Then, repeat the imaging to verify reduction and immobilize the patient in supination in an above-elbow splint.

CASE 4: PELVIC APOPHYSEAL AVULSION FRACTURES

An 18-year-old kick-boxer comes in to your ED after a fight. He attempted to kick his opponent in the head, but missed and felt a sudden onset of pain in his right buttock and thigh. He says he thinks he pulled his hamstring. He refuses to sit down on the stretcher because he says it really hurts. He has an antalgic gait.

Q: Would you x-ray this patient with a presumed hamstring strain?

A: Yes, you should. You need to rule out an apophyseal avulsion fracture whenever a young athlete (<25 years of age) presents with what seems like a pulled muscle that attaches to the pelvis – this includes hip pain, buttock pain or groin pain.

The mechanism of injury in apophyseal avulsions is sudden forceful concentric or eccentric muscle contraction during running, jumping or kicking a ball, which results in traction on the immature apophysis.

Q: What are the common sites affected by pelvic apophyseal avulsion fractures?

A: The *ischial tuberosity* is the most common site of a pelvic apophyseal avulsion fracture that results from a sudden contraction of the hamstring muscle.

Other Pelvic Apophyseal Injuries include:

- Iliac crest avulsion
- Anterior superior iliac spine (ASIS) avulsion
- Anterior inferior iliac spine (AIIIS) avulsion
- Greater trochanter avulsion
- Lesser trochanter avulsion



Ischial pelvic apophyseal avulsion fracture

Q: Why is it important for ED practitioners to know about pelvic apophyseal avulsion fractures?

A: These avulsion fractures take longer to heal compared to a simple strain (can take up to 6-8 weeks). Commonly, management is initiated with non-weight-bearing using crutches, then weaning as tolerated.

Click here for more in [Chapter 7: Tendon and Ligament Injuries](#) and [Chapter 6 for more on Occult Fractures and Dislocations](#)



Comments?

[Click here to leave a comment or to listen to this podcast](#)

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CHAPTER 2: PEDIATRIC HEAD INJURY

[LISTEN TO THE PODCAST WITH RAHIM VALANI AND JENNIFER RILEY HERE](#)



Objectives

1. Outline the classification of pediatric traumatic head injuries
2. Review and compare the PECARN and CATCH clinical decision instruments for minor head injury
3. Explore the role of skull x-rays in children with minor head injury
4. Review Return to Sport guidelines after pediatric head injury
5. Review elevated ICP management in a critically ill child with traumatic brain injury

CASE 1: MINOR HEAD INJURY

A mother presents to the emergency department with her 9-month-old male infant who fell down 4 steps onto a concrete sidewalk while in a stroller that had overturned. She reports that he cried immediately, did not vomit and did not have a seizure. The infant is otherwise healthy, with no previous head injuries or significant medical history.

On examination, he is alert and crying. His heart rate is 132bpm, blood pressure is 85/50, respiratory rate is 26, temperature is 36.5°C and O2 saturation is 99% on room air. His GCS is 15 with equal and reactive pupils. Neck range of motion is normal. He is moving all limbs normally. Full exposure of the infant reveals a 3cm boggy occipital hematoma. There are no signs of basal skull fracture, and no signs of injury of the chest abdomen back or limbs.

Q: How would you classify this head injury – trivial, minor, moderate or severe?

Trivial Head Injury:

- GCS 15
- No loss of consciousness, low energy mechanism
- Small frontal hematoma, no other signs of traumatic brain injury (TBI)
- Older than 1 year old

Minor Head Injury:

- 85% of non-trivial head injury
- GCS 14-15
- Loss of consciousness, amnesia, or confusion
- Disorientation
- Other symptoms/signs – vomiting, headache
- Impact seizure

Moderate-Severe Head Injury:

- GCS ≤ 13 or deteriorating GCS
- Penetrating head injury
- Focal neurologic findings
- Late seizure (not impact)
- Known child abuse

Q: Does this infant require a CT scan of the head to rule out significant TBI?

A: In general, the incidence of clinically significant TBI requiring intervention in children with minor head injury is low. While the yield of CT in minor head injury for any intracranial lesion is approximately 5%, neurosurgical lesions occur in only 0.5%.

Proportion of all-comers with minor head injury that will require intervention:

- Normal mental status – 0.8%
- AND No signs of skull fracture – 0.5%
- AND No history of vomiting – 0.2%
- AND No history of persistent headache – 0%

Selective populations have very low risk of TBI:

- *Isolated* vomiting
- *Isolated* LOC
- *Isolated* amnesia

Radiation Considerations in Pediatric Head Injury Imaging

The fastest growing group of patients getting CT scans is pediatric patients, with an estimated 600,000 CT scans done annually on children under the age of 15 years in the United States. The lifetime risks of cancer due to CT scans (which have been estimated in the literature using projection models based on atomic bomb survivors) are about 1 case of cancer for every 1,000 people who are scanned. For CT head in children in particular, a retrospective cohort study assessing leukemia and brain tumour risk from pediatric head CT estimated that one case of leukemia and one brain tumour will be caused by every 10,000 children scanned. Radiation exposure in infancy may effect IQ later in life.



PECARN Study:

Clinical Decision Instruments for Pediatric Head Injury

PECARN study – validated predictors of clinically important TBI in children younger than 2 years include:

- 1.** Altered mental status
- 2.** Non-frontal scalp hematoma
- 3.** Loss of consciousness for at least 5 seconds
- 4.** Severe mechanism of injury
- 5.** Palpable skull fracture
- 6.** Not acting normally according to the parent

The risk of clinically important TBI in a child with none of these six predictors was found to be 0.02%. In prospective validation, both the sensitivity and negative predictive value for the detection of TBI was 100% for children <2 years old.

For children with one or more of these predictors, either CT scan or observation may be appropriate, depending on several factors, such as physician experience, with a lower threshold to image children with multiple, more severe, or worsening signs or symptoms.

Clinicians should not use these criteria to trigger a scan in a child whom they otherwise would not image. Extra caution is still advisable in children younger than 3 months, in whom clinical evaluation is less reliable.

The PECARN group also performed a secondary analysis of a prospective observational cohort of children with minor head injury and a GCS of 14-15 who had isolated vomiting

For the CATCH study clinical prediction instrument and comparison to the PECARN rule, see Case 2.

Q: What is the significance of a scalp hematoma in an otherwise asymptomatic head-injured infant?

A: Among asymptomatic head-injured infants, the risk of skull fracture and associated intracranial injury is correlated with scalp hematoma size >2cm and location (non-frontal).

Q: Is there any role for a skull x-ray in ruling out clinically significant TBI?

A: Background: Eleven percent of children under the age of 2 years will sustain a skull fracture associated with head trauma. Fifteen to 30 percent of these will have TBI; therefore, in a child under the age of 2, a skull fracture is a predictor of TBI. Children with skull fractures require a CT head to rule out significant intracranial injuries.



While there is little evidence for the role of skull x-rays in ruling out clinically significant TBI, in practice locations where CT is not readily available, consider a skull x-ray for children under the age of 2 years who present with a significant scalp hematoma with no other signs of TBI as a screening test for skull fracture. Ensure a radiologist's interpretation, as emergency physicians' interpretations of pediatric skull x-rays have been shown to have poor accuracy for detecting skull fractures.



Clinical Pearls in Pediatric Minor Head Injury:

- 1.** Isolated loss of consciousness or amnesia: In one study of 2,043 children with minor head injury, isolated LOC and/or amnesia with no other signs or symptoms, none had a positive CT and none required surgery.
- 2.** Persistent irritability is always a worrisome sign in a head-injured child under the age of two years.
- 3.** Isolated vomiting is rarely associated with significant TBI. Some experts believe that post-head-injury vomiting may be more related to a personal history of recurrent vomiting; on the other hand, persistent vomiting associated with other symptoms of TBI does have a significant positive predictive value for TBI.

[Click here for an analysis of studies of isolated vomiting in pediatric minor head injury](#)

CASE 2: MODERATE HEAD INJURY

A 6-year-old boy was walking with his family on a windy evening. As they were walking by a construction site, a truck driver opened a large metal gate, which swung out of control and hit the child in the head. The child was thrown back approximately 6 feet and landed on the back of his head on the edge of a cement curb. There was a loss of consciousness of 3-5 minutes and upon awakening, the child was confused and had two episodes of vomiting. He arrives in the emergency department with paramedics. On further questioning he is amnestic, however, he does recall walking with his parents prior to the event. In the ED, he is perseverating.

On examination:

Heart rate is 110bpm, blood pressure is 118/60, respiratory rate is 20, Temperature is 36.5°C and O₂ saturation is 98% on room air.

A: Patent

B: Breathing spontaneously, good air entry bilaterally

C: Cap refill 3 seconds, pedal pulses present.

D: Pupils are equal and reactive at 4mm, GCS is 13.

There is a large hematoma to the forehead as well as a large occipital hematoma. There are no signs of basal skull fracture. Abdomen is soft, non-distended, bowel sounds are present. The pelvis is stable. Extremities are normal. No tenderness over the spine. Neurological examination is normal, aside from the GCS of 13.

The patient is otherwise healthy; all of his immunizations are up to date.

Q: Does this child require a CT scan?

A: As you know from Case 1, Kupperman's PECARN study helps us to decide whom not to CT scan. In addition, we can use the CATCH study to help us decide whom to CT scan.



CATCH Study:

The Canadian Assessment of Tomography for Childhood Head Injury (CATCH)

CT Head is required only for **minor head injury** patients with any one of these findings:

- Minor head injury is defined as injury within the past 24 hours associated with witness loss of consciousness, definite amnesia, witness disorientation, persistent vomiting or persistent irritability (in a child <2 years of age) with a GCS of 13-15.
- **High Risk (100% sensitive for neurological intervention)**
 1. GCS score <15 at 2 hours post-impact
 2. Suspected skull penetration or depressed fracture
 3. Worsening headache on history
 4. Irritability on exam
- **Medium Risk (98% sensitive for any lesion on CT scan)**
 1. Any sign of basilar skull fracture
 2. Large, boggy scalp hematoma
 3. Dangerous mechanism:
 - a. Fall from height ≥ 3 feet or ≥ 5 stairs, or
 - b. Motor vehicle related
 - c. Fall from bicycle with no helmet

[A prospective study](#) comparing the sensitivity and specificity of the PECARN and CATCH rules, as well as a third set of rules called the CHALICE, found the PECARN rules to be the most sensitive (100%), while the CATCH rules were found to be 91% sensitive. This is to be expected as the PECARN rules are meant to rule out the need for a CT in minor injuries, as opposed to rule in the need for one. The CHALICE rule was identified as the least sensitive.

Q: What are the signs of basilar skull fracture?

A:

- Hemotympanum
- Periorbital ecchymosis (raccoon eyes)
- Mastoid bone ecchymosis (battle's sign)
- Cerebrospinal fluid leak from the nose or ears (otorrhoea/rhinorrhoea)



Signs of Basilar Skull Fracture

Q: What are the key differences between the adult CT Head Rule and the CATCH rule?

A: The CATCH rule does not include vomiting and amnesia but instead includes irritability in a child <2 years old, or worsening headache in the older child, and the presence of a large boggy scalp hematoma.

Q: How long should a child with mild or moderate head injury who is deemed unsuitable for a CT scan be observed in the emergency department?

A: If the child has any of the following: history of loss of consciousness, amnesia, confusion, lethargy or persistent vomiting, severe or persistent headache, immediate post-traumatic seizure, then guidelines suggest either a 4-6 hour observation period, or going straight to CT scan.

Q: What discharge instructions should be given to children with minor head injuries or moderate head injuries who are deemed suitable to go home?

A:

- The first 6 hours post-injury are referred to as the “red zone”, and the following 24 hours are the “yellow zone”.
- Waking up the patient every two hours is probably not necessary (and if the clinician believes the patient to be high-risk, he/she should be kept in the department longer).
- Partially waking up the patient once during the night to assure reasonable behaviour might be reasonable, especially if within the “red zone” time.

Q: When can the patient return to sport?

A: A variety of guidelines exists to help answer this question, but every athlete needs an individual approach to prevent second-impact syndrome. A reasonable general guideline includes refraining from all activity until one week post-resolution of post-concussive symptoms (headache, amnesia, dizziness), and then to use a step-wise approach: mild exertion to increase heart rate, sport-related activity with no contact, progressive return to full practice, then return to game situations. If symptoms develop at any of these stages, go back to the previous stage and consult the primary caregiver of the patient. [See CPS summary on evaluation of concussion and Return to Play guidelines here](#)

EM Cases Cross-Link: [For Dr. Joel Yaphe's review of the guidelines 'Concussions and their consequences: current diagnosis management and prevention' from CMAJ, 2013 from Whistler's Update in EM Conference 2014, go here](#)

Q: How are pediatric head injuries different compared to adult head injuries?

- A:**
- Children's skull sutures are not closed yet, leading their skulls to be more distensible than those of adults. This leads to less TBI after head trauma with comparable mechanism of injury.
 - Children sustain fewer mass lesions and fewer hemorrhagic contusions.
 - Children sustain more diffuse brain swelling and can "talk and deteriorate" with edema alone.
 - Children sustain more diffuse axonal injury.
 - Children sustain more hypoxia.
 - Children have more seizures.

CASE 3: MAJOR HEAD INJURY

A 5 year-old girl was the front-seat passenger in a motor vehicle crash. The child was wearing her seat belt, but no airbags were deployed. The collision occurred when the driver lost control of the car on the highway, hitting the concrete divider on the left side of the vehicle. It was unknown whether the child lost consciousness. At the scene, the child was confused and combative. Unfortunately, the driver of the vehicle did not survive.



On examination, the vitals are as follows:

Heart Rate is 100 bpm, blood pressure is 130/90mmHg, respiratory rate is 24, temperature is 36.6OC, O2 saturation is 98% on O2.

- A: Patent
- B: Breathing, good air entry bilaterally
- C: Cap refill 3 seconds, pedal pulses present.
- D: Pupils are equal and reactive at 4mm, GSC is 7 (E3V2M2).
No focal neurological findings.

There are multiple abrasions, a contusion over one eye, a lip laceration, and a chipped tooth. There is a seat belt bruise on the abdomen, and the abdomen is tender. There are stellate lacerations of 3cm and a hematoma over the right parietal region, with no palpable skull depression. There are no signs of basilar skull fracture. In addition, there is an open, complex fracture of the right ankle.

As you are examining the child, her conditions worsen: The GSC drops to 3, while the heart rate and blood pressure remain steady at 95bpm and 140/95. The right pupil remains at 4mm while the left pupil is now 7mm.

Q: Assuming that you want to intubate this patient and send her for an immediate CT, how best would you sedate the child for intubation and CT scanning?

A: Although the literature is sparse and controversial for the effectiveness of premedication to blunt the effects of intubation on raised intracranial pressure (ICP) in the pediatric population, consider pre-medication of fentanyl or lidocaine as part of rapid-sequence intubation (RSI) algorithm. It is important to note that these medications need to be given a full 2-3 minutes before intubation to be effective, therefore they are not suitable in a “crash” intubation situation.

The induction agent should aim at preventing a drop in blood pressure, given that $CPP = MAP - ICP$ [cerebral perfusion pressure equals mean arterial pressure minus ICP]. Etomidate probably remains the agent of choice. However, there is evidence that ketamine is a safe and suitable alternative for sedation in TBI with recent systematic reviews failing to demonstrate increased ICP after ketamine use. Ketamine may offer neuroprotective effects secondary to its effects on NMDA receptor activity.

For sedation to enable CT scanning in the young pediatric patient, agents that decrease blood pressure should be avoided. Ketamine is an ideal agent for this purpose as it has been shown not to raise intracranial pressure, is an effective analgesic and amnesic, may be neuroprotective and does not lower the blood pressure. Ketamine can be given intravenously, intramuscularly or by the intranasal route.



Expert Tip:

To enable CT scan sedation, keep the very young child awake as long as possible before going to the CT scanner, and perform the CT scan when they fall asleep. Feeding the child and then performing the CT scan during their post-feed nap can also be an effective way to enable sedation.

Q: What signs should I be watching for if I am worried about elevated ICP?

A: Elevated ICP occurs in up to 80% of children with TBI. Clinical clues of increased ICP include worsening headache, visual or neurologic complaints, persistent vomiting, as well as abnormal pupillary reflexes, decreasing level of awareness, lateralizing features and Cushing's triad.

Q: How do I manage elevated ICP?

A: Methods for acutely decreasing ICP in the emergency department include elevation of the head of the bed 30 degrees with the head midline, intravenous mannitol or hypertonic saline administration and hyperventilation, which is only used as a temporizing measure in a patient who shows evidence of brain herniation or who is being imminently transferred to the operating room (target pCO₂ is 30-35mmHg).

Mannitol works by creating an intravascular osmotic pull, hence decreasing blood viscosity and increasing intravascular osmolarity. This helps to decrease brain edema by setting up an osmotic gradient across an intact blood-brain barrier (BBB). Mannitol is dosed as bolus of 0.25-1g/kg.

Q: Is there an alternative to mannitol for the treatment of elevated ICP?

A: Hypertonic saline (3%) was shown to be more effective than mannitol in lowering raised ICP in one meta-analysis of adult studies and is recommended especially if the patient is hypotensive as it has no osmotic diuretic effect. It is given as a bolus of 2-6mL/kg, followed by an infusion of 0.1-1mL/kg/hr.

FOAMed Link: [For a detailed analysis of elevated ICP management see Dr. Scott Weingart's suggestions on EMCrit](#)



Comments?

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CHAPTER 3: PEDIATRIC ORTHOPEDICS

[LISTEN TO THE PODCAST WITH SANJAY MEHTA AND JONATHAN PIRIE HERE](#)



Objectives

1. Develop an approach to managing a child with an acute knee injury
2. Have an age-appropriate differential diagnosis for the limping child
3. Review the evidence for the diagnosis of septic arthritis in a child
4. Develop an approach to closed ankle injuries in children
5. To assess children with a FOOSH
6. To diagnose a supracondylar fracture and properly assess it

CASE 1: KNEE INJURY

A mother presents to the emergency department with her 12-year-old son. While playing basketball in gym class, he planted his foot and rotated his left leg following a jump, resulting in a fall to the ground. He had to be carried off the court. He complains of severe pain in his left knee and says he cannot put weight on it. He says he may have heard a “pop” as he planted. He denies any other injury and is previously healthy with no medications or significant medical history.

On exam, his vitals are within normal limits. His left knee is swollen with a balotable effusion and is very tender to the touch diffusely. He is unable to extend completely and can only flex to about 45 degrees. There appears to be anterior laxity of the knee. He is unable to weight bear.

Q: What diagnosis is this history and physical exam classic for?

A: The mechanism for an Anterior Cruciate Ligament (ACL) rupture is classically rotation of the knee against an immobile foot, with sudden deceleration, often in sports such as basketball, tennis and soccer. Often a “pop” is felt or heard and significant swelling usually occurs within the first hour after injury with minimal ability to weight bear.

Q: What is the most sensitive physical exam maneuver for ACL rupture?

A: A meta-analysis from 2003 showed that the pivot shift test was found to be the most sensitive (88.8%), followed by the Lachman test (77.7%), with the anterior drawer test having a sensitivity of only 22.2%. All three of these tests have a specificity of more than 95%.



Clinical Pearl:

Always do a straight leg raise to rule out injury of the extensor mechanism of the knee for any knee injury.

Video: [Click here for a video of how to perform physical exam maneuvers for ACL tears](#)

Q: For a patient with a suspected ACL tear, is an x-ray required? Does the clinical decision rule, The Ottawa Knee Rules, apply to children?

A:



The Ottawa Knee Rules

A knee x-ray is indicated if ANY of the following is present:

- Age >55 (clearly can be omitted in paediatrics)
- Pain at the fibular head
- Isolated patellar tenderness
- Inability to flex the knee to 90 degrees
- Inability to walk four weight-bearing steps both immediately and in the ED

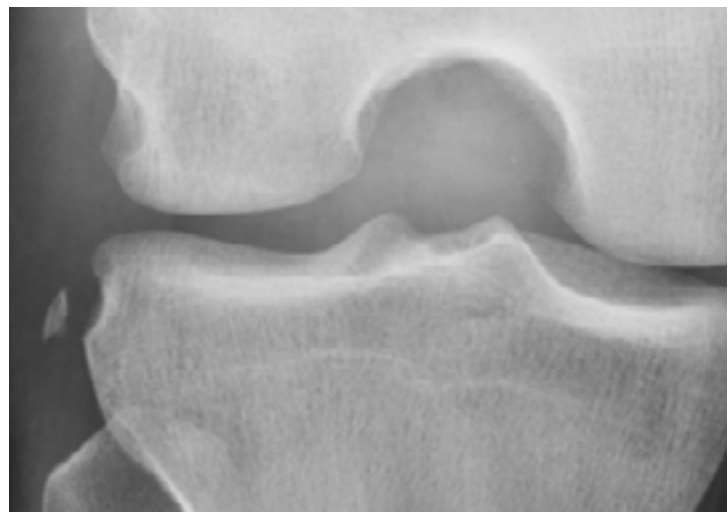
[The Ottawa Knee Rules](#) are 100% sensitive in children for clinically significant fractures and helps reduce x-rays by 31%. Note that the patient in our case would require an x-ray as per the Ottawa Knee Rules regardless of a suspicion of an ACL tear, because of the inability to weight bear.

A: Associated with ACL injuries, particularly in younger patients, are:

1. Tibial spine fracture
2. Segond fracture, a vertically oriented avulsion fracture off the lateral proximal tibia



Tibial Spine Fracture



Segond Avulsion Fracture

! Caution!

In general, children's ligaments are stronger than their bones and so fractures are more likely than sprains. Therefore, have a low threshold for ordering x-rays in children. Through adolescence and adulthood the opposite is true, as bones become stronger than ligaments, and so sprains are more likely than fractures.

Q: What additional x-ray views should I consider obtaining aside from the A-P and lateral, for suspected tibial spine and plateau fractures?

A: Tibial spine and tibial plateau fractures are best seen on a **"tunnel view"**.



Q: What is the ED management of suspected ACL rupture?

A: Removable splint as needed, crutches, and ROM exercises as tolerated until the patient can be re-examined in 2-3 days or up to 5 days later, once the swelling and pain have improved.

In general, patients with ligamentous injuries of the knee (not only ACL injuries but MCL injuries, or patients whose injuries you are unsure of but whose x-rays are negative and you suspect a ligament or meniscus injury) should be encouraged to remove their immobilizers and begin gentle range-of-motion exercises in 2-3 days to avoid quadriceps atrophy, which would lead to prolonged rehabilitation.

ACL tears are being repaired more frequently in pediatrics than in the past. However, there's no rush to get them to the surgeon because most surgeons recommend delaying surgery until full range of motion has been recovered.

Any displaced fractures or fractures with an impaired extensor mechanism associated with a suspected ACL rupture need urgent orthopedic consultation.



Some experts recommend no immobilizers for these so-called “soft tissue injuries”, with weight bearing as tolerated.



Clinical Pearl:

Children who present with knee pain often have a diagnosis arising from the hip as a source of their pain, so look proximally if the clinical picture doesn't fit.

CASE 2: THE CHILD WITH A LIMP

A two-and-half-year-old girl who attends daycare presents to the ED with a two-day history of limp and refusal to weight bear. Her parents report a temperature of 38.2°C at home for the past two days and say that she's not eating and drinking as much as usual. They brought her in because today, when they attempted to move the child's leg, she started to cry. There has been no significant recent trauma, except for a minor trip and fall while running on the sidewalk 3 days prior. She has had a runny nose and cough for the past 3 days, but no difficulty breathing, no vomiting, diarrhea or rash. There has been no recent travel and no contacts. She has no significant past medical history.

On exam, the child appears alert but anxious and in pain on Mom's lap, with no apparent respiratory distress. Vital signs reveal a temperature of 37.9°C, a heart rate of 124, a respiratory rate of 30 and an oxygen saturation of 99% on room air.

Her ENT exam is normal except for nasal discharge. Chest is clear. There are a few scattered bruises on the shins. When you attempt any movement of the right knee, the child cries. Palpation of the right hip elicits crying as well. The child refuses to weight bear when you attempt to examine her gait.



Approach to a child with a limp

1. Rule out septic arthritis
2. Look for fractures – ask about traumas (can be subtle)
3. Look for signs of systemic illness such as a rash, fever, bruising
4. Consider age-specific diagnoses as appropriate



Clinical Pearl:

If the initial physical exam is not revealing due to an uncooperative child, give analgesia and re-examine the patient in 30-60 mins.

Q. Does this child have a septic arthritis?

A: Septic arthritis should cross your mind for any monoarthropathy, particularly in the hip, which is the most common site in children. There is no single tool or piece of information that can reliably rule out or rule in septic arthritis without obtaining a synovial fluid sample. However, there are tools available to assist in making a decision whether to perform a joint tap.

Case continued: WBC comes back at 14.5, CRP at 20 and ESR at 40.

Q. Can we use the information we have so far in this case to rule in or out septic arthritis?

A: [The Kocher Criteria](#) can be a helpful tool to help risk stratify a patient whom you suspect might have septic arthritis. It is best used as a rule in and is not a very sensitive test on prospective validation. When all four criteria are present, the probability of septic arthritis is 99.6%.



The Kocher Criteria

1. Non-weight-bearing on the affected side
2. ESR >40 mm/hr
3. Fever
4. WBC >12,000

Q. How useful is CRP in risk stratifying patients with suspected septic arthritis?

A: [On a retrospective review](#) of 311 children with a hip effusion, those with a CRP >20mg/L had an odds ratio of 81.9 of having a septic arthritis. However, like other factors, it is neither specific nor sensitive enough to rule a septic arthritis in or out. In the context of a low pre-test probability, negative CRP and ESR have a fairly good negative predictive value.

Treatment: In patients in whom you suspect septic arthritis, usually you can wait to start empiric IV antibiotics until after the joint can be aspirated. However, if there will be a significant delay to joint aspiration, start antibiotics on speculation.

Q. What is transient synovitis of the hip?

A: Transient synovitis of the hip is a self-limited inflammation of the synovial lining. It is often preceded by a viral infection, and should resolve in 3–10 days. However, concurrent illness can make diagnosis challenging. Pay attention to vital signs, general appearance and symptom progression. The presence of an effusion on ultrasonography does not differentiate between septic arthritis and transient synovitis.

FOAMed Link: [For more information on differentiating synovitis from septic arthritis see this post on Academic Life in EM blog here](#)

Q. What is the role of ultrasound in the work-up of suspected septic arthritis?

A: Most effusions can be detected by ultrasonography; however, effusions do not differentiate septic arthritis from transient synovitis.

The sensitivity of ultrasound for an effusion is 95-100%. However, up to 5% of septic hip ultrasounds can be negative initially, which typically occurs in early presentations, less than 24 hours into the disease course.



Investigating Septic Arthritis:

Some experts suggest the following ultrasound-based algorithm:

Low pre-test probability + Negative ultrasound:

Careful outpatient follow-up

Moderate pre-test probability + <24hrs symptoms

Ultrasound

- If negative, then repeat ultrasound in 12 hrs or MRI
- If positive then arthrocentesis for synovial fluid analysis

Moderate pre-test probability + >24hrs symptoms

Ultrasound

- If negative, then discharge with follow-up
- If positive, then arthrocentesis for synovial fluid analysis

Q: Next in the approach to the child with a limp after differentiating transient synovitis from septic arthritis is looking for fractures. What is the most commonly missed fracture that presents in a toddler with a limp?

A: A commonly missed occult fracture is the **Toddler's fracture** (spiral fracture in children 9-36 months, usually of distal tibia). The mechanism of injury is often minor (simple twisting mechanism) or there is no report of injury at all! It can present with subtle physical exam and x-ray findings. There is usually minimal or no swelling and subtle, difficult to localize point tenderness. Pain with ankle dorsiflexion or calf rotation should raise suspicion. Oblique views can help visualize the fracture and increase x-ray sensitivity.

Toddler's fractures are treated with an **above-knee immobilizing splint with the knee in slight flexion**, and orthopedic follow-up. However, if x-rays are normal and symptoms are mild, consider follow-up without a cast after discussing pros/cons with parents. If you have a high suspicion despite a normal x-ray, consider a long leg splint with close follow-up. Ultrasound can sometimes pick up the fracture if clinical suspicion is high but x-rays are normal.



Toddler's fracture

Q. Next in the approach to the child with a limp is ruling out systemic illness. This can usually be assessed with a careful history and physical for signs and symptoms of systemic illness such as rash, lethargy, etc. Finally, age-specific diagnoses should be considered. Which age specific diagnoses should we consider in the children presenting with a limp?

A:

Leg-Calve-Perthes (LCP) disease is an avascular necrosis of the femoral head, typically seen in children aged 4 to 10. It can present insidiously or may follow an injury. The initial x-ray can be normal or show a very subtle change in femoral head appearance. Speak to the radiologist on call to carefully review the images, and follow with a bone scan or MRI if very suspicious.

Slipped Capital Femoral Epiphyses (SCFE) is easy to miss! It can present subtly, with pain that radiates into the thigh or knee. Typical patients are older children, overweight, but also skeletally immature. On exam, pain is usually greatest with *internal rotation* of the hip, and they can present with the hip held in external rotation.

- Get x-rays of both hips, including frog's-leg view in addition to standard views. Draw a **Kline's line** from the external part of femoral neck, which should intersect part of the femoral head. As it slips, the femoral head becomes medial to that line. Compare both sides, but remember SCFE can be *bilateral*.
- If suspicious, call orthopaedics—these cases need surgical management and SCFE will worsen if patients continue to weight bear.



Kline's Line for SCFE



Non-accidental Trauma

Some fractures should *always* raise suspicion for non-accidental trauma (i.e. posterior rib fractures). However, non-accidental trauma can result in any type of fracture pattern. Always remember to be systematic when taking histories, and document carefully! Clues include:

- 1. Delay in presentation
- 2. Vague or inconsistent explanation of mechanism
- 3. Mechanism described that is inconsistent with injury
- 4. Injury inconsistent with developmental stage of child

FOAMed link: [Click here for a short lecture on child abuse injury patterns from Academic Life in EM](#)

Q: Before leaving the subject of the acutely limping child, what discharge instructions should be given to the parents for the limping child with an unclear diagnosis?

A: AVN of the hip can be missed early in its course, so repeat imaging may be required if there is no improvement of symptoms.

Septic arthritis can be missed early in its course, so arthrocentesis may be required if fever progresses, systemic symptoms and signs develop or pain increases.

Toddler fracture can be easily missed on x-ray, so a repeat x-ray may be required if symptoms persist.

CASE 3: ANKLE FRACTURES

A 6-year-old boy is running during recess at school and twists his ankle. He's unable to walk afterwards. On exam he's tender and swollen maximally over the distal fibula. The x-ray is normal.

Q: Do the [Ottawa Ankle Rules](#) apply in children?



A: Yes, [a 2009 meta-analysis](#) showed 98.5% sensitivity for ankle and midfoot fractures in children older than five years old, with nearly all the missed fractures being Salter-Harris I or classified as insignificant fractures.

[A 2001 prospective study](#) showed 100% sensitivity in ruling out clinically significant fractures in children using a “low-risk examination” technique where pain and swelling are limited only to the distal fibula and its associated ligaments.



The Ottawa Ankle Rules

If any one of the following is present, the patient requires a radiograph:

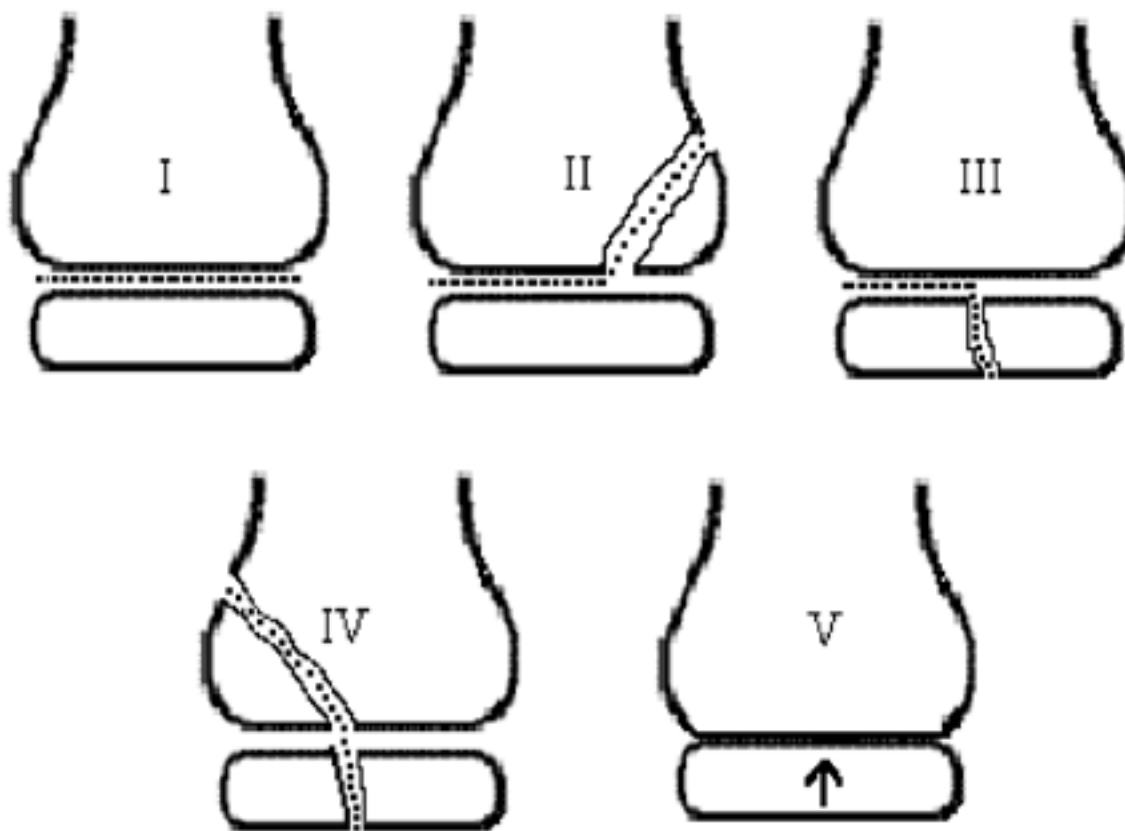
1. Tenderness of the posterior edge of distal 6cm of the fibula
2. Tenderness of the posterior edge of distal 6cm of the tibia
3. Tenderness of the head of the 5th metatarsal
4. Tenderness of the navicular
5. Unable to weight bear immediately and at the emergency department

EM Cases Cross-link: [Click here for images and explanations on Clinical Decisions Rules go EM Cases' Stiell Sessions 1: CDRs and risk scales](#)

Q: What is the Salter Harris pediatric fracture classification?

A: The **Salter Harris (SH)** system classifies fractures involving the growth plate of a long-bone. These are common in the distal fibula. Fractures are classified from one to five and can be remembered by the mnemonic **SALTER**:

- I – **S** = **Slip**. Fracture of the cartilage of the physis (growth plate)
- II – **A** = **Above**. Fracture above physis
- III – **L** = **Lower**. Fracture below the physis in the epiphysis
- IV – **T** = **Through**. Fracture is through the metaphysis, physis, and epiphysis
- V – **R** = **Rammed**. The physis has been crushed/heavily damaged



Salter Harris I and II fractures are the most common and rarely result in growth arrest.

MRI evidence suggests SH-1 fractures are similar to a sprain, and do well when treated as such. Non-displaced SH-II lateral malleolar fractures (isolated non-displaced lateral malleolus fractures) heal as well in a removable over-the-shoe ankle air-stirrup brace with weight bearing as tolerated as in a cast or boot, but patients prefer an ankle air-stirrup brace, and mobilize earlier.

[Click here for the Canadian Paediatric Society statement on paediatric ankle sprains](#)

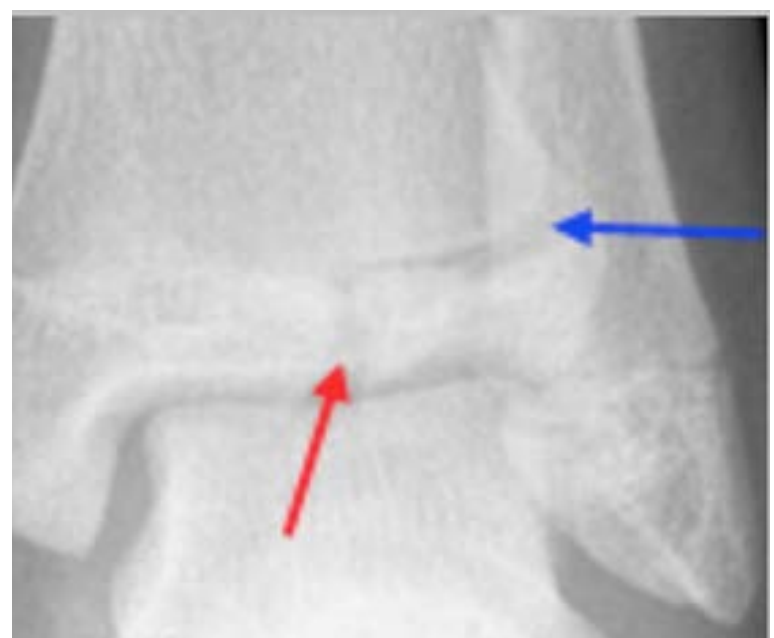
Two specific SH fractures are easy to miss in the pediatric population:



- 1. Tillaux fracture** is an intra-articular SH-3 with avulsion of the anterolateral tibial epiphysis, often from a low energy mechanism of external rotation of the foot or medial rotation of the leg on a fixed foot in children with partial growth plate fusion (aged 11–15). Pain and tenderness is at the anterior joint line of the ankle.
- 2.** Look carefully for a distal tibia **triplanar fracture** in adolescents (an unstable combination of SH-1, 2 and 3), which requires operative management.



Tillaux ankle fracture of the distal tibia



Triplanar ankle fracture of the distal tibia

CASE 4: THE FALL ON AN OUTSTRETCHED HAND

A 12-year-old boy was running on the sidewalk. He tripped and fell on his outstretched right hand. He complains of pain at his wrist only. Examination from the elbow to the snuffbox reveals slight tenderness at the distal radius. He is neurovascularly intact.

On x-ray there is a buckle fracture of the distal radius.

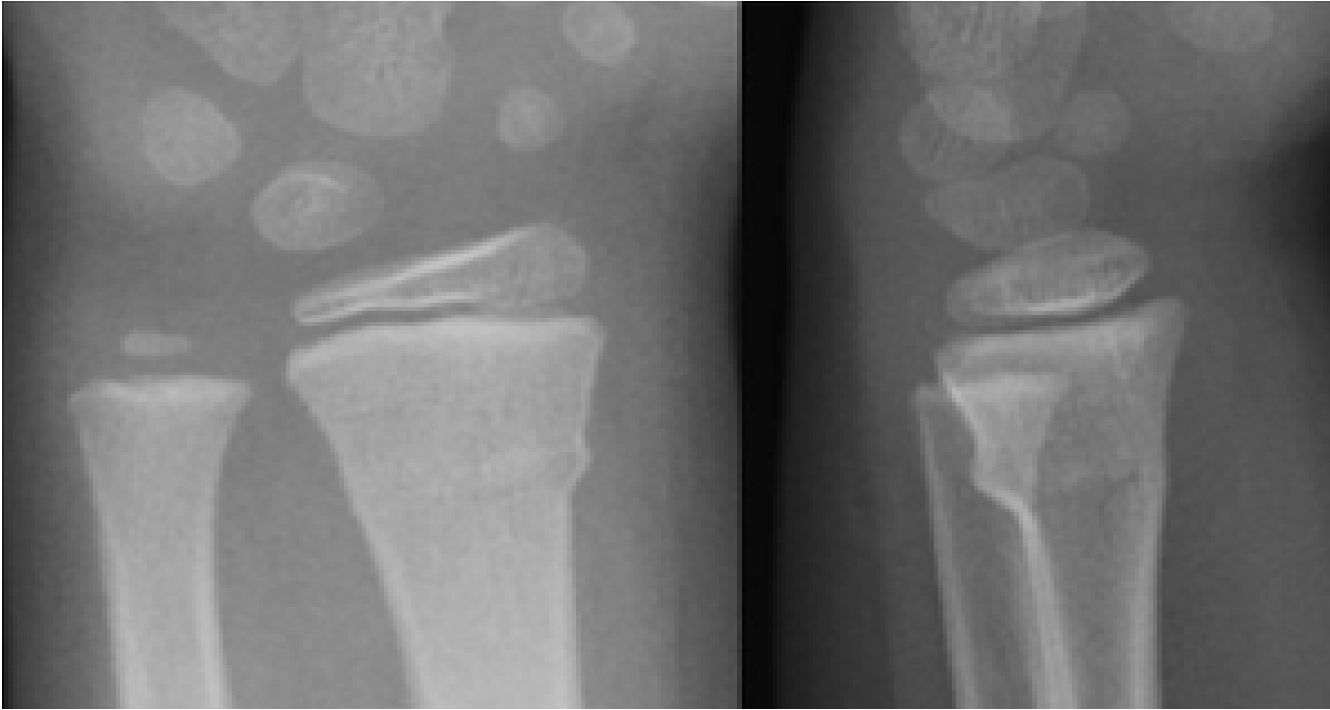
Q: What is a buckle fracture and how is it managed, compared to a greenstick fracture and a transverse fracture of the distal radius?

A: A **buckle fracture**, also known as a torus fracture, is an incomplete fracture of a long bone that is commonly identified by bulging of the cortex. The main mechanism is axial compression of soft, immature bones in children.

Buckle fractures of the distal radius heal well in a removable splint, and studies show that patients prefer this over a cast. A randomized control trial shows better physical function, less difficulty with activities, the ability to return to sports sooner, and pain scores that are either not significantly different when compared to a short arm cast, or less than with casting. There is even a study with just a soft bandage showing similar outcomes compared to a short arm cast.

Not only that, but studies have shown that the removal of the splint can be safely done at home rather than at a fracture clinic, guided by the child's symptoms. This of course assumes that the parents are agreeable, and are given good discharge instructions with regards to when they might need to seek medical care. In addition, parents prefer the removal of the splint at home over having to follow up in a fracture clinic.

Minimally angulated greenstick fractures (one cortex broken, the other intact) also do well with minimal splinting. Even minimally angulated transverse distal radius fractures of less than 15 degrees can also be treated effectively with a removable splint.



Minimally angulated buckle fracture of the distal radius

Q: What are the acceptable degrees of angulation in pediatric distal radius fractures?

A:

- <5 years old: up to 30 degrees is acceptable
- 5-10 years old: up to 20 degrees is acceptable
- 10-12 years old: up to 15 degrees is acceptable



Caution!

Bone in children remodels well in the dorsal/volar plane but not in the radial/ulnar plane, so if there is any displacement in the radial/ulnar plane, it usually needs to be reduced. On the other hand, if there is displacement in the dorsal/volar plane, you can accept more angulation and the bone will remodel well.

CASE 5: THE FALL ON AN OUTSTRETCHED HAND

A 12-year-old boy was running on the sidewalk. He tripped and fell on his outstretched right hand. He complains of pain at his wrist only. Examination from the elbow to the snuffbox reveals slight tenderness at the distal radius. He is neurovascularly intact.

Q: What are the most common fractures in general we can expect to see with a FOOSH mechanism?

A: From distal to proximal: scaphoid, distal radius, radial head, suprachondylar, proximal humerus and clavicle fractures

Q: Suprachondylar fractures are the most common elbow fractures in children and are rarely seen in patients older than 15 years. How should we assess neurologic status in children suspected of a suprachondylar fracture?

A: Suprachondylar fractures have a high risk of neurologic and vascular injuries.

Brachial Artery injury is reported in up to 20% of displaced fractures, with 80% of these regaining pulses after closed reduction.



Clinical Pearl:

Five percent of children with elbow fractures will have a second fracture at a distal site (at the wrist, for example), so it is imperative to examine the joint above and below the elbow for all children with elbow injuries.



Clinical Pearl:

If the distal pulses are not palpable after a suprachondylar fracture, the child will usually be holding their arm in extension. Try flexing at the elbow 15-20 degrees and splint while waiting for emergency reduction.

The anterior interosseous nerve injury is the most common nerve injury in extension-type injuries, while ulnar neuropathy is the most common in flexion-type injuries.

To test motor function of the anterior interosseus nerve, look for weakness in flexors of IP joint of thumb and DIP joints of index and middle fingers by observing how the patient pinches using their thumb and index finger. Normally when an individual pinches something between their index finger & thumb, the MP & IP joints of thumb and index finger are flexed; with nerve damage, the distal phalanges of thumb and index finger are extended or hyperextended.



Abnormal



Normal



Upper extremity peripheral nerve testing

Ask the child to do hand signals to test motor function of each nerve.

- Radial nerve - make a “thumbs up”
- Median nerve - make a fist, and pinch a piece of paper with a pincer grip
- Ulna nerve - make scissors with the index and middle finger, or a “peace” sign

For the sensory examination, test the first dorsal webspace (radial), dorsum of 2nd or 3rd fingertip (median) and fifth fingertip (ulna).

[Click here to jump to hand chapter for images on peripheral nerve testing](#)



Pitfall:

Avoid multiple attempts at closed reduction, given the vulnerable position of the neurovascular structures.

Q: Compartment syndrome is a potential complication of suprachondylar fractures. How can the chances of compartment syndrome be minimized and what would make you suspicious for compartment syndrome in a child with a suprachondylar fracture?



Pitfall:

Flexing the elbow to 90 degrees when immobilizing a patient with a suprachondylar fracture who has significant swelling may increase the risk of compartment syndrome, as this will decrease blood flow.

Q: What is your approach to the pediatric elbow X-ray?

1. **"Figure of Eight sign"** – confirms a true lateral (see image)
2. **Anterior fat pad** – "Sail sign" – an enlarged sail-shaped hypodensity should raise suspicion for a fracture
3. **Posterior fat pad** – any hypodensity posterior to the humerus should raise suspicion for a fracture
4. **Radio-capitellar line** – a line through the middle of the radius normally bisects the capitellum; any disruption of this line should raise suspicion for a fracture
5. **Anterior humeral line** – a line along the anterior border of the humerus should bisect the middle 1/3rd of the capitellum; any disruption should raise suspicion for a fracture
6. **"CRITOE"** – Capitellum, Radial Head, Internal epicondyle, Trochlea, Olecranon, External epicondyle. Review each ossification centre, which appears approximately every 2 years from age 2-13 to rule out an avulsion fracture masquerading as an ossification centre.



Clinical Pearl:

Consider x-ray of opposite elbow for comparison



1. **Figure of Eight sign** confirms a true lateral



2. **Anterior "Sail sign"**



3. Posterior fat pad sign



4. Radio-capitellar line



5. a) Suprachondylar fracture with posterior fat pad
b) Anterior humeral line



6. CRITOE mnemonic for elbow growth plates

C – capitellum
R – radial head
I – inner (medial) epicondyle
T – trochlea
O – olecranon
E – external (lateral) epicondyle

Q: How should suprachondylar fractures be managed in the ED?

A: Suprachondylar fractures should be immobilized in an above-elbow splint with the elbow at >90 degrees of flexion and lots of padding. Orthopedic consultation in the ED is necessary for all displaced suprachondylar fractures. Non-displaced fractures can be immobilized and followed up by an orthopedic specialist.

FOAMed Link: [Click here for a video tutorial on suprachondylar fractures on Radiopedia](#)



Pitfall:

Do NOT apply a circumferential cast for suprachondylar fractures as it increases the risk for neurovascular damage and compartment syndrome.

Flexing the elbow to 90 degrees when immobilizing a patient with a suprachondylar fracture who has significant swelling may increase the risk of compartment syndrome, as this will decrease blood flow.



Comments?

[Click here to leave a comment or to listen to this podcast](#)

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CHAPTER 4: HAND EMERGENCIES

[LISTEN TO THE PODCAST WITH ANDREW ARCAND & LAURA TATE HERE](#)



Objectives

1. Develop awareness and approach to some subtle yet important hand injuries
2. Learn key pearls and pitfalls in the management of “fight bites”, tendon lacerations, high-pressure injection injuries, gamekeeper’s thumb, flexor tenosynovitis, paronychia and felons

CASE 1: FIGHT BITE LACERATIONS

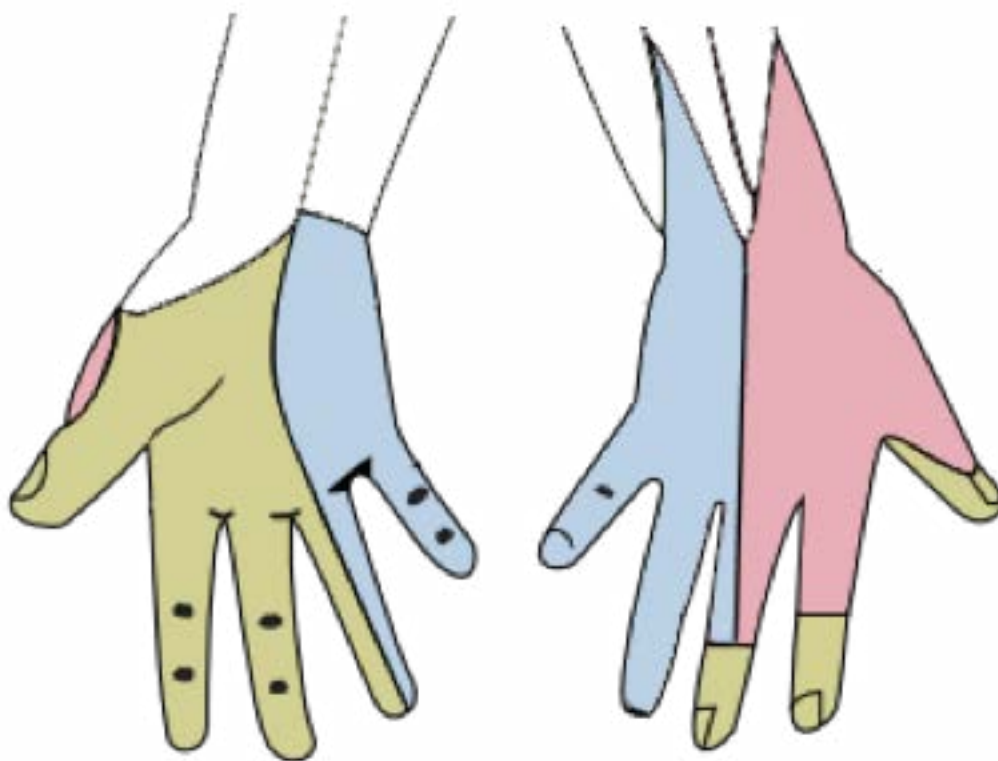
A 19-year-old man presents to your ED on a Sunday afternoon with right hand pain since waking up that morning. He is not sure how he was injured as he admits to being very drunk the night prior. On exam there is a 1cm laceration over the dorsal aspect of his 4th MCP joint with a lot of swelling and tenderness around the lac.

Q: Review the quick and easy neuro exam that you do for your patients who have sustained a laceration to the hand.

A:

Sensation: start with light touch, but if equivocal then use 2 point discrimination (5mm or less is normal and compare to other side)

Use the question “Does this feel normal?” rather than “Can you feel this?”



Sensation:

Radial n – first dorsal webspace (pink)

Median n – tip of index finger (green)

Ulnar n – tip of pinky finger (blue)

Motor:

Radial n – “hitch hiker’s sign” with examiner resisting extension of the thumb

Median n – “peace sign” with examiner resisting abduction of the fingers

Ulnar n – “a-okay sign” with examiner attempting to break the ring



Radial n - “hitch hiker’s sign”



Median n - “peace sign”



Ulnar n - “a-okay sign”

Q: This patient had a very small unimpressive laceration. Why can this be deceptive for the practising EM provider? And why do we worry about this apparently innocuous laceration?

A: Serious infection such as **septic arthritis** occurs in about 10% of “fight bites”.

The **reason for high risk of infection** is that the skin overlying the MCP joints are relatively thin and so oral bacteria from the victim’s mouth can easily get into the joint, which essentially results in septic arthritis.

As the fingers are extended after the injury, the extensor tendon and soft tissues are retracted proximally, thereby pulling bacteria deep into the wound.

The extensor tendons and MCPs are relatively avascular structures.

Q: While this patient with a fight bite will need antibiotics, we don't give prophylactic antibiotics to everyone with a simple laceration of the hand. For simple uncomplicated hand lacerations in immunocompetent patients we shouldn't be giving prophylactic antibiotics. How about prophylactic antibiotics for animal bites? Should you give antibiotics for all animal bites?

A: A Cochrane Review systematic review of 8 RCTs (total n = 522), six of which (n = 463) enrolled only subjects with dog bites, showed no clear benefit to antibiotic use overall, HOWEVER:



The site of the bite was the most powerful predictor of infection:

Bites to the hand (3 studies) had a high rate of infection in the control group (28%), and in this small subgroup a beneficial effect of antibiotics was statistically significant with a number needed to treat (NNT) of 4.



AH-HA

Give Antibiotics for:

1. Hand bites
2. Immunocompromised patients
3. Bites directly over a joint

Q: Let's say you've got a patient with a finger laceration and you've decided to do digital nerve block. The classic teaching when it comes to using lidocaine WITH epinephrine is that it should be avoided in the "fingers, nose, toes & penis". Yet I often see plastic surgeons using epinephrine to do their digital blocks. Can we use epinephrine for digital blocks?

A: Studies show that there is no risk of ischemic injury or digital necrosis using epinephrine for digital blocks and there are some advantages to epinephrine:

1. Less requirement for tourniquet
2. Less likely to require a second block
3. Epinephrine prolongs the effect of lidocaine
4. Epinephrine decreases the amount of local anesthetic needed through vasoconstriction so that there is less deformity of the tissues
5. Epinephrine decreases the amount of bleeding

Video:

[Watch a video of a single needle digital block by Alfred Sachetti on Youtube](#)

Q: When it comes to our run-of-the-mill laceration anywhere on the body, there seems to be a lot of variability in what doctors choose to clean the wound with. What should we use to clean laceration wounds in general?

A:

Don't soak hand wounds, because bacterial counts may increase.

Tap water was as effective as sterile saline in 4 studies.

No alcohol – alcohol prevents healing by killing the cells that are trying to heal the wound – don't use alcohol in an open wound!

Q: Which hand lacerations do NOT require suturing?

A: A 2002 study from the BMJ in 95 patients with simple hand lacerations <2cm and exclusion criteria (no immunocompromised pts, no bites, no gross contamination, no punctures) showed that there was no difference in cosmetic outcome at 3 months and no difference in return to activities between the group that received sutures and those that received a simple dressing.

Q: Let's get back to our case of the young man who punched someone in the mouth. An x-ray was done which showed a 4th metacarpal neck fracture with 40 degrees of angulation – a so-called “boxer's fracture”. Now this patient has a boxer's fracture with an open wound in close proximity – in other words, he has a “fight bite”. How do you manage “fight bite” injuries differently than a closed run-of-the-mill boxer fracture?

A: If the patient presents **a few days after the injury**, or you find on exploration that they have an **injury to the extensor tendon**, most experts recommend **admission** for IV antibiotics and surgical debridement.

For those patients who present **immediately after the injury**, the management is a bit more **controversial**: some experts recommend admitting all these patients for surgical debridement regardless of the appearance of the wound, but most experts **manage these patients conservatively** with:

1. Copious irrigation
2. Oral antibiotics such as Clavulin or IV antibiotics such as Ampicillin-Sulbactam
3. Allowing the wound to heal by secondary intention
4. Close follow-up for wound check



Pitfall:

Neglecting to **look for tooth fragments** on the x-ray and when exploring the wound can result in devastating infection and long-term dysfunction.

Q: Let's learn more specifically about metacarpal fractures themselves. Why is it so important to assess for rotational deformity for metacarpal fractures, and how do you assess for it?

A: Rotational deformity can result in:

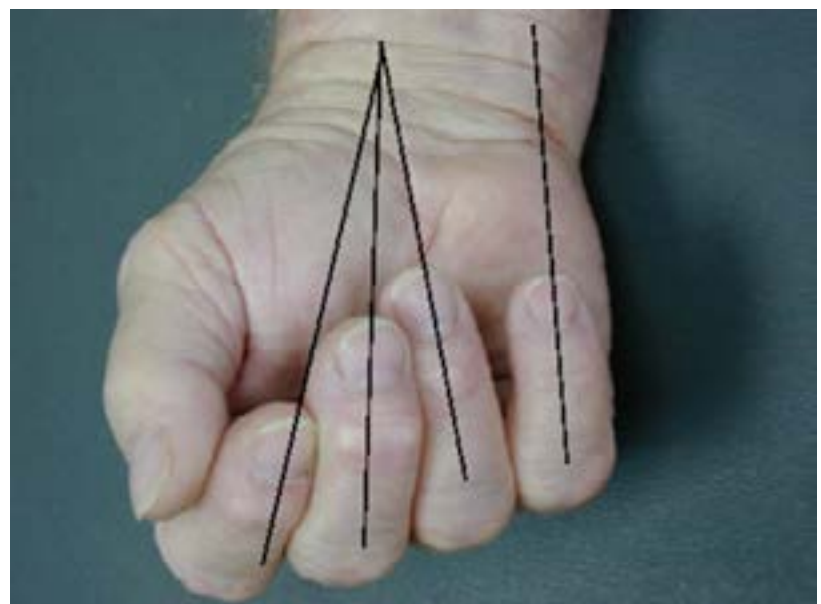
1. Mal-union and permanent disfigurement
2. Disability of grip strength
3. If you wait too long to reduce it, a more invasive corrective osteotomy is needed to repair the defect

Assessing Rotational Deformity:

1. Patient makes a fist and all phalanges should point to the **scaphoid** (but often limited by pain and soft tissue swelling) **OR**
2. Looking for rotation of the fingernails when looked at head-on with fingers in extension

Note that some patients with soft tissue injury and even without any injury can have a rotational deformity AND many people have asymmetrical hands so that comparing to the other side doesn't always work.

What might be more accurate is simply looking for scissoring when the fingers are flexed at MCP joint.



Rotational abnormality of the 5th digit: note that the 5th digit does NOT point towards the scaphoid

With metacarpal fractures, one degree of overlap of a fracture can result in 5 degrees of rotation at the fingertips.

After reduction, check for rotational deformity again and if any doubt get early followup.

Q: What are the acceptable degrees of angulation for a true boxer's fracture?

A: The fifth MCP joint, which is the most mobile, also tolerates the most volar angulation.

Acceptable angulation for angulated metacarpal neck fractures (boxer's fractures):

- 5th metacarpal – 40 degrees
- 4th metacarpal – 30 degrees
- 3rd metacarpal – 20 degrees
- 2nd metacarpal – 10 degrees



Expert Tip:

Consider using an ultrasound-guided ulnar nerve block to reduce metacarpal fractures in the ED.

EM Cases Cross-link: [Click here to listen to a discussion on ultrasound-guided ulnar nerve blocks on the Pediatric POCUS podcast episode](#)

Q: How do you reduce a boxer's fracture?

A: For most fracture reductions in general, remember **TRAMP**.

- **Traction** – consider “Chinese Finger Trap”
- **Reduction** – direct pressure or 90/90 method for metacarpal fractures and correct rotation if present
- **Apply** splint
- **Mold** – push up on MC head palmarly with counterpressure dorsally
- **Position** – MCPs in flexion (80-90 degrees) and IPs in extension



Neutral position for immobilizing hand injuries

EM Cases Cross-link:

[Click here for a discussion on ultrasound-guided fracture reduction in the ED with Jordan Chenkin](#)

Q: We've learned about simple lacerations of the hand. Let's learn now about big, bad, ugly lacerations – ones with potential for tendon injury. What are the essentials of assessing for tendon injury in the hand on physical exam?

A: Inspect and test against resistance **gradually** (start with no resistance, then gentle resistance to avoid converting a partial tendon lac into a complete one).

Note that pain along the tendon during resistance testing suggests a partial laceration even if strength appears adequate.

Flexor Digitorum Profundus (FDP) – flex the DIP while the rest of finger is held straight (try it on yourself)

Flexor Digitorum Superficialis (FDS) - flex at PIP while all other fingers held in extension (try it on yourself)

Extensor tendons - assess MCP extension (not at the DIP or PIP).



Clinical Pearl:

Some people have a false positive FDS test in their pinky finger, so it is important to compare to the contralateral side

Q: There is some controversy as to which tendon lacerations of the hand should be repaired in the ED and which should be splinted and referred for delayed repair. Some experts say NOT to repair any flexor tendons and only repair extensor tendons that are completely lacerated where you can clearly see the ends. Some literature says that we should not repair extensor lacerations that are up to 75% cut, but should repair partial lacerations that are more than 75%.

Which tendon lacerations should be repaired by the ED doc and which ones should be splinted and left for the hand surgeon to repair?



A: Do **NOT** repair:

1. Flexor tendons
2. Contaminated wounds
3. Partial tendons up to 50-75% cut

However, if both ends of a flexor tendon can be visualized in the ED it is not unreasonable to place 1 or 2 simple sutures or horizontal mattress sutures between the two ends to prevent retraction of the proximal portion, which can make formal repair more challenging.

There is some evidence that repairing tendons that are less than 50% lacerated can prevent the normal healing process and rehabilitation of the tendon strength if sutured.

If the tendon ends are easily identifiable in the wound, you should repair the tendon when you first see the patient. However, if immediate repair is not possible or you do not have the necessary surgical skills, the tendon can be repaired at a later time when a specialist is available within 24-72 hours. Evidence shows that outcomes are similar between immediate and delayed repair.

Perhaps the most important point is to **thoroughly wash out and loosely close the skin as soon as possible** after injury and apply a **splint to avoid tension** on the injured tendon.

Consider taking a picture of the injured tendon and emailing it to the hand surgeon, regardless of whether you repair the tendon or not.

CASE 2: GAMEKEEPER'S THUMB

You're attending an Emergency Medicine conference in Whistler, British Columbia, and you bump into your colleague's wife, who has just come off the ski slopes after a fall onto her ski pole. She tells you that she can barely move her thumb, and she wonders whether she should get an x-ray.

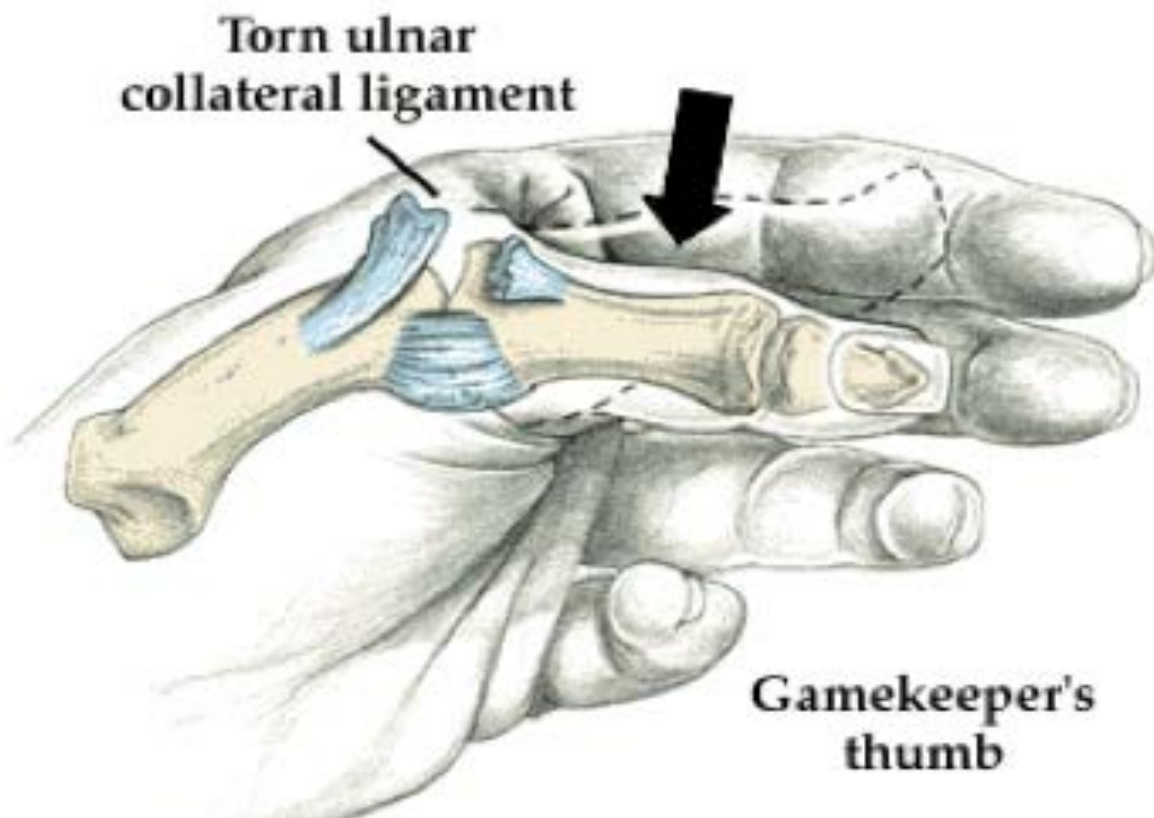
Q: What diagnosis are you most worried about in this patient and why?

A: Gamekeeper's Thumb is an injury to the ulnar collateral ligament of the MCP joint of the thumb, usually from a lateral or valgus stress, resulting in anything from a partial tear of the ulnar collateral ligament to a complete avulsion of the base of the medial proximal phalanx of the thumb – a Gamekeeper's *fracture*.

The name Gamekeeper's Thumb comes from Scottish gamekeepers who got the injury after repetitively killing animals by hyperextending the neck of animal between their thumb and index finger.

The acute injury these days is called "**Skier's Thumb**" from falling with a ski pole attached to the hand, causing a lateral or valgus stress on the MCP joint, but the injury can happen after anything that applies a lateral stress to the MCP joint.

This injury is easily missed in the ED, and if the diagnosis is delayed, it can affect the future functionality of the hand.



Video:

[Click here to watch a video on valgus stress testing of the thumb in Gamekeeper's Thumb](#)

Mechanism: Valgus force to abducted thumb.

Exam: Point of maximal tenderness is usually over the volar/ulnar aspect of 1st MCP. Pincer grasp is often painful with partial tears.

Assess stability by applying radial stress to the distal thumb while immobilizing the proximal thumb and compare to contralateral thumb.

If >30 degrees deviation, assume instability.

Q: What do you look for on x-ray in a patient whom you suspect has sustained a Gamekeeper's Thumb injury?

A: Look for an avulsion fracture of the proximal phalanx. (See image on the right)



Q: Let's say you've got this patient from whom you get the typical history for a Gamekeeper's Thumb. You get an x-ray and it shows no fracture. How would you examine the patient to determine whether the MCP is unstable and may require surgical repair despite there being no fracture present?

A: Three things to look for:



1. Weak pincer grasp
2. Tenderness at volar-ulnar aspect of MCP
3. Applying radial stress while thumb is extended as well as flexed 30 degrees and finding >40% of radial deviation in extension or 20 degrees in flexion

Consider 3mL 1% lidocaine directly into the MCP if the patient is in too much pain to assess adequately.

The displaced proximal end of the ulnar collateral ligament may become trapped by the adductor apponeurosis in a position that will not allow healing. This is referred to as Stener's lesion.

Q: Once you're convinced that you're dealing with a Gamekeeper's thumb, how would you manage the injury in the ED and how are these injuries definitively managed by the surgeon?

A: For a partial injury, a 6-week splint may heal the tendon, but a complete tear requires surgery, so surgical exploration is often necessary for cases where a partial tear cannot be confirmed. All patients should be placed in a thumb spica splint and seen early for follow-up (within 7 days) as nonunion of a complete tear requires extensive reconstruction.

CASE 3: HIGH-PRESSURE INJECTION INJURIES

A 40-year-old mechanic was at work using a grease gun, and a break in the hose caused the grease to blast into his left index finger. He reports that there was only a little bit of swelling and pain but was told by his boss that he had to go to the ED to get it checked out. He sees you about 2 hours after the injury occurred and tells you that the pain seems to be getting worse with time.



Q: This patient has sustained a high-pressure injection injury. What is a high-pressure injection injury and why is it often an elusive yet potentially devastating diagnosis?

A: This is a scary diagnosis with amputation rates as high as 30%!

Any liquid (e.g. grease, hydraulic fluid, water) under a high pressure that releases and hits the skin triggers an intense inflammatory response that can lead to significant ischemic injury and sometimes ends up requiring amputation.

It is elusive because it often looks relatively benign in the early stages. However, with time the finger becomes edematous, pale and severely tender to palpation.

Liquid under high pressure causes severe injury when injected into the hand by:

1. Direct dissection of tissue planes and tissue ischemia
2. Cytotoxicity of materials
3. Possible secondary infections



Clinical Pearl:

Consider all high-pressure injection injuries a compartment syndrome of the hand until proven otherwise.

Q: In the [EM Cases episode on Vascular Catastrophes](#), there was a discussion about compartment syndrome of the leg and some pearls about the 'Six Ps' of assessment for compartment syndrome. Why is compartment syndrome of the hand considered an even more elusive diagnosis than compartment syndrome of the leg?

A:

1. Compartment syndrome of the hand may not be associated with paresthesias the way lower-limb compartment syndromes typically are
2. The motor deficit may be very subtle
3. Compartment pressures are very difficult to measure and not very accurate in the hand, so it is a *clinical* diagnosis

Consider compartment syndrome of the hand in:

Any patient with a crush injury or high-pressure injection injury who has:

- a) Pain out of proportion
- b) Who is holding their hand in an “intrinsic minus” position (MCP joint extended with PIP joint slightly flexed, otherwise known as a “claw hand”)
- c) Has tense and tender swelling of the finger

Q: How can an x-ray help you in a patient with a high-pressure injection injury?

A:

1. Look for subcutaneous air
2. Lead-based liquids will show up on x-ray and give you an idea of the extent of injury

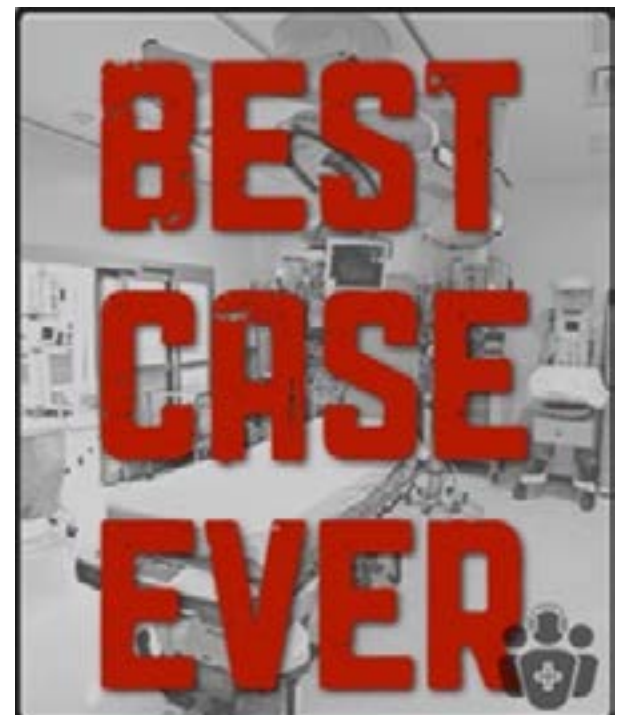
Q: How should we manage patients with high-pressure injection injury in the ED?

A: High-pressure injection injuries are *a true surgical emergency*.

Definitive management is early surgical decompression and debridement. Get your hand specialist on the phone!



“Claw Hand”: Intrinsic minus position seen in compartment syndrome of the hand



[Take a break and have a listen to Dr. Laura Tate's Best Hand Emergency Cases ever!](#)

CASE 4: FLEXOR TENOSYNOVITIS

A 30-year-old man was at work on his farm when he punctured his volar index finger with the tip of a dirty tool the day prior to seeing you. He comes in to the ED today because of increasing pain and swelling. On exam he has an exquisitely tender and swollen finger that he's holding in slight flexion.

Q: What is flexor tenosynovitis, and how can you distinguish it clinically from a simple cellulitis?

A: Flexor Tenosynovitis is an inflammation of the synovium and can be infectious (seen more often in the ED) or inflammatory.

Infectious causes are usually secondary to penetrating injury (bite or puncture wound).

Q: Why is it so important to diagnose and manage flexor tenosynovitis in a timely manner?

A: Infection and inflammation can lead to tendon scarring, adhesions, tendon necrosis and permanent disability.

Q: What is the treatment of flexor tenosynovitis?

A: If flexor tenosynovitis is diagnosed early and is relatively mild, then it may be managed medically with immobilization, elevation, IV antibiotics and close observation.

If the flexor tenosynovitis is diagnosed late or is severe, treatment is surgical with incision, drainage, irrigation and often catheter placement.



Kanavel's 4 Cardinal Signs of Flexor Tenosynovitis are:

1. Finger held in slight flexion
2. Fusiform swelling
3. Tenderness along the flexor sheath
4. Pain with passive extension.

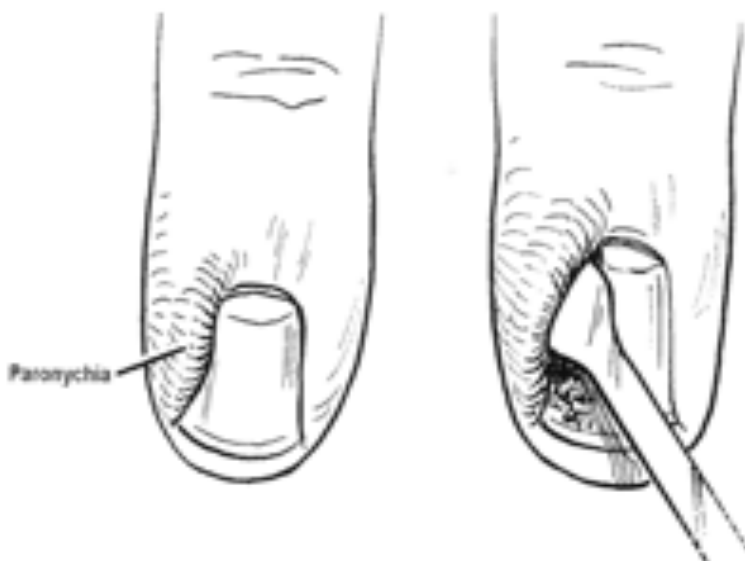
CASE 5: PERONYCHIA & FELON

A 43-year-old otherwise healthy man presents to ED with a 5 day history of increasing swelling and pain around the finger nail of his 5th left digit. On exam he has an obvious sizable peronychia.



Q: This is a very common condition we see in the ED that's relatively simple to diagnose, but the variety in management strategies is quite remarkable. What are the best management options for peronychia?

A: A minor infection without abscess may improve with soaking the finger and oral antibiotics. However, if an abscess has formed, the area should be cleaned well and anesthetized, preferably by digital nerve block. This is followed by blunt dissection with the tip of a sharp instrument or point of a surgical blade so that the lateral nail fold is elevated and the sulcus between the lateral nail plate and the lateral epithelium is entered. The pus is drained and the cavity is irrigated with normal saline using a catheter tip syringe.



Elevation of the lateral nail fold to evacuate pus in a peronychia

When a large paronychia is present, the cavity should be splinted open with a small wick to prevent adhesion and re-accumulation.

If pus has tracked underneath the nail, a partial excision of the nail may be required. The presence of a subungual abscess ('floating nail') requires nail plate removal with the degree of debridement being commensurate with the degree of nail bed infection.

Q: How does the management change if the pulp of the finger is involved?

A: The presence of a finger pulp abscess or *felon* may require an additional incision of the pad of the fingertip to adequately drain.

Compartments of the volar skin may form abscesses, which require careful and thorough surgical decompression. If urgent referral to a hand surgeon is not available, these must be managed in the ED. Cut and detach septae along the whole length of distal phalanx nearest to the abscess site, releasing and irrigating very thoroughly. Avoid making incisions across the lateral aspect, to avoid injuring the digital nerve. After releasing all septae, swab, pack and treat with IV antibiotics, splinting, and elevation. Ensure urgent follow-up.

STOP Pitfall:

Be careful to **avoid the neurovascular bundles** that run on the lateral edges of the finger when draining a felon, as seen in the figure.



Additional Tips for Hand Injuries From Dr. Laura Tate

1. When considering when to remove sutures in the hand, leave sutures that are over areas of tension (i.e. over a joint) at least 12 days so they heal completely.
2. If controlling bleeding is an issue, do NOT clamp any digital arteries, as the digital nerve is very nearby and hard to visualize. Use pressure, limited tourniquet and elevation to control bleeding safely.
3. If referring a hand abscess to a clinic, consider swabbing the drained fluid so MRSA status can be determined.
4. Immobilizing the PIP joint in extension can stiffen the collateral ligaments causing permanent disability, so don't splint a PIP joint for greater than 1–2 weeks unless necessary. If splinting, ensure an early referral within 1–2 weeks.



Comments?

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CHAPTER 5: BACK PAIN EMERGENCIES

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Objectives

1. Develop an awareness and an approach to the work up of acute lower back pain in the emergency department.
2. Know what key diagnoses need to be ruled out in patients presenting with back pain
3. Recognize the subtle findings and laboratory investigations for spinal epidural abscesses.
4. Identify the risk factors on history for vascular causes of back pain.
5. Entrench the red flags of back pain into your back pain work-up.

CASE 1: SPINAL INFECTION

A 63-year-old woman arrives at the emergency department with a chief complaint of abdominal pain. This is her third visit in the last 10 days. Her illness started about two weeks ago, when she developed back pain. A few days ago, she developed lower abdominal pain, bilateral leg weakness and difficulty urinating. She complains that she has been sweating and becoming flushed. On further questioning, she describes mostly burning right lower back pain radiating to both thighs that is not relieved by acetaminophen or changes in position. On her previous visit she was discharged after a Foley catheter “in and out”.

Her past medical history includes diabetes and a 40-pack-year smoking history. She denies alcohol or drug abuse.

On exam she appears to be in significant distress, writhing in the stretcher. Her vitals include a blood pressure of 173/103, heart rate of 96, respiratory rate of 20, and a temperature of 37.2 degrees Celsius. She is tender over the lower-midback and right para-spinal muscles. Her abdominal exam reveals suprapubic fullness, no mass and no peritoneal signs. She has brisk reflexes in the lower extremities with proximal right leg weakness and decreased sensation in the right leg. A digital rectal examination was not done.

Lab results reveal a serum WBC count of 28 and a urine analysis that is positive for leukocytes and nitrates. An x-ray of the back is initially read as normal by the emergency physician but the radiology report later identifies “endplate erosion” L3/L4. An MRI is ordered based on these results and identifies a spinal epidural abscess.

Q: What are the challenges in diagnosing a spinal epidural abscess (SEA) and what is its acute presentation?

A: SEA is a rare diagnosis with non-specific symptoms. It is seen in only 1:10,000 admissions, although its incidence has doubled over the last 20 years. The classic triad of SEA, which is only seen in 15% of cases, includes **fever, back pain and neurological deficit**.

Fever, an extremely non-specific sign, is seen in only 50% of cases. Two-thirds of patients will present with a completely normal neurological exam on the first visit. Initially, localized back pain is the chief complaint, progressing to nerve root radiation, followed by sensory, motor and bowel and bladder dysfunction as late findings. Typically, patients present to the emergency department multiple times before they are diagnosed.

Q: What are the risk factors for a SEA?

A: Patients who are immunocompromised and have a specific nidus for infection are at risk. Diabetes is the most common risk factor. Other risk factors include:

- IV drug use
- Spinal intervention or surgery
- Indwelling catheter
- Other infection – especially skin infections
- HIV
- Repeat ED visits with no resolution to back pain and symptoms

Spine infection incidence following a spinal procedure is approximately:

Epidural anesthesia	0.05%
Minidiscectomy	0.13%
Standard discectomy	1-3%
Multilevel vertebral fusion	1-10%



Clinical Pearl:

In early SEA the signs and symptoms are often non-specific, however, in a patient with risk factors combined with fever and back pain, or back pain with neurologic deficit, the diagnosis should be entertained.



Pitfall:

One common pitfall in patients with SEA is ruling out the diagnosis just because the patient does not have risk factors. In approximately 20% of cases of SEA there are no risk factors for the disease.

Q: What lab work is helpful in ruling in or ruling out a SEA?

A: The white blood cell (WBC) count, the erythrocyte sedimentation rate (ESR) and the C-reactive protein (CRP) are three principal blood tests that you should consider ordering in the emergency department for a patient with a suspected SEA.

Leukocytosis is a late finding and is quite non-specific. About 60% of patients with SEA have an elevated WBC count. Following neurosurgery, leukocytosis can be expected for a prolonged period of time with no infection.

ESR and CRP can be thought of as the “D-dimer of low back pain”. They are very sensitive but not very specific. This means that a patient with a low pretest probability and a normal ESR and CRP is unlikely to have a SEA. An ESR value of less than 20 is 98% sensitive in ruling out SEA. CRP is approximately 82-98% sensitive. A CRP >50 mg/L was detected in 13/14 SEAs in one case series. The only patient who had a normal CRP was on a prolonged course of antibiotics. In patients presenting post spinal surgery, the CRP is rarely helpful before post-op-day 5, as it will be elevated secondary to the surgery, while the ESR can be elevated for quite a prolonged period of time.



In patients presenting to the emergency department with positional back/neck pain following a spinal procedure (ESI, obstetric epidural anesthesia, minidisectomy) consider obtaining a CRP. If it is >50 mg/L then consider imaging (primarily MRI with Gadolinium contrast). As a caveat to the CRP, prolonged antibiotic course or steroids may lower the CRP, creating a false negative.

Q: What lab work is helpful in ruling in or ruling out a SEA?

A: MRI is the test of choice for SEA as it is able to assess the spinal cord. A CT scan can show osteomyelitis which may accompany SEA, and can miss up to about 25% of SEA cases. Any finding of osteomyelitis on spinal CT should be followed by an MRI.

Q: What is the emergent management for SEA?

A: Diagnosis should not be delayed and treatment should be initiated as soon as possible. Neurological outcome is best correlated with pre-surgical neurological function.

The most common infectious organism in SEA is staph aureus. However, broad-spectrum antibiotics including vancomycin should be started empirically if risk factors are present. A spinal surgeon and infectious diseases should be consulted. In some hospitals, interventional radiology is able to percutaneously drain SEA.



Pitfall:

Assuming that osteomyelitis found on a CT is the only diagnosis in a patient with a clinical picture consistent with spinal epidural abscess and admitting them to the Internal Medicine service, rather than moving on to an MRI to diagnose SEA, which usually requires urgent surgery.



Summary of Spinal infections:

There are 3 situations in which you should suspect the diagnosis of SEA:

1. Back pain or a neurologic deficit accompanied by a fever
2. Back pain in any immunocompromised patient
3. Recent spinal procedure plus any one of 1 or 2

If you have a low index of suspicion after a good history and physical, get a WBC, ESR, CRP and plain x-ray and if they're all negative, the patient can be safely discharged home with close follow-up. If you have a high index of suspicion after a good history and physical, MRI should be ordered regardless of the findings on blood work as no blood marker is sensitive enough to rule out SEA.

Q: What is your general approach to low back pain in the ED?

A: General Approach to Lower Back Pain in the Emergency Department

All patients presenting to the emergency department with acute lower back pain can be broken down into three main categories:

1. Those with non-specific lower back pain or lumbosacral strain.
2. Those with nerve root or radicular sciatica.
3. Those with serious or emergent spinal or vascular pathology.

The third, emergent category includes issues that should be ruled out in the emergency department. Emergent spinal pathologies include spinal infection like spinal epidural abscess, massive central disc herniation with cauda equina syndrome and metastases to bone causing spinal cord compression. The vascular causes include leaking or ruptured AAA, retroperitoneal bleed, spinal bleed and spinal epidural hematoma.

Abdominal and retroperitoneal space pathologies such as renal colic and pyelonephritis may present with acute low back pain as their chief complaint. However, it is critical to consider life-threatening diagnoses discussed above. Non-specific lumbosacral sprain is usually unilateral and may radiate to the buttocks or posterior thigh but not past the knee. Pain increases with movement and improves with rest.



Red Flags Approach to Back Pain Emergencies:

- 1. Age <18 or >60** – increased risk of spondylolysis in teenage athletes
- 2. For metastases to the spine** which can cause spinal cord compression, ask about pain lasting >6wks, history of cancer, night sweats, unexplained weight loss, night pain and pain that is worse when lying down
- 3. For spinal infection**, ask about fever and chills, recent bacterial infection, IVDU, spinal intervention and any reason for an immunocompromised state
- 4. Trauma** – even minor trauma in the elderly can cause significant vertebral fractures
- 5. For Cauda Equina and Spinal cord compression** – any loss of bowel or bladder function, urinary retention, erectile dysfunction, saddle paresthesia, progressive or bilateral distal leg numbness or weakness

N.B. : In general, difficulty ambulating is seen in the majority of patients with lower back pain and is not a reliable red flag in the absence of sensory and motor complaints.



Clinical Pearl:

Constant severe pain that is worse with lying down is a red flag for infection or cancer.



EXPERT OPINION

One useful cognitive forcing strategy for patients who present to the emergency department with low back pain is the following:

- If a patient presents with renal colic, always think of AAA.
- If a patient presents with pyelonephritis, always think of a spinal infection.

CASE 2: SCIATICA VS. CAUDA EQUINA SYNDROME

A 49-year-old man presents to the emergency department with a complaint of severe crampy abdominal pain. He has had difficulty urinating for the past 12 hours. Four days prior, he fell off his bicycle and has been suffering from low back pain ever since. There was no head or extremity injury. He complains of decreased sensation to the lateral foot.

He has a history of chronic back pain for which he takes ibuprofen and goes to physiotherapy but has no other medical problems. He denies any other change in bladder or bowel function.

On exam he is pacing around the room in obvious distress in a stooped, bent-forward posture, resting his hands on his thighs for support. His vitals are normal. His abdominal exam reveals a diffusely tender protuberant abdomen with no palpable mass, normal bowel sounds and no peritoneal signs. He has no spinal process tenderness, paraspinal muscle tenderness or costovertebral angle tenderness. He has an abnormal straight leg raise on the left, and a positive crossed-straight leg raise on the right. He has no saddle anesthesia. He has decreased sensation and strength in the L5-S1 distribution and his ankle tendon reflexes are absent.

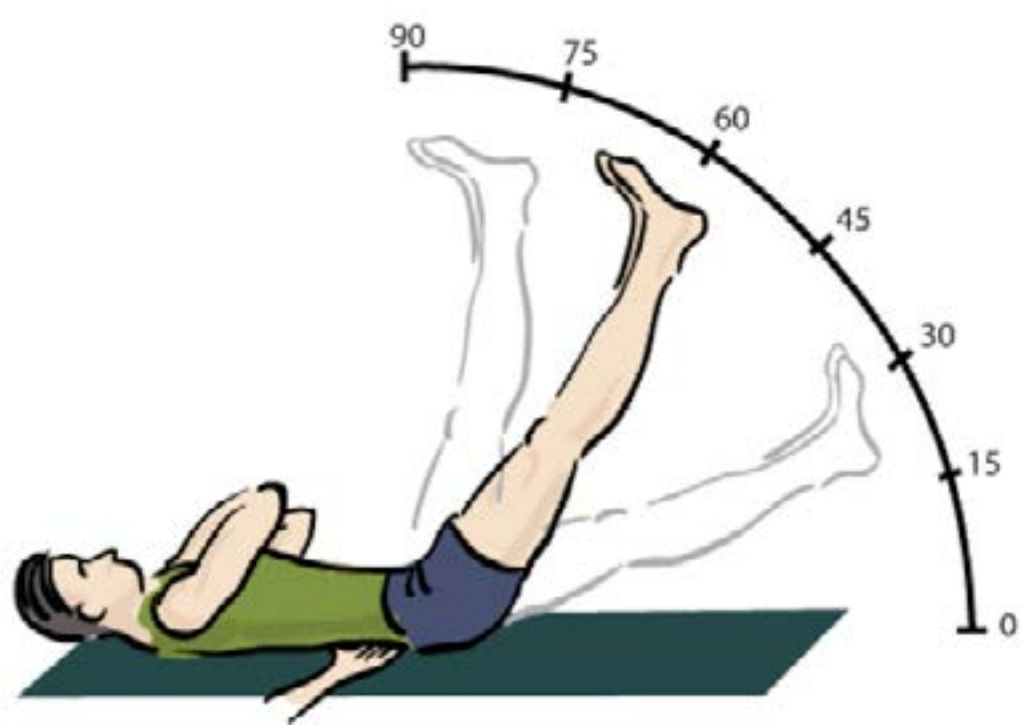
Q: What physical exam findings do you look for in patients with back pain?

A: All patients with back pain should have a full set of vitals done. This should be followed by observation, palpation, percussion and gait. A central and peripheral neurological exam should be done as well as an abdominal exam looking for bladder distension or AAA. Digital rectal exams should be done for any patient suspected of spinal cord compression or cauda equina syndrome.

Specific exam findings to look for include:

PHYSICAL EXAM SIGNS IN A PATIENT WITH BACK PAIN	POTENTIAL CAUSES TO RULE OUT
Fever	Pyelonephritis vs. psoas abscess vs. spinal infection
Hypotension	AAA leak
Writhing in pain	Renal colic or spinal cord compression
Stooped posture	Spinal stenosis or cauda equina syndrome
Saddle anesthesia	Cauda equina syndrome
Decreased rectal tone, and sensation	Cauda equina syndrome
Gait disturbance (Ataxia)	Spinal cord compression (may be the only sign)

Physical exam signs of sciatica



Crossed Straight Leg Raise (SLR) is the most specific physical exam maneuver for sciatica as a result of a herniated disc (85-100%). In a crossed straight leg raise, pain radiates from the back down the contralateral leg between 30 and 70 degrees straight leg raise.



A Bragard sign can further increase the specificity for the diagnosis of sciatica. A straight leg raise is done until the point of radiating pain. The leg is lowered below the point of pain and the ankle is then dorsiflexed. A positive test is if the pain returns with dorsiflexion.



A Slump Test also correlates well with an SLR. The patient sits at the edge of the stretcher and slumps forward while flexing the neck and trunk, followed by knee extension and ankle dorsiflexion which causes radicular pain, indicating sciatica.

Q: What quick bedside test can help rule out cauda equina syndrome?

A: A post-void residual that is less than 100 mL has a negative predictive value for cauda equina syndrome of 99%, essentially ruling it out.

Case Continued: This patient's post-void residual was 900mL. The neurosurgical team was consulted immediately for suspected cauda equina syndrome. The MRI showed a massive central disc herniation with cauda equina intrusion and the patient was taken to the operating room for discectomy. Unfortunately, the patient was left with a life-time indwelling Foley catheter, but had full normal function of his lower extremities as well as erectile function.

Q: What were some of the clues from this patient's story that would trigger you to urgently rule out cauda equina syndrome?

A: Chronic back pain is a risk factor for cauda equina syndrome. Most patients who develop cauda equina syndrome will have a history of chronic low back pain. Stooped posture as well as pain worse with lying down in a patient with sciatica is cauda equina syndrome until proven otherwise. In patients with abdominal pain that follows a back pain, think about urinary retention. In this case, both ankle tendon reflexes were absent.

Q: What is the role, if any, of IV corticosteroids in the patient with cauda equina syndrome?

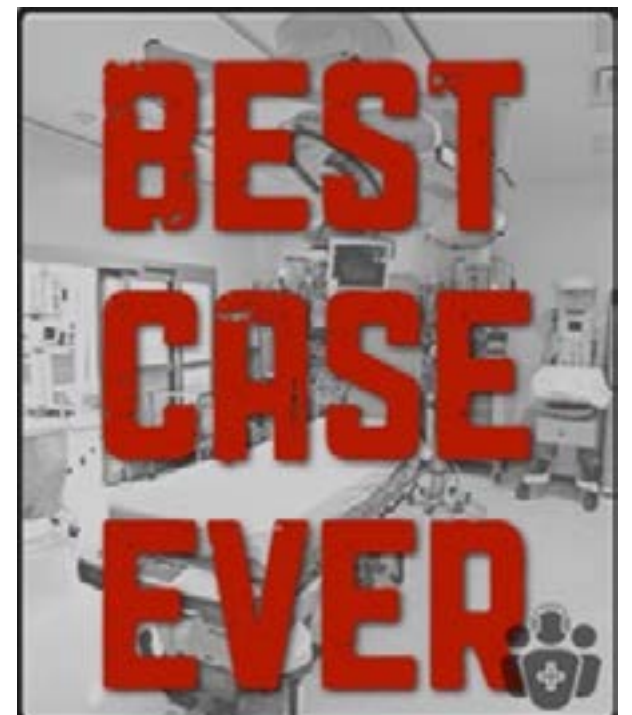
A: The evidence for IV corticosteroids in cord or cauda equina compression syndromes is strongest for metastatic lesions to the spine. Unfortunately there are no good data to tell us whether there is any benefit from IV steroids for patients with compression from massive central disc herniation, hematoma or infection.



BMJ Definition of Cauda Equina

Must have both of these:

- 1.** One or more of urinary retention, rectal dysfunction or sexual dysfunction
- 2.** One or more of saddle anesthesia, hypoesthesia or rectal hypoesthesia



[Take a break and have a listen to Dr. Walter Himmel's Best Case of Cauda Equina Syndrome here!](#)

CASE 3: METASTATIC INVASION OF THE SPINE

A 43-year-old woman presents to the emergency department with a 3-week history of progressive low back pain. She decided to come to the ED today because the pain is so severe that she is unable to sleep. There is no radiation of the pain and no alleviating or aggravating factors. She has been having difficulty walking because of numbness of the right leg, but denies saddle paresthesias. She has normal bowel and bladder function. She denies fever, chills or night sweats. She also complains of general weakness and vague muscle aches, mild headache as well as nausea and constipation.

Her past medical history includes hypothyroidism and diabetes, both of which are well controlled with medication. She had a mastectomy 2 years prior, and is in remission from breast cancer, according to her oncologist. There is no history of trauma or back issues.

On exam, she appears a bit drowsy and is unable to find a comfortable position. Her vitals are unremarkable except for a heart rate of 110. She has spinous process and paraspinal muscle tenderness around the upper L-spine. Her lower extremity exam reveals scattered decreased sensation that does not fit a dermatomal distribution, global 3/5 power in the lower extremities with normal patellar but absent ankle reflexes.

The patient is sent for an L-spine x-ray and routine blood work. The x-ray showed a L1 compression fracture. Blood work was unremarkable except for decreased hemoglobin and platelet count.



Clinical Pearl:

The finding of a non-traumatic vertebral compression fracture should prompt a search for possible malignancy and infection

The patient went on to have a full spine MRI, which showed moderate cord compression at L1 as well as multiple bony metastatic lesions at multiple vertebral levels. Neurosurgery and Internal Medicine were consulted. The internist ordered a TSH, T4, Ca, Mg, Phos and ESR. The patient was found to be severely hypercalcemic, accounting for her generalized weakness, drowsiness, nausea and constipation, and had an ESR of 110. She received a fluid bolus, IV pamidronate and IV Dexamethasone 100mg and was taken to the operating room. She walked out of the hospital three weeks later with normal lower extremity function and corrected calcium on an oral bisphosphonate.

Q: What are the key findings on x-ray in undifferentiated back pain patients who have spinal process tenderness? How good is X-ray at detecting metastases?

A: X-ray is 60% sensitive for lytic or blastic lesions. Up to 50% of the bone must be eroded to be visible on x-ray. However, an abnormal finding on x-ray that is consistent with metastasis to the spine portends a 60% chance of having cord compression.

Findings in metastases to bone (lung, breast & prostate cancer are the most common primary sources):

1. Compression fractures
2. Blastic lesions (pedicle white out – “Winking Owl Sign”)
3. Lytic lesions



The Winking Owl Sign: The missing pedicle corresponds to the closed eye, the contralateral pedicle to the other open eye, and the spinous process to the beak of the animal on AP views of the thoracic or lumbar spine. The winking owl sign is due to the destruction of the pedicle secondary to blastic bone lesions

Q: What is the role of CT and MRI in working up patients with suspected spinal cord or cauda equina compression?

A: While dangerous conditions should be strongly considered, the literature shows that MRI and CT are overused for patients with back pain in the emergency department. Generally, in the absence of a serious or progressive neurologic deficits, or concern for cauda equina syndrome, neoplasm or spinal infection, CT or MRI should not be part of the diagnostic evaluation of back pain. Additionally, isolated sensory loss or the absence of reflexes is not considered to be a progressive neurologic deficit.

CT is more accurate than x-ray for detecting vertebral fractures and metastases and may show bony fragments within the spinal canal, which would necessitate an MRI to assess spinal cord integrity. MRI is the modality of choice for spinal infection (sensitivity 96%, specificity 92%), malignancy (sensitivity 88%, specificity 94%) and cauda equina syndrome (sensitivity 93%, specificity 97%).

Bulging discs are seen in about a quarter of the asymptomatic adult population younger than 60 years old and 1/3 of people over 60 years of age. Disc disease is a component of normal aging and is a nonspecific finding.

Q: What are the indications for an urgent spinal MRI?

A: MRI should be considered for the following patients:

1. Patients who have a sudden or rapid change in their back pain and who have developed new or progressive signs or symptoms suspicious for cord compression, such as bowel or bladder incontinence, weakness, loss of reflexes or the development of bilateral or multilevel findings, need an MRI while they are in the ED.
2. Patients suspected of metastases, with stable symptoms for days or weeks with mild unilateral weakness, sensory loss or radiculopathy in a single nerve root without evidence of cord compression should have an MRI within 24 hours.
3. Patients who present with back pain with no neurological deficit but who are suspected of having metastases and have findings on the x-ray should have an MRI within 3-7 days.



Clinical Pearl:

Image the *entire* spine in patients suspected of spinal metastases as additional metastases are common and assessing the level of cord compression clinically may be difficult in these patients.

Q: This patient had low hemoglobin, low platelets, an elevated ESR and hypercalcemia. What is the significance of these findings?

A: Low hemoglobin and low platelets in the absence of bleeding should raise your suspicion for cancer. A significantly elevated ESR (particularly over 100) can help risk stratify the patient. It is important to note that patients with metastatic cancer are at risk for hypercalcemia regardless of whether they have bony metastases or not.

Q: Is there a role for bisphosphonate therapy in patients with compression fractures in general and in patients with metastases to bone that an emergency physician should know about?

A: Patients with bone metastases may have hypercalcemia and if so, bisphosphonates are indicated. There is also evidence that bisphosphonates decrease bone resorption and bony pain in patients with metastases to the bone.

There is some convincing evidence that IV pamidronate is superior to placebo in relieving pain associated with vertebral compression fractures in the acute phase. There is no evidence about the efficacy of any oral bisphosphonates. A larger, well-designed clinical trial is still needed to demonstrate clear benefit.

Q: This patient with spinal metastases received 100mg of dexamethasone as soon as cord compression was diagnosed – a high dose. What is the evidence for this?

A: While corticosteroids have been shown to improve symptoms in patients with spinal cord compression secondary to spinal metastases, the preferred dosing regimen has not been clearly defined. A 1994 study showed ambulation rates were higher in patients receiving 96mg of dexamethasone compared to no dexamethasone. However, another study in 1989 showed no difference between 10mg and 100mg of dexamethasone in ambulation or bladder function. There is no consensus and some experts recommend using motor symptoms to guide dosing decisions with the more severe or progressive deficit getting the higher dose (Sørensen).

Spinal metastases are one of the most common causes of spinal cord compression and are often diagnosed too late. Because pre-treatment neurologic status is the most important predictor of long term outcome, early diagnosis and treatment is essential.

In patients suspected of spinal metastases, first, get an x-ray and look for compression fractures, soft tissue changes and blastic or lytic lesions. Consider ordering an ESR and CRP to help guide prognosis and management as well as a calcium level if the patient has any symptoms or signs consistent with hypercalcemia such as polyuria. Give Dexamethasone, at least 10mg IV, as soon as you suspect metastases to the spine in a patient with any neurologic symptoms, and consider calcitonin and IV Bisphosphonate in patients with compression fractures, metastases to bone or hypercalcemia. An MRI should be ordered as discussed above.



Clinical Pearl:

Known cancer +
new onset back
pain = spinal
metastases until
proven otherwise

CASE 4: SPINAL EPIDURAL HEMATOMA AND VASCULAR CAUSES OF BACK PAIN

A 67-year-old woman presents to the emergency department with a 12-hour history of bilateral flank pain, low-grade fever, urinary frequency and confusion. Her past medical history includes type II diabetes, recurrent UTIs, CHF and atrial fibrillation on warfarin.

On exam, she appears unwell. She is febrile at 38.1 degrees Celsius. The rest of her vital signs are normal. She has CVA and suprapubic tenderness. Although pyelonephritis was initially suspected, the Urine R&M was negative. On further exam, the patient has low back spinal process percussion tenderness as well as a bilateral lower extremity motor deficits.

At this point a spinal epidural abscess with cord compression is suspected and an emergent MRI is arranged. The MRI identified an L1 spinal epidural hematoma with cord compression. On reassessment, 3-hours after presentation, the patient had flaccid paralysis in both legs.

The patient was given dexamethasone, IV prothrombin complex concentrates and IV Vitamin K. She was transferred to a neurosurgical centre where she underwent evacuation of the epidural hematoma as well as a laminectomy. Unfortunately, she remained paraplegic with an indwelling Foley catheter.

Q: There are three major vascular causes of back pain: retroperitoneal bleed, AAA leak and spinal epidural bleed. How do these typically present?

A: Spinal Epidural Hematoma usually presents post-spinal procedure in a patient on blood thinners, but can be spontaneous as in the patient presented above. The presentation can be anywhere on the spectrum from isolated back pain to flaccid paralysis.



A spinal epidural hematoma

A **leaking abdominal aortic aneurysm** most classically manifests as back pain with a pulsatile abdominal mass in a patient over 50 years old with a history of HTN. However, the symptoms may be vague, risk factors may be absent, and the abdominal mass may be missed in the obese patient. Symptoms may include groin pain, syncope, paralysis, or flank fullness. The diagnosis may be confused with renal calculus, diverticulitis, incarcerated hernia, or lumbar spine disease. Transient hypotension should prompt consideration of rupture because this finding can progress to frank shock over a period of minutes to hours. Temporary loss of consciousness with syncope is also a potential symptom of rupture. These patients may present in frank shock. It is important to note progressive symptoms (e.g. abdominal or back pain, vomiting, syncope, claudication). These should alert the clinician to the possibility of expansion with imminent rupture.

A **Spontaneous Retroperitoneal Bleed (SRB)** may present similarly to an AAA because AAAs most often bleed into the retroperitoneal space. Many of the clinical features of AAA overlap with those of SRB. The typical presentation is abdominal and low back pain radiating to the groin, hip or anterior thigh in a patient taking anticoagulants.

Q: What are some physical exam pearls to diagnose an AAA leak or a retroperitoneal bleed?

A: Patients with retroperitoneal bleeds will often have a **femoral neuropathy** so their hip is typically in *abduction* and *external rotation*, as this is a position of comfort. A positive **psoas sign** is suggestive of retroperitoneal irritation. Often a **Cullen's sign** (ecchymosis around the umbilicus), **Grey-Turner sign** (flank ecchymosis) or swelling and bruising in the groin may be seen. ED ultrasound should be considered an extension of the physical exam for patients over age 50 who present with low back pain to rule out AAA.

Q: As a thorough emergency physician, you have ruled out all the life-threatening causes of back pain discussed in this chapter. The common diagnosis of lumbosacral sprain is made. How do you treat patients with lumbosacral sprain in the emergency department and what instructions do you give them for home?

A: It is important to convey to the patient that “this is a mechanical problem requiring a mechanical solution” and that medications alone will not fix the problem. While pain medications are often needed acutely, patients need to understand that they must play an active role in getting better. It is important to reassure the patient that more than 90% will improve over days to weeks and remind them to remain active, as bed rest has been shown to be associated with worsening pain. The Cochrane Collaboration supports heat application, NSAIDs, acetaminophen, massage therapy and physiotherapy, although these recommendations are based on low-quality evidence.



Patients with retroperitoneal bleeds may present with their hip abducted and externally rotated secondary to femoral neuropathy.



The Rule of 5s for Back Pain Management in the Emergency Department

5 Important Diagnoses to consider:

1. Cord compression
2. Infection
3. Cancer
4. Bleed
5. Fracture

5 Key Questions to ask:

1. Bowel or bladder symptoms?
2. Risk factors for immunodeficiency?
3. History or symptoms of cancer?
4. Recent spinal intervention?
5. Coagulopathy?

5 Signs on physical exam:

1. Spinous process percussion tenderness
2. Saddle anesthesia
3. Rectal tone and sensation
4. Fever
5. Bilateral, progressive or multilevel neurological deficit

5 Initial Tests to Consider in the Emergency Department:

1. Post-void residual
2. ESR and CRP
3. X-ray L-spine
4. Point of Care Ultrasound (POCUS)
5. Serum calcium in those with spinal metastases and the right clinical picture



Lumbosacral sprain is a diagnosis of exclusion. Be extra cautious of patients who return to the ED a 2nd or 3rd time with back pain. Don't just assume that they are drug seekers.

If you're thinking renal colic – force yourself to think AAA or retroperitoneal bleed. If you're thinking pyelonephritis – force yourself to think spinal epidural abscess or osteomyelitis.

Known cancer + new onset back pain = spinal metastases until proven otherwise. The finding of a non-traumatic vertebral compression should prompt the search for cancer and infection.



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CHAPTER 6: OCCULT FRACTURES & DISLOCATIONS

[LISTEN TO THE PODCAST WITH ARUN SAYAL AND NATALIE MAMEN HERE](#)



Objectives

1. To review the diagnostic clues for some important occult fractures and dislocations
2. To understand why some fractures and dislocations are easy to miss
3. To review ankle sprain mimics
4. To compare and contrast imaging modalities for occult fractures

CASE 1: A SNOWBOARDER'S FRACTURE

An 18-year-old girl presents to your ED one day after injuring her left ankle while snowboarding. She was attempting a jump and landed “funny”. Since then, she says she cannot put weight on it without excruciating pain and tells you that her ankle is really swollen.

On physical examination, she fails the Ottawa Ankle Rules, being unable to weight bear 4 steps, but has no tenderness over the posterior medial or lateral malleoli. She is very tender and swollen just infero-anterior to the distal tip of the fibula, over the anterior talo-fibular ligament.



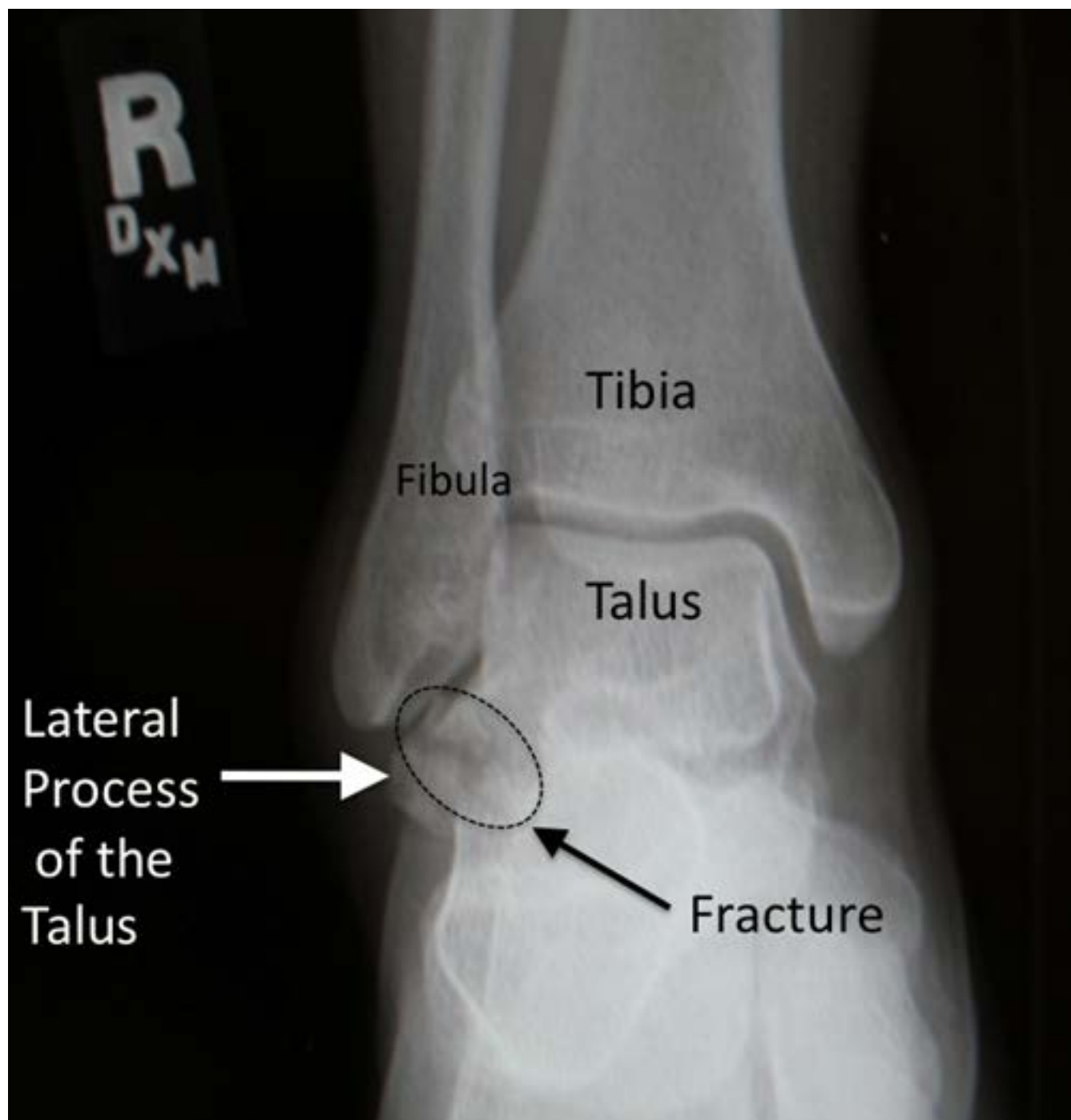
Q: What is the mechanism of injury of a Snowboarder's Fracture?

A: The mechanism of injury of a Snowboarder's Fracture involves axial loading with the ankle in dorsiflexion and eversion, which occurs because snowboarders always have their ankles dorsiflexed. When they fall, it is usually the leading leg that rotates toward the front of the board, causing the dorsiflexed ankle to evert or externally rotate. This mechanism of injury can very easily cause a fracture of the lateral process of the talus, a Snowboarder's Fracture.

Case Continued: Three views of the ankle return with a report reading “no fracture seen.”

Q: What would you do next?

A: Further imaging is often necessary; consider a *Broden's view x-ray*, which is a mortise ankle view with the foot plantar-flexed. On Broden's view the plantar talus should show a symmetrical “V”. If this is not seen, consider a displaced fracture that may require surgery. A CT, if available, is highly sensitive for snowboarder's fracture.



Q: Why are Snowboarder's Fractures often mistaken for a simple ankle sprain?

A: Snowboarder's Fractures are typical ankle sprain mimics. These patients are typically tender over the anterior talofibular ligament, which is in the same area where most common ankle sprains have swelling and tenderness. This makes it easy to write off these injuries as a simple ankle sprain.

Q: How would you treat this patient?

A: Treatment of non-displaced or minimally displaced (<2mm) fractures of the lateral process of the Talus or of a suspected occult fracture is with immobilization in a back slab and then a cast and with non-weight-bearing for 6 weeks. For displaced fractures of more than 2mm, consult orthopedics for an Open Reduction and Internal Fixation (ORIF).



Clinical Pearls

Other ankle sprain mimics include:

- Anterior process calcaneus fractures (mechanism: inversion)
- Posterior talar process fractures (opposite of snowboarder's fracture)
- Talar dome fracture (mechanism: inversion)
- Achilles tendon rupture (forced dorsiflexion against active contraction)



Caution:

Fractures of the lateral process of the talus may be associated with peroneal tendon dislocations, so examine for a tender peroneal tendon posterior to the lateral malleolus, more prominent with ankle dorsiflexion

VIDEO:

[Watch a video explaining Snowboarder's Fracture anatomy and management here](#)

CASE 2: OCCULT HIP FRACTURE

A 67-year-old woman, on chronic steroids for severe COPD, loses her balance and falls on her left hip 1 week prior to her emergency room visit. She is complaining that it still hurts to walk. She is triaged to the minor area of your ED. The triage nurse's note says "Fell from standing, ambulating well. Also complaining of groin pain."

Q: What clues in this case make you suspect a hip fracture?

A: Groin pain is a diagnostic clue for pelvic and hip fractures. In addition, chronic steroid use and a systemic disease such as COPD are risk factors for osteoporosis and fragility fractures.

Q: What physical exam maneuvers would you perform to help you decide whether or not this patient has suffered a hip fracture?

A: Besides your basic musculoskeletal examination of the hip, consider:

1. Percussion test: Place the diaphragm of your stethoscope on the pubis symphysis and percuss the patella on each side. Diminished percussion sounds on the side of suspected fracture were shown to have a positive predictive value of 98% for a femoral neck fracture in one study.
2. Tenderness in groin area
3. Inability to straight leg raise
4. Painful limitation of rotation of the hip
5. Pain on axial loading of the limb makes fracture more likely



The Straight Leg Raise Test is a high-yield physical exam maneuver, not only for occult hip fractures but also for quadriceps tendon injuries, patella fractures and patella tendon injuries in addition to the classic assessment for sciatica.

VIDEO:

[Watch a video demonstrating the percussion test here](#)

Q: You decide to order an x-ray of the pelvis. What findings would suggest a hip fracture?

A: Shenton's Line, the smooth arc formed by the superior border of the obturator foramen and medial aspect of the femoral neck, will be disrupted in a femoral neck fracture.



Q: The x-ray reveals no fracture. You order a CT and it too reveals no fracture despite your strong clinical suspicion. What is your plan?

A: Given your high clinical suspicion, consideration should be given to an MRI of the hip and pelvis.



A recent retrospective study of 235 patients with occult hip fractures demonstrated that 64-slice CT scan had a miss rate of 2%, which were subsequently detected on MRI.



A Proposed Algorithm for Suspected Occult Hip Fracture:

In **young** patients with **high-energy** trauma, a fracture in the cortex will **likely** be seen:

If x-rays are negative but clinical suspicion is high, move on to CT scan

In **elderly** patients with **low-energy** trauma, occult fractures are **less likely** to involve the cortex of the bone:

If x-rays are negative but clinical suspicion is high, move on to MRI (preferred) or 64-slice CT if MRI is not available



- A small study out of Israel showed a 100% sensitivity of U/S for hip fracture
- Femoral Neck and Pelvic Ring Fractures are mutually exclusive. A study of more than 100 elderly patients, who were unable to weight bear after a fall, had an MRI done of their pelvis. There were no patients with a fracture of the femoral neck and an associated fracture of the pelvic ring. Nor were there any patients with a pelvic ring fracture and an associated fracture of the femoral neck. Thus, femoral neck fractures and pelvic ring fractures were found to be mutually exclusive. However, 10% of femoral neck fractures will have an associated ipsilateral femoral shaft fracture so be sure to “look south” on the x-ray.

CASE 3: OCCULT KNEE DISLOCATION

A 40-year-old man lost control while driving and collided with a pole at 80km/hr. He was belted, no airbag was deployed and there was no passenger intrusion. He did not lose consciousness and has full recollection of the event. His only complaint is severe right knee pain. He is boarded and collared.

On exam, his primary survey is unremarkable. On secondary survey, there are no signs of head injury, there is slight C-spine tenderness but no T- or L- spine tenderness. His chest and abdominal exams are normal. His pelvis is stable. His extremity exam reveals a swollen tender right knee with an obvious effusion and very limited range of motion.

Q: What extremity injuries are on your differential diagnosis?

A: Posterior hip dislocation, tibial plateau fracture, patellar fracture, knee dislocation, posterior acetabular fracture.

Case Continued: You complete a full knee exam including neurovascular examination of the lower extremity. This reveals normal pedal pulses bilaterally; however, there is significant ligamentous laxity of the knee. After the C-spine is cleared and the patient is observed for 6 hours with serial examinations, he is placed in a full leg back slab and sent home with orthopedic follow-up.

Three days later the patient returns to the emergency department with severe foot pain, and a cold, pulseless foot. He goes on to have emergency vascular surgery for a massive popliteal thrombosis and never recovers full function of his right lower extremity.

Q: If you could go back in time, what would you do differently?

A: Recall that this was a high-energy trauma. Knowing that 50% of all knee dislocations are reduced before the patient arrives at the ED and that one-third of knee dislocations will have neurovascular injuries, further investigations to rule out vascular injury need to be considered. Vascular injury should always be considered in patients with severe ligamentous injuries and high-energy mechanisms. Ankle Brachial Index (ABI) and Doppler ultrasound imaging may miss small intimal injuries that clot after a few days. The gold standard is an arteriogram, with a CT angiogram being the more readily available investigation.

The presence of normal distal pulses does not preclude occult popliteal artery injury as this has been shown to have a rate of 5-15% when normal pulses are present.



Pitfall:

Failure to revascularize within 6–8 hours results in an unacceptably high amputation rate of up to 86%. Peroneal nerve injuries are less common than popliteal artery injuries because the nerves are not as tightly anchored; however, when a nerve injury is present, a concomitant vascular injury must be considered.



Clinical Pearl:

Three out of four knee ligament laxity (ACL, PCL, MCL, LCL) is suspicious for an occult knee dislocation



Caution:

Do not forget that low-energy trauma can still cause knee dislocations, especially in patients with a body mass index >40. One study found that 47% of knee dislocations were due to low-energy trauma (e.g. slips/falls), with 75% being in obese patients. Obese patients with low-energy trauma were **more** likely to have associated neurovascular injury than high-energy trauma patients in this cohort.

CASE 4: OCCULT SCAPHOID FRACTURE

A 10-year-old boy comes into the ED after he was tripped at school while playing soccer. He fell onto his outstretched right hand. He now has pain in his right wrist. On physical examination, there is no swelling of the wrist or thumb and he has full active range of motion of both the wrist and thumb. He has no distal radius tenderness, but does have some tenderness to palpation in his snuffbox. His elbow has full range of motion and no tenderness.

Q: How would you manage this child initially in the ED?

A: Address the following issues:

- 1. Pain control in children** - a study of outpatient treatment of arm fracture pain in children found ibuprofen was at least as effective as acetaminophen with codeine as an analgesic, had better functional outcomes and less adverse effects.
- 2. Obtain specific scaphoid views**
- 3. Consider a “clench fist view”**, which splays the carpal bones and may reveal a scaphoid lunate distance $>3\text{mm}$, which is consistent with a scapholunate tendon tear.

[Click here to jump to Chapter 1 on Commonly Missed Uncommon Orthopedic Injuries for more on Scapholunate Injuries](#)



Clinical Pearl:

Keep in mind that scaphoid fractures are much less prevalent in children compared with adults.

Q: What clues on physical exam can you use to help diagnose scaphoid fractures?

A: There are other physical examination findings besides snuffbox tenderness that can help to diagnose scaphoid fractures. When you use all 5 of the following physical exam maneuvers in addition to snuffbox tenderness, the sensitivity for scaphoid fractures nears 100%

1. Pain on palpation of the scaphoid tubercle volarly with radial deviation of the wrist
2. Pain with axial compression of the thumb metacarpal
3. Pain with resisted supination
4. Limited thumb range of motion and pain at the end of the arc of motion, especially with flexion and radial deviation
5. In a prospective study of the clinical exam of the scaphoid, pain during pincer grasp (pinching of the thumb and index fingers together) was found to have the best positive predictive value for subsequent scaphoid fracture



Another study looked at the following 3 key maneuvers for scaphoid fracture:

1. Palpation of snuffbox with wrist ulnarly deviated
2. Axial loading of thumb with pain in the anatomical snuffbox
3. Palpation of volar aspect of scaphoid with wrist radially deviated

3 of 3 gives 90% risk of scaphoid fracture (70% with 2 of 3)

Video: [Watch a video of the scaphoid shift test here](#)

Q: What proportion of patients with scaphoid fractures will have normal x-rays?

A: Approximately 15% of patients with a suspected scaphoid fracture on physical exam and normal radiography go on to have confirmed scaphoid fracture in follow-up.

Q: Assuming you have access to all imaging modalities, how do x-ray, bone scan, CT and MRI compare in general for finding occult fractures?

A: The following is an overview of the different imaging modalities:

Bone Scan: Bone scans demonstrate increased uptake at the fracture site corresponding to increased osteoblastic activity. In the hyperacute phase, bone scans may be negative in the setting of occult fractures because the reparative process has not yet begun. Bone scans should be delayed for at least 48 hours after the acute injury in young patients and at least 72 hours in elderly patients. One study found that use of bone scan at 3-5 days post-injury was not able to reduce the length of immobilization.



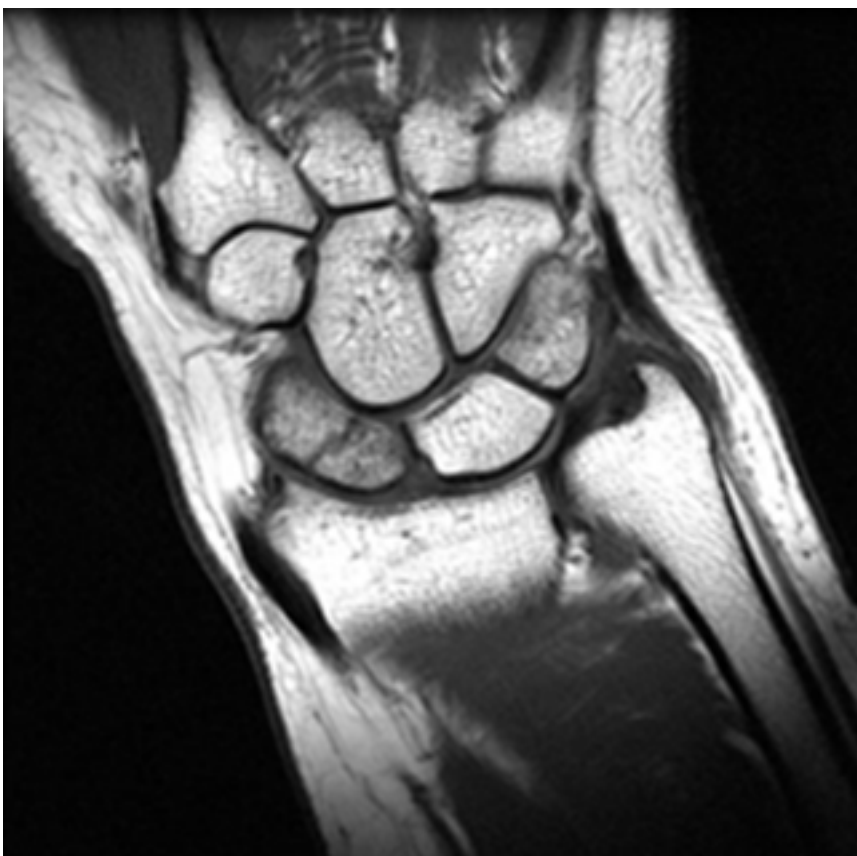
Bone Scan of a Scaphoid Fracture

CT: CT may miss some fractures early on, especially if they are not cortical fractures. The use of early CT following suspected scaphoid fracture with normal radiographs has been shown to be sensitive for detecting scaphoid fractures and reduces length of immobilization by avoiding the need to repeat radiographs 7-10 days post-injury. However, CT is not 100% sensitive.



CT Scan of a Scaphoid Fracture

MRI: MRI is the imaging modality of choice, with a sensitivity of 100% for occult fractures of the scaphoid, and can pick up other fractures and tendon injuries that were not apparent on x-ray. MRI is very good at picking up trabecular fractures or fractures with low energy mechanism that other imaging modalities may miss. In a perfect world, every patient with a suspected occult fracture would get an immediate MRI, however, resource utilization issues preclude the use of MRI for scaphoid fractures in most centres.



MRI of a Scaphoid Fracture

Repeat x-ray in 7-10 days: Repeat x-rays are still commonly used in the management of scaphoid fractures, often due to limited availability diagnostic imaging and orthopedic surgery follow-up. However, compared to the imaging modalities above this can be associated with greater duration of immobility and limited functional status, which can impact patient satisfaction. The risk of radiation with CT and bone scans is likely of greater consideration in the pediatric population, which may favour the use of repeat x-rays.



X-ray of a Scaphoid Fracture

Q: What type of splint should be used for a suspected scaphoid fracture?

A: A Colles splint is at least as effective as a thumb spica splint, suggesting that immobilization of the thumb is likely not necessary. Consider an above-elbow splint for waist and proximal third fractures, as these are at the highest risk for avascular necrosis.

Q: How long should the wrist remain immobile?

A: Duration of immobilization varies relative to the location of the fracture, but the average is 12 weeks. More proximal fractures require longer immobilization to ensure adequate healing. This variability in healing time is related directly to the pattern of blood supply to the scaphoid, which flows from the distal to the proximal portion of the bone through the scaphoid tuberosity. This pattern of blood flow also accounts for the higher incidence of avascular necrosis (AVN) and fracture nonunion in the more proximal fractures.

FOAMed Link: [*For video on the anatomy of scaphoid fractures see Emergency Medicine Ireland*](#)

FOAMed Link: [*For more on the ED perspective on scaphoid fractures*](#)

Q: What are the indications for surgery for scaphoid fractures?

A: Because of the increased risk of AVN or nonunion, any scaphoid fracture that is displaced more than 1mm or is associated with an increase in the normal scapholunate or capitolunate angles requires prompt orthopedic referral for consideration of operative treatment.

In addition, some orthopedic surgeons elect to operate on scaphoid fractures for all proximal scaphoid fractures, and non-displaced fractures in athletes who request early return to sport.

CASE 5: THE HYPOGLYCEMIC PATIENT

A 56-year-old man was found at home by his wife, confused and sweaty on his bedroom floor. She immediately called 911. When EMS crews arrived, they found the patient with a GCS of 12, a heart rate of 120, a blood pressure of 110/70, a respiratory rate of 24, an oxygen saturation of 100% and temperature of 36 degrees Celsius. Capillary glucose was 1.0 mmol/L and glucagon was given. On arrival in the ED the vital signs were unchanged, GCS 14 and glucometer showed a glucose of 3.5 mmol/L (abnormal is below 4). You give an ampule of D50W IV and the glucose normalized, as well as the GCS.

On further history, the patient does not remember what happened and is now complaining of bilateral shoulder pain. His review of systems is otherwise unremarkable. He has a history of diabetes mellitus (DM) and is on ASA, insulin, ramipril and atorvastatin. His cardiac and neurologic examination is grossly normal. There are no signs of head injury or basal skull fracture. His ECG is normal and a usual cardiac workup is ordered.

On examination, he is holding both of his shoulders in internal rotation, and upon passive external rotation, you feel a great deal of resistance and the patient yells out "ouch!".

Q: What is the cause of this patient's shoulder findings?

A: While this appears to present as a simple hypoglycemic episode with some sort of shoulder trauma, there are some peculiarities. You need to ask yourself what can cause bilateral shoulder pain: vascular events like acute coronary syndrome or aortic dissection are possibilities and these need to be considered in patients who present to the ED with non-traumatic bilateral shoulder pain. From a trauma perspective there are not too many things that can cause isolated bilateral shoulder pain.

The cause of the shoulder findings in this case is most likely bilateral posterior shoulder dislocations as a result of tonic-clonic seizure secondary to hypoglycemia.

Other patients that you should be suspicious for this diagnosis in are alcohol- or drug-related seizures, electrocution and high-energy trauma.



In the absence of a history of direct trauma to the shoulder, posterior shoulder dislocation is virtually pathognomonic of a seizure.

Q: What is the mechanism of injury for a posterior shoulder dislocation?

A: The mechanism of injury is an axial force with the shoulder internally rotated and abducted.

Q: What are some key diagnostic features?

A: Key diagnostic features:

1. The arm will be held in internal rotation
2. Mechanical block to external rotation is the most consistent finding (caused by engagement of a Reverse Hill Sachs deformity on the posterior aspect of glenoid)

Q: What are the typical x-ray findings for a posterior shoulder dislocation?

A: Fifty percent of posterior dislocations are missed on the 1st visit because they are difficult to pick up on plain radiographs.



Look for the subtle “light bulb” sign on AP



Remember to order an axillary view if the AP is not revealing.



Clinical Pearl:

The axillary view is diagnostic but sometimes difficult to perform due to limited abduction. Consider *apical oblique*, *velpeau* and *modified axial* views to aid in the diagnosis.

Video:

[Click here to watch a video of a posterior shoulder dislocation reduction](#)

Q: Why is it important to pick up a posterior shoulder dislocation early?

A: The reason posterior shoulder dislocations are important to pick up on the 1st visit is that over time the Reverse Hill Sachs enlarges and becomes corticated, which can lead to osteoarthritis.

Q: What is the ED treatment for posterior shoulder dislocations?

A: Attempt reduction if <50% of humeral head articular surface is involved and if dislocation is within 6 weeks of injury. Otherwise consult orthopedics for consideration of operative management. Many of these patients end up with arthroplasty.

For reduction, consider procedural sedation. You must first disimpact the Reverse Hill Sachs deformity by GENTLY manipulating the shoulder while in 90 flexion and abduction, followed by external rotation to relocate the dislocation.

Immobilize the shoulder with the elbow at 90 degrees and the shoulder at 90 degrees of external rotation with the palm facing up.

[Click here for an article on how to make a splint for post-reduction immobilization of a posterior shoulder dislocation so that the arm is in abduction with the shoulder externally rotated](#)

CASE 6: THE MUTE ADDICT

A 29-year-old man comes in by ambulance after he was found lying on the ground in an alleyway. There is no history on the patient as he is completely non-verbal. On arrival in the ED, he appeared very agitated but alert, sitting up on the stretcher. He is diaphoretic and has the following vitals: heart rate of 130, blood pressure of 170/110, respiratory rate of 20, oxygen saturation of 99%, and temperature 37.8 degrees Celcius. Glucose is normal. Primary survey reveals stable ABCs. His pupils are dilated and reactive and his GCS is 12 on account of being non-verbal. He is disrobed and you discover crack pipes in his jean pockets. An IV is started, blood work is sent and Lorazepam 2 mg IV is given for presumed sympathomimetic toxidrome and for agitation.

On secondary survey, there are no signs of head injury, C-spine is difficult to assess due to the patient continuing to be non-verbal. Chest and abdominal examination are unremarkable. FAST exam is negative. The patient is tender to palpation everywhere on the lower extremities. While he is moving his arms and appearing to be agitated, he is not moving his lower extremities at all. Both of his ankles and feet are swollen, with no obvious deformity. His pedal pulses are not attainable by palpation, but are found with a hand-held Doppler machine. Reflexes and sensation of the lower extremities are impossible to attain. Lorazepam 2 mg IV is repeated due to ongoing agitation and he is sent for x-ray of the C-spine, chest, pelvis, feet and ankles. He continues to be agitated and diaphoretic, and finally, after a total of 10 mg IV Lorazepam, begins to talk.

He states: "I hurt all over, I can't move anything, give me water."

His CPK is > 5000 and a bolus of 2 L normal saline is given.

All of his radiographs appear normal on first review.

Upon re-examination, the patient is most tender on the heels, bilateral malleoli and lumbar spine. With this new information, you send him for a lumber spine x-ray. This shows multiple compression fractures of the spine.

It turns out, on further history, that the patient was trying to climb the fire escape at his drug dealer's home, and fell onto his feet on the cement sidewalk below.

Q: What do you do next?

A: Given this new finding of traumatic spinal compression fractures, a focused neurological examination of the lower extremities including a rectal exam to assess tone and saddle anesthesia would be warranted. A CT of the head and spine should also be strongly considered.

Given the history of fall and significant heel and ankle tenderness, it is prudent to more closely examine the foot and ankle radiographs. Also, look for plantar ecchymosis on physical exam as it may be a clue to calcaneal fractures or a Lisfranc dislocation.

If a calcaneal fracture is suspected clinically or radiographically, consider a CT scan to determine whether a fracture involves the subtalar (or talocalcaneal) joint as intra-articular fractures are more common (comprising 75% of calcaneal fractures) and are associated with greater morbidity.

Calcaneal fractures have a high morbidity overall with 20% of patients debilitated at 3 years post-injury. Early diagnosis and treatment are important to improve outcomes.



Clinical Pearl:

Any fall from a height onto one's feet should prompt you to look for associated injuries including spinal injuries (especially lumbar spine), contralateral calcaneal fractures and ankle fractures. Overall, more than 50% of patients with a calcaneal fracture will have other associated spinal or extremity fractures and 10% will have spinal injuries.

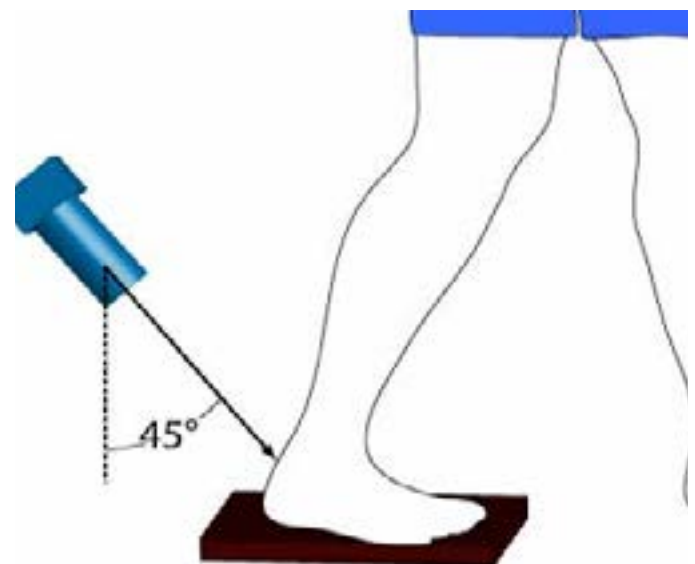
Q: What else should you be aware of or looking for in these patients?

A: Up to 10% of calcaneal fractures will develop a compartment syndrome so it is important to check serial compartment pressures in suspicious cases!

Q: Which additional x-ray views can improve diagnostic accuracy for suspected calcaneus injury?

A: A Harris view x-ray of the ankle should always be obtained if there is suspicion of calcaneal injury.

Look for Bohler's Angle on the lateral foot radiograph. This angle is obtained by drawing 2 lines on the calcaneus: one line is from the posterior tuberosity to the apex of the posterior facet, and the other from the apex of the posterior facet to the apex of the anterior process of the calcaneus. Bohler's angle may vary from 20 to 40 degrees; a calcaneal fracture is strongly suggested (with a sensitivity and specificity of 99%), with an angle less than or equal to 20 degrees.



Q: How should calcaneus fractures be managed in the ED?

A: These fractures often require open reduction and internal fixation but the criteria for this is very poorly defined and the treatment is controversial. The less common extra-articular fractures rarely require anatomic reduction and can usually be treated conservatively. All displaced fractures, both extra- and intra-articular, require prompt orthopedic consultation for further management.

The ED management centres on minimizing swelling to the surrounding soft tissues. Soft-tissue injury that accompanies these injuries cannot be emphasized enough. Apply a bulky, compressive dressing with a posterior splint. Combine this with elevation and ice to prevent fracture blisters and skin sloughing. This could help prevent any delays in surgical intervention.



Comments?

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CHAPTER 7: TENDON & LIGAMENT INJURIES

[LISTEN TO THE PODCAST WITH IVY CHENG AND HOSSEIN MEHDIAN HERE](#)



Objectives

1. Develop further awareness and approach to commonly missed uncommon orthopedic injuries
2. Diagnose and appropriately treat syndesmosis injuries
3. Learn to distinguish distal bicep tendon ruptures from proximal bicep tendon ruptures in order to treat appropriately
4. Diagnose and appropriately treat a quadriceps tendon rupture
5. Recognize a gastrocnemius tear and avoid unnecessary DVT work-ups

CASE 1: SYNDESMOSIS ORTHOPEDIC INJURIES

A 22-year-old football player comes in to your ED after sustaining an ankle injury while being tackled during a game. He cannot recall the exact details of the mechanism of injury. He complains of pain at the anterolateral ankle. There is no swelling or tenderness noted at the medial or lateral malleoli. His Ottawa Ankle and Foot Rules are negative.

Syndesmosis injuries or “high ankle sprains” typically occur in impact sports. They are missed in about 20% of cases, as x-rays findings are often subtle or absent. The mechanism, physical exam findings, such as the Hopkin’s Test, and associated injuries are important to understand to help make the diagnosis and provide appropriate ED care.

Q: What is the mechanism of a syndesmosis injury?

A: The mechanism of injury involves a rotational force, whereby *external* rotation of the ankle, with or without hyper-dorsiflexion, overstretches the syndesmosis that lies between the distal tibia and fibula, near the talus. This mechanism of injury is far less common than the classic ankle sprain that would be the result of an *inversion* mechanism.

Q: What are the 3 common physical exam findings of a syndesmosis injury?

A:

- 1. Toe walking:** Patients may not weight bear appropriately, and may walk on their toes to prevent painful dorsiflexion.
- 2. Squeeze/Hopkin’s Test:** The tibia and fibula are squeezed together at the mid-calf level. A positive test occurs when pain is felt at the syndesmosis located at the distal tibia/fibular junction, near the talus.
- 3. External Rotation Test:** The patient’s leg is stabilized with the hip and knee flexed to 90 degrees. Holding the patient’s foot and externally rotating it with a small amount of dorsiflexion will elicit pain at the syndesmosis.



Toe walking



Squeeze/Hopkin's Test



External Rotation Test

Q: X-ray findings are often absent with syndesmosis injuries, however, some subtle clues on x-ray may be present. What are the x-ray findings of a syndesmosis injury?

A: There are three often subtle x-ray findings:

- 1. Decreased tibio-fibular overlap** - normally $>6\text{mm}$ of overlap on the AP view and $>1\text{mm}$ on mortise view
- 2. Increased medial clear space** - normally $\leq 4\text{mm}$
- 3. Increased tibiofibular (syndesmosis) clear space** - normally $<5\text{mm}$ on AP and mortise views



Tibio-fibular overlap: normally $>6\text{mm}$ of overlap on the AP view and $>1\text{mm}$ on mortise view



Increased medial clear space: normally $\leq 4\text{ mm}$



Normal Tibio-fibular Clear Space: $<5\text{mm}$ on AP and mortise views

Q: What is the appropriate ED management for a patient with a suspected syndesmosis injury who has normal x-rays?

A: Patients should be non-weight-bearing in an aircast boot or back slab and be followed up by orthopedics.

If you suspect widening of the syndesmosis, the joint may be subluxed and the patient may require screw fixation.

Q: While syndesmosis injuries may occur in isolation, they are often associated with other injuries. What other injuries are commonly associated with syndesmosis injuries?

A:

Other commonly associated injuries include:

- Ankle fractures (Weber B and C)
- Base of 5th metatarsal fracture
- Proximal fibula fracture

CASE 2: DISTAL BICEPS TENDON RUPTURE

A 48-year-old man comes to the ED from a construction site where, after attempting to lift a bag of cement, he hears a loud snapping sound followed by a sudden onset of pain in his arm. On exam, he's able to actively move through a full range of motion of his elbow, but you notice a bulge in his biceps muscle – the so-called “Popeye” sign. He's diagnosed with a partial biceps tendon rupture, put in a sling, sent home with a script for physiotherapy and told to follow up with his family doctor.

Distal biceps tendon rupture is almost exclusively a male injury and occurs in a younger age group compared to the proximal biceps rupture. It is important to distinguish these injuries as their management and outcomes are different. The mechanism and physical exam findings of distal biceps tendon rupture, such as the Hook Test, are key in this respect.

Q: What are the mechanisms of injury in distal vs. proximal biceps tendon ruptures?

A: *Proximal* biceps tendon ruptures typically occur in older patients with age-related degeneration of the tendon and rotator cuff symptomology. There is usually no obvious acute injury.

Distal biceps tendon ruptures typically occur in younger patients, such as construction workers or weightlifters with chronic repetitive microtrauma that causes weakening of the tendon that attaches to a well-built muscle. This large bicep muscle is capable of a sudden massive eccentric contraction that tears the tendon. This occurs almost exclusively in males.

Q: What are the physical exam findings of biceps tendon ruptures?

A: In *both* distal and proximal biceps tendon ruptures, a **“Popeye” sign** (named after the old cartoon “Popeye The Sailor Man”) is typical.



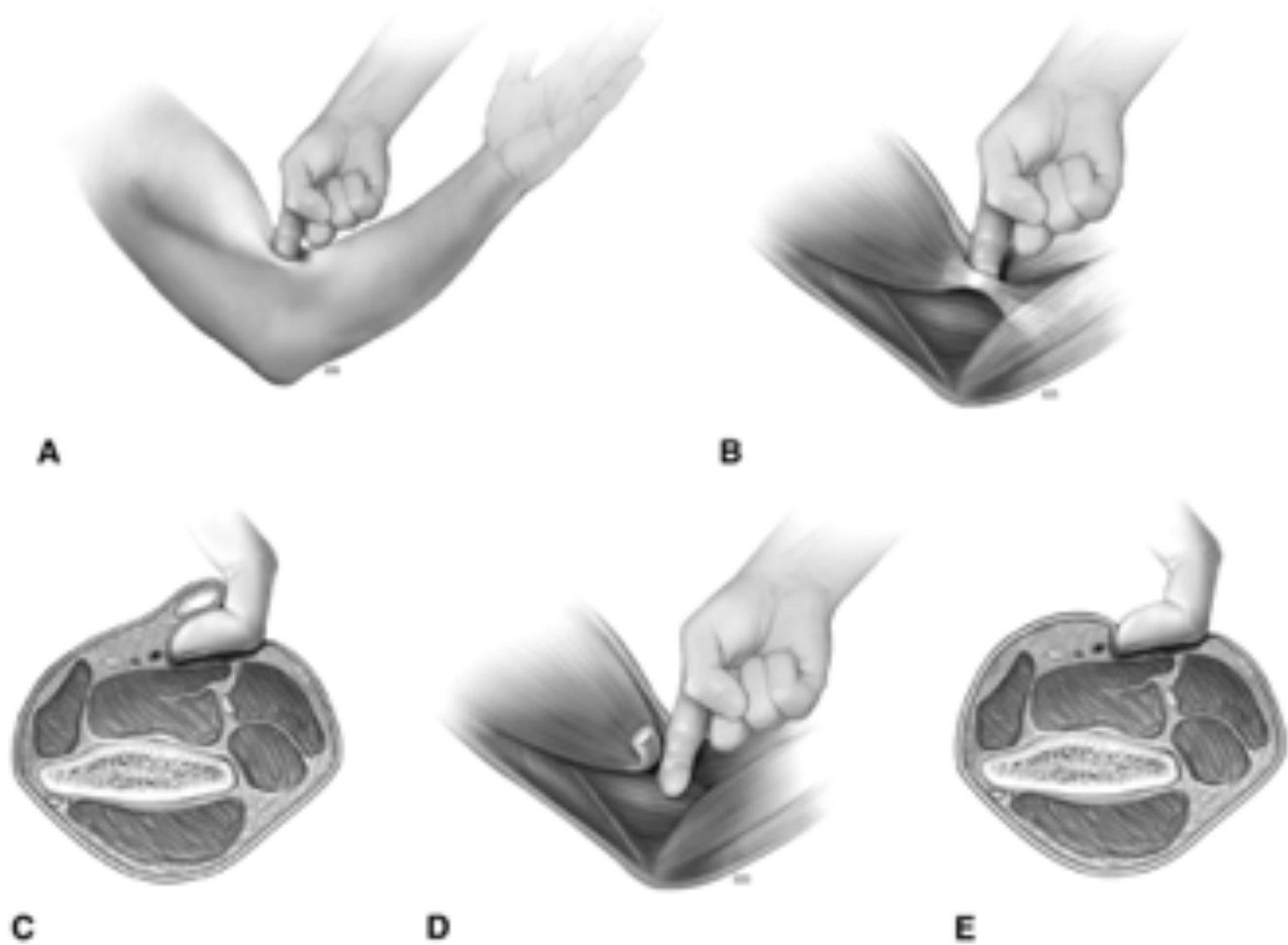
Popeye sign of biceps tendon ruptures

In a *distal* biceps tendon rupture, you will often see ecchymosis on the anterior aspect of the elbow. There is usually decreased force of supination and/or pain with supination.

Look for the Hook Sign: Use your index finger and go lateral to the insertion of the biceps and hook your finger around the biceps tendon. If there is no Hook Sign (an empty space) – there is likely a distal biceps rupture.



Distal biceps tendon rupture



Hook Sign

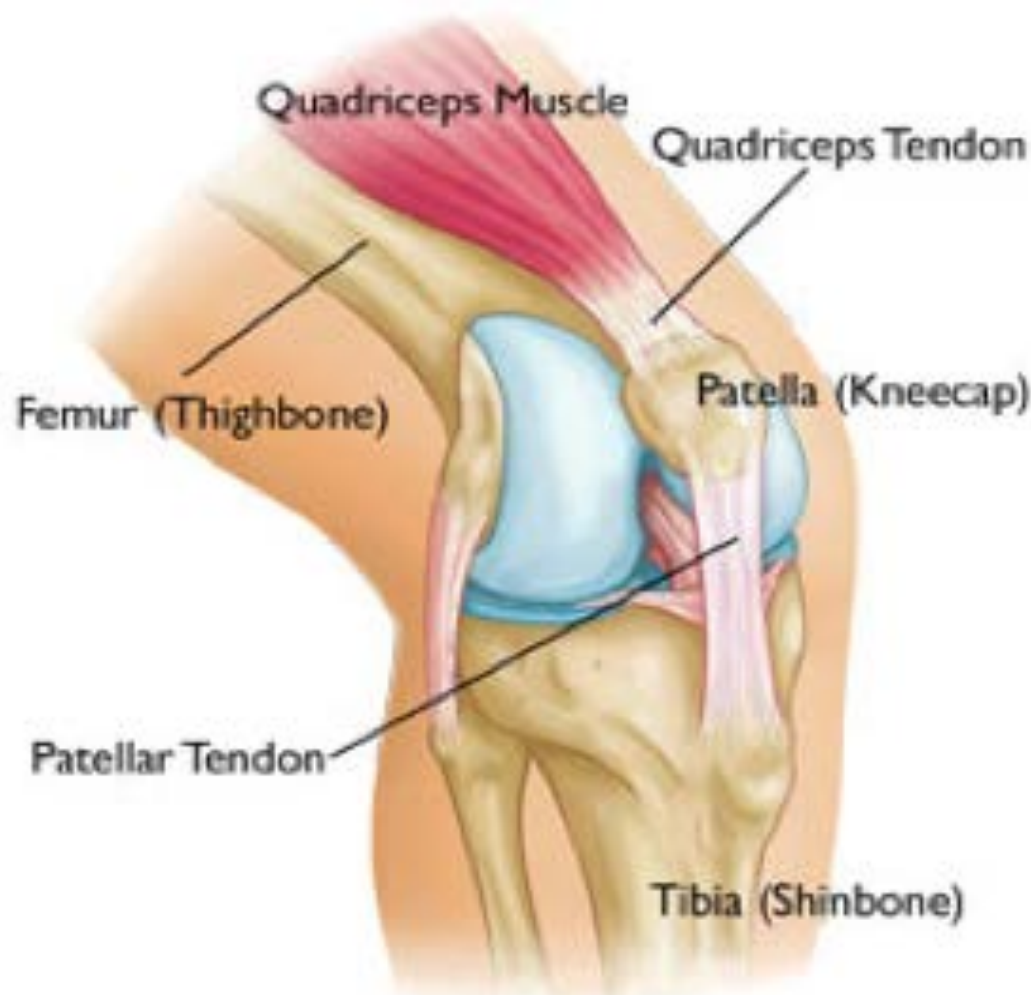
Q: How does the management of the distal biceps tendon rupture differ from that of a proximal biceps tendon rupture?

A: Patients with a *distal* biceps tendon rupture should be immobilized, with early referral to orthopedics, as surgical repair within 2 weeks is desirable to avoid tendon retraction. In contrast, patients with *proximal* biceps tendon ruptures are managed non-operatively with physiotherapy.

CASE 3: QUADRICEPS TENDON RUPTURE

A 45-year-old man, with a history of diabetes, was recently on Ciprofloxacin for suspected pyelonephritis. He has recently decided to play soccer with his teenaged son three times a week. He comes in to the ED after slipping on the soccer field, stumbling, and then not being able to weight bare due to severe left knee pain. He is unable to extend his knee against resistance and he has a lot of trouble performing a straight leg raise. On physical examination, you notice a knee effusion, but there is no joint line tenderness and his ACL, PCL, MCL, and LCL all seem to be intact with a negative Lachman test and pivot shift test. He also has a negative McMurray test for meniscal tear.

There is a spectrum of knee extensor injuries that should be understood in order to provide proper care to these patients, with the Straight-Leg-Raise Test being abnormal in all of them. This is one of the most important physical exam maneuver to perform on every ED patient with a knee injury. The x-ray findings of these injuries may be subtle or absent, and proper immobilization of these injuries is important to prevent recoil of the tendon.



Q: This patient probably just has a simple “knee sprain”, right?

A: Wrong. Quadriceps tendon rupture is often misdiagnosed as a simple “knee sprain”, and should be given appropriate, immediate follow-up for consideration of surgical intervention. Quadriceps tendon ruptures are more commonly seen in patients older than 40 years of age while the less frequent patella tendon ruptures are more commonly seen in patients under the age of 40. Interestingly, up to 1/3 of patients present with *bilateral* quadriceps tendon ruptures, so comparing physical examination signs in the knee of concern with the contralateral knee may be misleading.

Q: What is the spectrum of injuries in quadriceps mechanism dysfunction and how can you differentiate between them?

A: The spectrum of injuries includes: quadriceps tendon rupture, patellar fracture, and patellar tendon rupture.

Q: What are physical exam findings in quadriceps mechanism injuries?

A: All three injuries present with an inability to perform a straight leg raise.

In a quadriceps tendon rupture, you can usually palpate a gap in the tendon above the knee. You may be able to see a suprapatellar gap when inspecting the knee from the side. In a patellar fracture, patients will have tenderness over the patella. In a patellar tendon rupture, there will be a gap distally in the tendon below the patella.



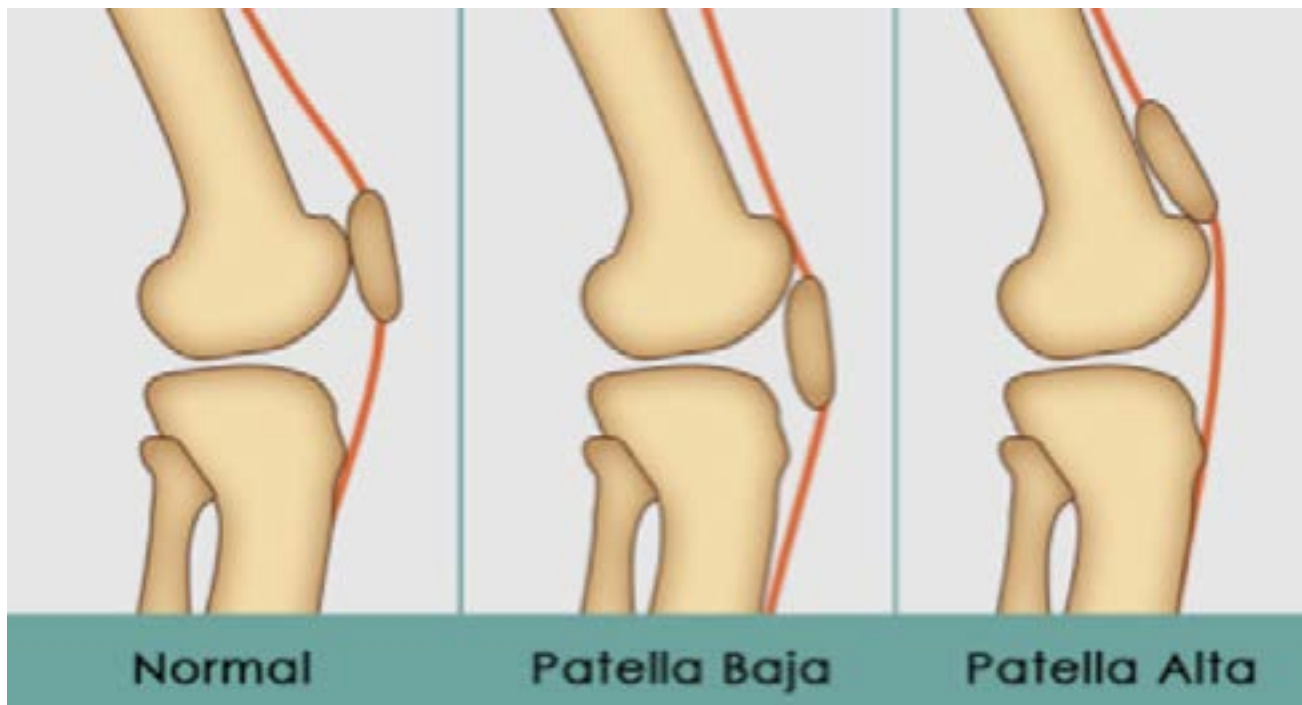
Suprapatellar Gap often seen in a quadriceps tendon rupture



The triad of 1) acute knee pain, 2) inability to actively extend the knee and 3) a suprapatellar gap suggest the diagnosis of quadriceps tendon rupture.

Q: What are the typical x-ray findings in quadriceps tendon injuries?

A: Usually patients have normal x-rays. With a quadriceps tendon rupture, you *may* see **Patella Baja** (patella rides lower than usual). In a patellar tendon rupture, you *may* see **Patella Alta** (patella rides higher than usual).



Patella Baja & Alta

Q: What is the ED management of patients with a suspected quadriceps tendon rupture?

A: These patients can be weight bearing with a knee immobilizer (e.g. “Zimmer splint”), and should have orthopedics follow-up within a few days, for surgical consideration.



Clinical Pitfall:

Quadriceps mechanism injury is one of the only injuries that requires a knee immobilizer. Meniscal tears, ACL, MCL and PCL injuries are often inappropriately immobilized in a Zimmer splint.

CASE 4: GASTROCNEMIUS TEAR

A 55-year-old man comes in to the ED after playing tennis where she lunged for a shot. She reports hearing a pop and felt like a baseball bat struck her in the calf. She comes in limping, but able to bear weight, complaining of calf pain radiating to the knee. Her calf is slightly swollen and tender down to the ankle. The calf pain is worse with range of motion of the ankle.

Patients with calf pain and Gastrocnemius Tears are often misdiagnosed as having a Deep Vein Thrombosis (DVT). In fact, one small study showed that gastrocnemius tears were misattributed to DVT in 29% of patients. This confusion occurs because sometimes patients who suffer a gastrocnemius tear report a prodrome of calf tightness several days before the injury, suggesting a potential chronic predisposition. With a good history and physical, and point of care ultrasound, if you're skilled at it, needless work-ups for DVT can be avoided.



Q: What is the mechanism of injury in a gastrocnemius tear?

A: This injury typically occurs in sports that require jumping, or from running up a hill, when a forceful pushoff with the foot causes the gastrocnemius to attempt a forceful contraction against an already lengthened state. The gastrocnemius tear injury is also known as “*Tennis Leg*” or the “*Weekend Warrior*” because it usually occurs in people who are only intermittently active in sport.

Q: How can a gastrocnemius tear be differentiated from a DVT?

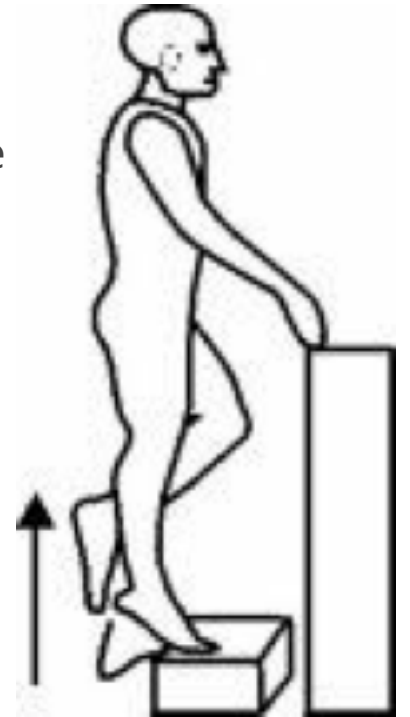
A:

1. If there is swelling as a result of a gastrocnemius tear, it is usually isolated to the medial aspect of the leg, rather than the entire calf as is often seen with a DVT.
2. You may be able to palpate a divot between the junction of the gastrocnemius muscle and tendon in the setting of a complete tear.
3. You may see early bruising with a gastrocnemius tear.

Q: What are the key physical exam findings in a gastrocnemius tear?

A: Patients will have tenderness along the entire medial gastrocnemius muscle, with maximal tenderness at the medial musculotendinous junction. You may be able to see a visible defect in the medial aspect of the gastrocnemius or palpate a gap in the muscle.

Perform a **Calf Raise Test:** The patient stands and plantarflexes one ankle so that they stand up on their tiptoes with one leg. In an Achilles tendon rupture, patients will not be able to perform this test. In a gastrocnemius tear, this test will reproduce the pain, but patients can partially complete the test.



Q: What is the role of imaging for a gastrocnemius tear?

A: X-rays have no value. A non-urgent ultrasound, while it has not been studied in any large RCTs, can be considered as an outpatient (or a point of care ultrasound, if you have the necessary skills). It is important in your request for an ultrasound to ask the radiologist to look for a gastrocnemius tear in particular.

Q: What is the ED management for patients with a gastrocnemius tear?

A: Conservative management with “RICE” (Rest, Ice Compression & Elevation) and early weight bearing as tolerated is the treatment of choice. Early physiotherapy is important, as well as explaining to the sportsperson that it may take 3-4 months before they are back to full participation.

Consider an *ankle stirrup or brace* in a position of maximal tolerable dorsiflexion for patients who are experiencing severe pain with minimal ankle ROM, as studies have shown an increased rate of healing with ankle bracing.

EM Cases Cross-Link: For more commonly missed orthopedic injuries on EM Cases see [Episode 1: Occult Fractures and Dislocations](#) and [Episode 52: Part One of Commonly Missed Uncommon Orthopedic Injuries](#)



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CHAPTER 8: TRAUMA BAY PEARLS AND PITFALLS

LISTEN TO THE PODCASTS WITH
DAVE MACKINNON AND MIKE BRZOWSKI - [PART 1](#), [PART 2](#), [PART 3](#)



Objectives

1. Develop an approach to the management of the unstable trauma patient
2. Identify trauma patients presenting with occult shock
3. Understand the principles of damage control resuscitation and how they guide care of trauma patients
4. Development an approach to appropriate imaging investigations in the trauma patient
5. Understand the common pitfalls in managing patients' blunt and penetrating injuries
6. Understand how best to work-up and manage a trauma patient prior to transfer to a trauma centre

CASE 1: GENERAL CONSIDERATIONS IN THE TRAUMA PATIENT

A 27-year-old man, previously healthy, loses control on his motorcycle on the highway and crashes into the barrier. According to EMS, the motorcycle had major damage, he was wearing a helmet and full motorcycle gear, he was not ambulatory at the scene and there was a brief loss of consciousness as reported by bystanders. EMS found him to have a BP 85/55, a HR 125, oxygen saturation of 99% and a GCS of 14. He complained of abdominal, shoulder and neck pain, and denied alcohol or drug use.

He was given a normal saline bolus by EMS and 100 micrograms of Fentanyl IV.

In the ED his initial vitals had now normalized and were: BP 110/70, HR 90, RR 24, oxygen sat 99%. A second large-bore peripheral IV was placed and his helmet was carefully removed with in-line C-spine immobilization. His primary survey revealed diffuse abdominal tenderness. His initial FAST exam was positive and his chest x-ray (CXR) and anterior-posterior (AP) pelvis x-rays were normal.

Q: What are the airway considerations in the trauma patient?

A: While this patient does not require airway intervention, as you go through your ABCs it is important to always anticipate a difficult airway in the context of trauma due to the possibility of facial fractures and facial bleeding, as well as the fact that the patient will likely be in C-spine precautions.

Q: Does this patient have sufficient vascular access?

A: Two large-bore (16 Gauge) antecubital peripheral IVs are sufficient in most trauma cases. In severely injured patients our experts recommend a femoral cordis for central line access. Although there are some studies showing higher risks of thrombus formation and infection in the femoral site compared with other central line locations, they will likely be changed rapidly in the ICU and they avoid the difficulties associated with subclavian (i.e. iatrogenic pneumothorax) and intra-jugular access (i.e. in the way of the intubation and patient is in C-spine

precautions). In patients with difficult IV access, consider using intra-osseous (IO) line. Any medicine, including blood products that can be given IV, can be given through an IO line.

Q: What is the initial choice for fluid administration?

A: Studies have found no difference in mortality in the choice of initial fluid for trauma resuscitation when given up to 1-2L. Normal saline, Ringer's lactate and colloids appear to have similar efficacy. There is no role for the routine use of vasopressors in trauma, except in neurogenic shock when other causes of shock have been excluded.

Q: What aspects of this case put this patient at a high risk of deteriorating in the ED?

A: This patient's positive FAST exam is certainly concerning for a serious intra-abdominal injury. The general teaching regarding the approach to a positive FAST in the setting of trauma would say that if the patient is stable, then they go to the CT scanner to localize the injury and if they are unstable, go directly to the OR. While the patient's vitals appear stable in the ED, one observational study showed that a single hypotensive episode in a polytrauma patient, including a pre-hospital BP, predicts a poor outcome. Thus, it is important not to ignore pre-hospital vitals in trauma patients.

Case Continued: As part of our trauma bloodwork (including CBC, electrolytes, liver enzymes, a group and screen and a cross and type), a venous blood gas is ordered, which reveals:

- pH 7.28
- pCO₂ 38
- Bicarbonate 14
- Base Deficit 8

Q: How does the blood gas aid in the management of this trauma patient?

A: This blood gas is consistent with a metabolic acidosis. In trauma, this is caused by significant hemorrhage, which leads to tissue hypoperfusion. As a result, lactate production is increased and bicarbonate is consumed, causing metabolic acidosis. The degree of acidosis is quantified by the base deficit. Studies have shown that the greater the base deficit, the higher the risk of mortality in trauma patients. One particular study attempted to identify a constellation of factors that predicted the need for operative intervention in trauma patients.

The so-called crump factor was the combination of:

1. Systolic BP <105 mmHg
2. Positive FAST and
3. Base deficit >6.

These patients had a greater need for operative intervention in this study and so the authors recommended avoiding CT scan and going directly to OR in patients with this triad.



A venous blood gas is an acceptable alternative to an arterial blood gas in the multi-trauma patient.

Case Continued: The team decides on a non-operative course at this time and will closely watch the patient.

Q: Is there a role for serial blood tests in this patient and which tests should we monitoring?

A: Serial hematocrits, serial lactates and serial end-tidal CO₂ may play a role in predicting poor outcomes and the need for intervention.

Serial hematocrits have been used as a surrogate for occult bleeding in the trauma patient but may not have adequate sensitivity. Alternatively, serial lactates have been shown to have greater sensitivity and may be helpful in monitoring these patients. End-tidal CO₂ is thought to be a marker of elevated lactate and in one study was found to correlate well with an increased risk of operative intervention.

Q: If this patient was found to have a pH of 6.9 on their venous blood gas, would administration of bicarbonate be of benefit?

A: While administration of bicarbonate in severely acidotic patients makes intuitive sense, clinical benefit has not been demonstrated and may even be associated with harm. Most studies in this area have been retrospective, and patients who are more likely to be given bicarbonate are likely sicker to begin with, so if there was benefit, it would be difficult to detect. In these patients, aggressive fluid resuscitation and early initiation of massive transfusion protocols in addition to operative or interventional management are the most important resuscitative measures.



From the history and physical exam as well as the imaging and laboratory investigations, you have multiple data points to aid in the decision-making around your trauma patients. Do not rely on one test in isolation to direct management. Rather, base your decisions on a combination of mechanism of injury, physical examination, POCUS/FAST, serial hematocrits, serial lactates and end-tidal CO₂.



While there is considerable controversy about the best choice of initial laryngoscope type in trauma patients, clinicians should be comfortable with both direct and indirect laryngoscopy as they will likely complement each other during a difficult intubation. If there is considerable blood in the airway, consider using a “bougie” to aid direct laryngoscopy, as video laryngoscopy will likely prove difficult.

Case Continued: While this 27-year old trauma patient is awaiting further investigation, his GCS begins to deteriorate and you decide that emergent intubation is required prior to further investigations.

Q: How do direct laryngoscopy and video laryngoscopy compare in terms of success of securing the airway in the multi-trauma patient? What if the patient’s airway is obscured by blood?

A: A randomized controlled trial in 2013 sought to determine whether there was a difference in mortality between trauma patients who were intubated with direct vs. video laryngoscopy. They found that overall there was no mortality difference between the two modalities. However, there was a higher mortality in severe head injury patients who were intubated with video compared with direct laryngoscopy. In addition, intubation time and episodes of desaturation below 80% were greater in the video laryngoscopy group. This study suggested that overall, direct laryngoscopy may be a better first-line strategy in trauma patients.

Q: What is the induction agent of choice for rapid sequence induction (RSI) in the multi-trauma patient?



A: With regards to induction agents, there are generally two options in trauma: etomidate or ketamine. Etomidate has a stable cardiovascular profile but no analgesic properties and may result in myoclonic jerks when not given with a paralytic or in sub-therapeutic doses. Ketamine has an excellent cardiovascular profile as well and is recommended by our experts to be considered in the hypotensive, head-injured patient. The notion that ketamine raises intracranial pressure (ICP) in the head-injured patient is not supported by the literature. Propofol has a high risk of hypotension in trauma patients and it should be avoided, even in normotensive trauma patients.



Clinical Pearl:

Remember to perform a basic neurological examination before chemical paralysis of an altered patient. Specifically, assess the patient's GCS, pupillary size and response and movement of all extremities to avoid missing a spinal cord lesion or cerebrovascular injury.

CASE 2: OCCULT SHOCK

A 40-year-old marathon runner fell asleep at the wheel while driving home on the highway after an overnight shift. He rear-ended a tractor-trailer and comes into the ED complaining of belly pain. His vitals are temperature 37.4°C, HR 90, BP 130/80, 96% oxygen saturation on room air with a GCS of 15. Examination reveals the presence of a faint seat belt sign on his lower abdomen.

Q: How would you interpret this patient's vital signs?

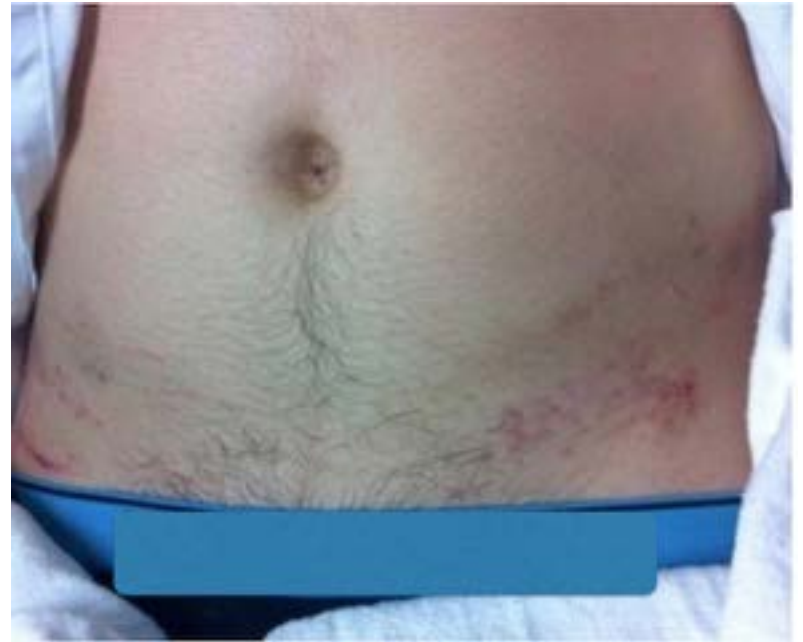
A: This patient's vital signs are perfectly normal. While this is somewhat reassuring, normal vital signs do not rule out the presence of occult shock. A young athlete with a low resting heart rate and blood pressure as well as an elderly patient on a beta-blocker can both present with normal vitals signs in the context of significant ongoing bleeding. Hypotension is a late stage of shock and patients at extremes of age are especially at risk of deteriorating rapidly.

Q: If this patient is in occult shock, how could you identify the source of bleeding?

A: This patient is complaining of abdominal pain, which would point to the most common source. In general, the most common places for haemorrhage are in the chest, abdomen, retroperitoneum (from a pelvis fracture) and on the floor. As such, a CXR, pelvis x-ray and FAST exam provide valuable information in the assessment of the trauma patient with possible haemorrhage.

Q: What is the significance of the seat belt sign?

A: The seat belt sign refers to a contusion corresponding to the location of the seatbelt and can be found on the neck, chest or abdomen. In this case, the abdominal seat belt scan is associated with an increased risk of intestinal and intra-abdominal injury.



Abdominal seat belt sign.

Case Continued: A FAST exam is completed, which is negative.

Q: What are some pitfalls when it comes to the FAST exam?

A: The FAST is a “rule-in” exam. That is, a positive scan helps in directing an unstable patient directly to the OR. It cannot be used to rule out intra-abdominal injuries if there is a significant clinical suspicion. The FAST exam has poor sensitivity for injuries with <200cc of blood, mesenteric and bowel hematomas, and diaphragmatic and pancreatic injuries, which CT scans can also miss.



Clinical Pearl:

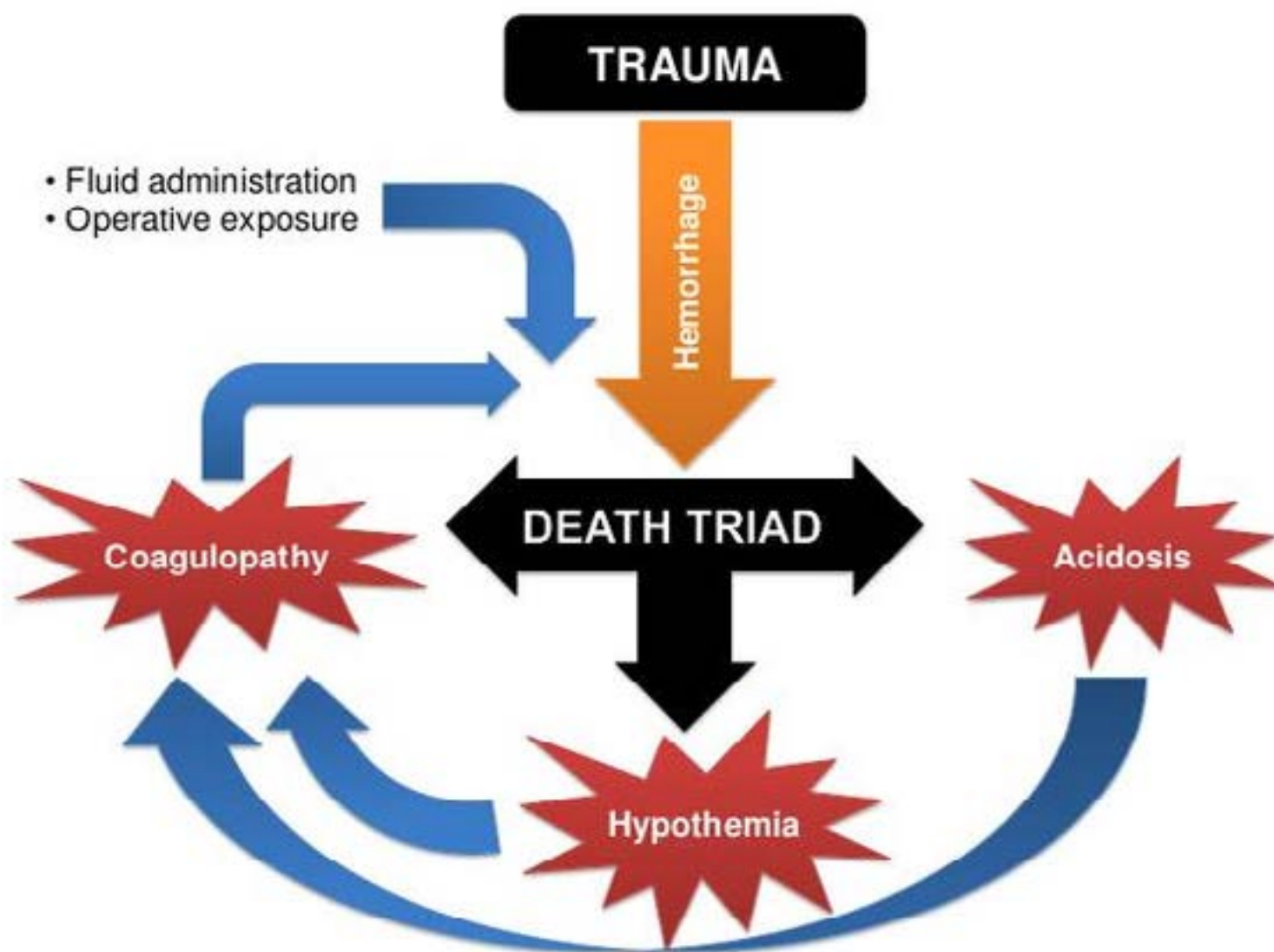
Every trauma patient is unstable until proven otherwise. Don't be falsely reassured by normal vital signs. And in the patient with high clinical suspicion for intra-abdominal injury, do not be falsely reassured by a negative FAST exam.

CASE 3: DAMAGE CONTROL RESUSCITATION

A 54-year-old man, previously healthy, falls from 10 feet and is brought to the ED in a cervical collar. He is alert and oriented but looks unwell and is complaining of abdominal pain. His vitals are HR 120, BP 90/40, RR 26, oxygen saturation 96% and GCS of 13. Abdomen is distended and tender with guarding. There is a significant hematoma on his left occiput. His FAST Exam is positive for fluid in both upper quadrants.

Q: What are the 5 components of damage control resuscitation that guide care of trauma patients?

A: Damage control resuscitation (DCR) is an evolving concept in the care of trauma patients with the goal of avoiding the **lethal triad** of **coagulopathy**, **hypothermia** and **acidosis**.



The 5 components of DCR are:

- 1. Avoid hypothermia**, which worsens coagulopathy, by keeping the trauma room warm, having warmed crystalloids and blankets readily available, using Bair huggers and Level 1 infusers to warm fluids, and covering the patient as much as possible.
- 2. Permissive hypotension** refers to a strategy whereby BP is maintained lower than the individual patient's normal values in order to allow thrombus formation of injured vessels while still perfusing end-organs. The majority of evidence for permissive hypotension comes from animal studies and the theoretical risk of over-resuscitation causing disruption of a formed clot and further worsening bleeding in trauma patients.

The best clinical evidence for this practice is in penetrating trauma and was done in a major trauma hospital with very short transport times. As such, this may not be applicable to blunt trauma or care delivered in non-trauma centres. Based on the current evidence, permissive hypotension can be considered as a short-term temporizing solution while the patient is awaiting the OR. If this is the case, a systolic BP target of 90-100 mmHg would be appropriate, however, it is important to consider clinical factors, such as whether the patient is mentating well, and has an adequate urine output. Also, an elderly patient with a history of hypertension will likely require a higher blood pressure target than a young healthy adult. Permissive hypotension would not be appropriate in the context of head injury, as we know that a single episode of hypotension has been associated with significant increases in mortality in these patients. Finally, avoid over-resuscitation, which may lead to compartment syndrome (abdominal and extremity), worsening ICP, and acute respiratory distress syndrome (ARDS), pulmonary edema and prolonged ICU stay.

4. Early use of blood products to avoid excessive use of crystalloids.

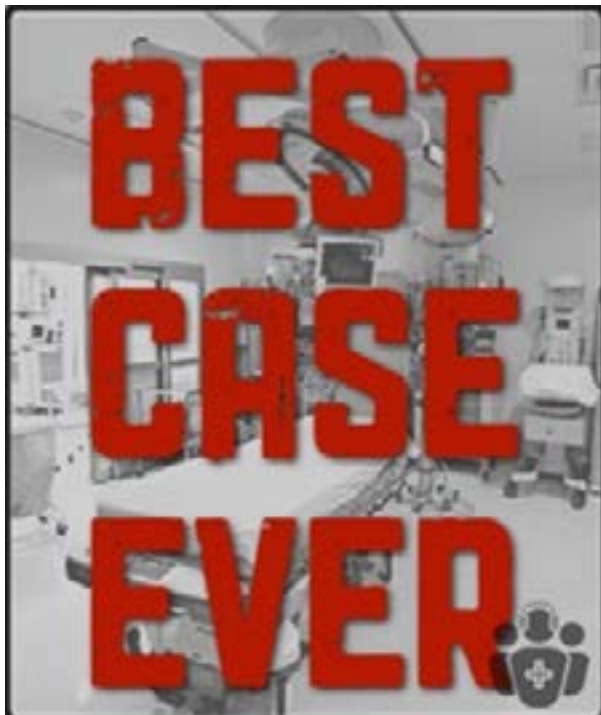
The updated 2013 Advances Trauma Life Support (ATLS) guidelines suggest that following 1L of crystalloid, blood products should be given. This is consistent with studies demonstrating that over-resuscitation with crystalloid is associated with increased rates of acute respiratory distress syndrome and coagulopathies among other complications.

5. Rapid and early correction of coagulopathy, which can result from both dilutional effects from excessive crystalloid administration and secondary to the injury itself.

6. Damage Control Surgery, whereby the abdomen is simply packed to stop the bleeding (+/- splenectomy if necessary) without immediate definitive repair, then the patient is brought to the ICU where the patient's parameters are improved, and finally, the patient is taken back to the OR for definitive repair of all injuries.



In practical terms, if you find you have given more than 3 units of red cells, it is likely appropriate to activate your MTP.



[Listen to Dr. Katerina Pavenski, Transfusion specialist's Best Case Ever of a trauma patient on Warfarin who received prothrombin complex concentrates](#)

Q: How can we decide when a patient requires activation of a Massive Transfusion Protocol (MTP)?

A: It is very difficult to predict which trauma patients will require activation of a massive transfusion protocol.

One study found 3 independent predictors of MTP activation:

1. Base deficit >5
2. INR > = 1.5
3. Hemoperitoneum

Q: What transfusion strategy should we be using in trauma patients receiving massive transfusions?



A: In February 2015, the Pragmatic, Randomized Optimal Platelet and Plasma Ratios (PROPPR) study was published, which was the first RCT to compare the transfusion of plasma, platelets and red blood cells in ratio of 1:1:1 and 1:1:2 ([Abstract](#)). While there was no mortality difference in the two groups, more patients in the 1:1:1 group achieved hemostasis and fewer suffered death due to exsanguination at 24 hours. While there is not a definitive answer on this topic, transfusion in a 1:1:1 strategy may be better option if feasible in your centre.

FOAMed Link: [Interview with lead author of PROPR study John Holcomb by Scott Weingart on EMCrit podcast](#)



Key Points from EMCrit Podcast (with permission):

- Our current definitions of massive transfusion are outdated. Better may be the [Critical Administration Threshold](#) – if you give 3 units of blood in any 1 hour period, it is a massive transfusion. But ...
- Dr. Holcomb doesn't wait for the 3 unit threshold. At his shop, they try to make the 1st unit transfused plasma or platelets and start matched transfusion from that point forward.
- In the PROPPR trial, only about 2/3 of the patients received tranexamic acid, but CRASH2 indications would have had all of them receive it. Dr. Holcomb uses TEG (see explanation below on use of this bedside test to guide therapy) to decide, and wants to see more RCTs (they are being done) to better clarify the role of tranexamic acid.

Q: What evidence supports the use of hemostatic agents in this trauma patient?

A: Recombinant factor VIIa was previously widely used in trauma but has been shown to be not beneficial and possibly harmful (i.e. increased thrombo-embolic events such as MI or DVTs) in trauma patients.

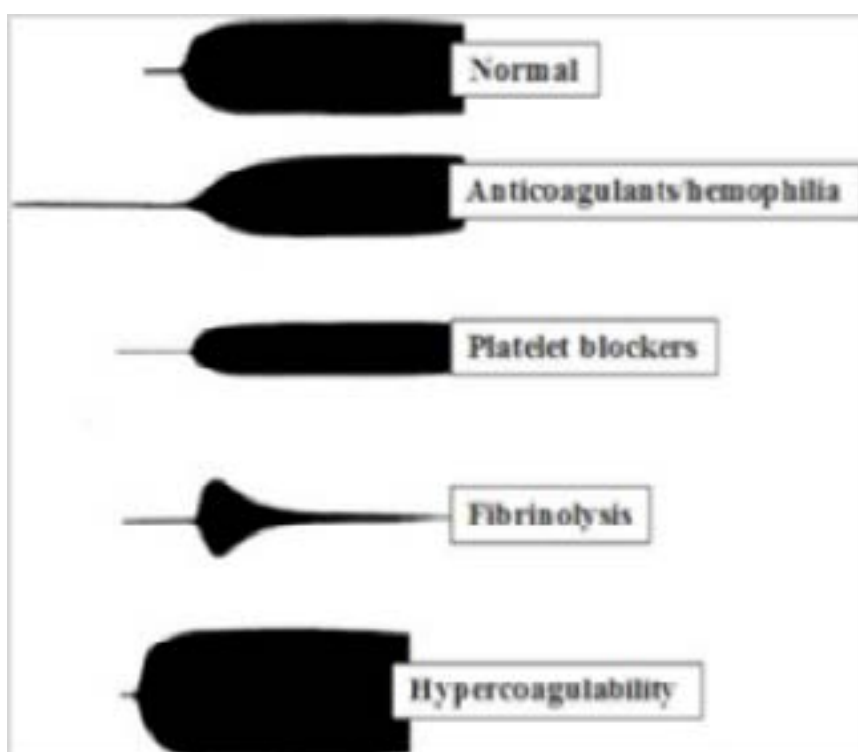


Tranexamic acid (TXA) is an antifibrinolytic that was found to have a 1.5% reduction in mortality in the The CRASH-2 trial, with over 20,000 trauma patients worldwide. While the population in this study was very heterogeneous and mostly in developing countries, the greatest reduction was seen when TXA was given within 1 hour to those requiring massive transfusions. However, there was an increase in mortality if it was given after 3 hours.

The use of prothrombin complex concentrate (eg: Octaplex in Canada) with vitamin K for reversal of warfarin-induced coagulopathy in trauma is controversial. While the INR returns to normal very quickly and with much less volume compared to fresh frozen plasma (FFP), it is unclear whether it translates into improved clinical outcomes over FFP.

Q: Are there point-of-care tools that we consider using to help use guide which products to use?

A: An evolving point-of-care test is thromboelastography (TEG) or rotational thromboelastometry (ROTEM), which allows one to measure the viscoelastic properties of the blood based on the interaction of platelets with the clotting cascade. This can be used to guide administration of blood products as well as antithrombotics such as TXA in massively transfused patients. This technology is not yet widely available but is a promising tool to guide the management of the bleeding trauma patient.



Example TEG tracings



Recombinant VIIa is generally discouraged due to increased risk of thromboembolic events, but may be considered in severe hemorrhagic shock refractory to 7-8 U of RBC. TXA, however, is cheap and likely has little downside so it may be considered in your bleeding trauma patient to whom you are considering giving blood, but only if given within the first hour or 2 after injury.



Clinical Pearl:

Consider giving TXA as early as possible to patients who will likely require transfusion. Administer as 1g intravenously administered over 10 minutes, then 1g intravenously administered over 8 hours.

CASE 4: HEAD INJURY

A 55-year-old man presents to your ED from the local hockey arena, where he was knocked unconscious after being boarded (body-checked from behind without warning). He has normal vital signs and a GCS of 7.

Q: How would you prevent raised intracranial pressure (ICP) in this patient?

A: The management of increased ICP includes:

- 1. Patient Positioning:** Raise the head of the bed 30° if thoracic and lumbar-spines are cleared or put the patient in reverse Trendelenburg. Also ensure the neck is midline, and if a cervical collar is applied, that it is not too tight, to avoid causing venous congestion.
- 2. Hyperventilation:** Hyperventilating the patient with impending brain herniation is a commonly cited strategy to decreased ICP, but when done in excess results in respiratory alkalosis, which causes cerebral vasoconstriction and resultant decreased cerebral perfusion. As such, mild hyperventilation (down to PCO₂ of only 35mmHg) should be reserved for the patient with evidence of brain herniation (blown pupil, hemiparesis) as a bridge to definitive management with a burr hole.
- 3. Medications:** IV Mannitol and/or hypertonic saline have both been shown to blunt raised ICP, with evidence showing that hypertonic saline may be superior. Seizures will raise ICP and so if there is a documented seizure with a head injury, a loading dose of an anticonvulsant should be given. Some centres will give prophylactic anticonvulsants for a one-week course in patients with intracranial hemorrhage.

Q: Will you give pre-treatment medicines prior to RSI for this head-injured patient?

A: While pretreatment for RSI in head-injured patients has not been shown to improve patient outcomes, there is weak evidence for lidocaine pre-treatment 3 minutes prior to induction for RSI in this group of patients.



If there is adequate time, also consider fentanyl pre-treatment in head-injured patients, although good clinical outcome data are lacking.

CASE 5: C-SPINE INJURY

A 38-year-old man is brought into the ED following an MVC. He was wearing his seat belt when he veered off the road and struck a guardrail at approximately 80 km/hr. He comes to the ED boarded and collared, complaining of neck pain and abdominal pain. His vitals are normal and his GCS is 12.

Q: Why is it important to clear the C-spine as soon as possible?

A: C-collars are associated with decubitus ulcers, raised ICP, pneumonia and delirium, on top of providing relatively poor immobilization (compared to sand bags and tape), which leads to increased ICU and hospital length of stay. For these reasons, you should clear the C-spine as soon as possible.

Q: Should we apply the Canadian C-spine or NEXUS C-spine rules to this patient?

A: The Canadian C-spine rules and NEXUS Criteria for C-spine imaging are appropriate for neck injuries in patients without high-risk mechanisms of injury. As such, they would not be appropriate in a multi-trauma patient or if there was alteration in LOC.



Some experts have recommended not using C-spine collars in trauma patients, however, the ATLS guidelines still recommend their use.

[For an analysis of the lack of evidence for the use of C-spine collars, see SCANCRIIT.COM blog](#)

Q: The NEXUS Criteria for C-spine imaging state that a distracting injury prevents clinical clearance of the C-spine. How do we decide which injuries are considered distracting?

A: The definition of distracting injury must be made on a case-by-case basis, as there are no strict criteria. Patients with severe pain from another injury that requires repeated doses of opioids and prevents clinical assessment of the C-spine will likely be unable to be cleared clinically. A study from 2012 showed that in patients with a GCS of 14-15 with a distracting injury, clinical exam picked up 85 of 86 C-spine injuries. The case that was missed involved significant facial and upper extremity fractures, which likely would have made clinical assessment of the C-spine difficult. As such, use your clinical judgment as to whether an injury is truly distracting.



C-Spine Tools:

- [Visit the Canadian C-Spine Rule Algorithm here](#)
- [Use the NEXUS C-Spine Rule Calculator here](#)

Q: Which imaging modality is the most appropriate to assess the C-spine in this patient?

A: In the alert trauma patient in whom imaging of the C-spine is required, a plain radiograph is appropriate. However, in a multi-trauma patient, x-rays have been shown to be less sensitive than CT scan. In addition, most trauma patients will receive a CT head, especially if there is altered level of awareness. In these patients, it may be safer, with little additional radiation to continue the scan to include the C-spine.

Case Continued: This patient goes on to require intubation for depressed GCS. He has a CT scan of his C-spine, which reveals no fracture or signs suggestive of ligamentous injury.

Q: What is the next step in managing this patient's C-spine after a negative CT scan?

A: C-spines of an intubated patient may be cleared if the CT scan is completely normal, i.e. no bony fractures and no soft tissue abnormalities, realizing that if ligamentous injuries are missed, they should become obvious when the patient regains consciousness and can then be re-examined, after which an MRI can be considered.

Q: If there is a documented spinal cord injury, will steroids be of benefit?

A: In spinal cord injuries, steroids are not recommended, as they do not have a clinically significant benefit and lead to a significant increase in complications, including pulmonary infections.

CASE 6: IMAGING DECISIONS IN TRAUMA

You are the overnight doc at a community hospital. A 42-year-old male is the driver of a truck that loses control and ends up in a ditch at the side of the road. He comes in yelling profanities with vitals signs HR 80, RR 16, BP 115/80, oxygen saturation 97%. His GCS is 14. You manage to secure 2 large-bore IVs, oxygen is given by mask and he's logrolled. His GCS is 15 and he smells of alcohol. He's complaining of pain "everywhere". After your primary and secondary surveys you've identified a scalp laceration, and a probable distal radius fracture, but he's still complaining of pain everywhere and seems to be tender everywhere. The initial FAST is negative.

Q: What would be appropriate initial imaging tests to order in this patient?

A: In general, the CXR, pelvic x-ray and cross table C-spine x-ray would be appropriate initial imaging investigations. See Case 4 for further discussion of C-spine imaging.

Q: Which patients require a pan scan (CT head/C-spine/chest/abdomen/pelvis)?

A: It is common practice for intubated trauma patients to receive a pan-scan to identify all injuries, as a targeted physical exam is less feasible in this group. Recently it has been shown that chest-abdo-pelvis CT in the initial evaluation of blunt trauma compared to clinical exam with FAST examination did not result in mortality difference, missed injuries or delay to diagnosis. While there are other studies demonstrating high miss rates, these misses are likely not clinically significant.



Our experts do not recommend pan-scanning all major trauma patients, and feel that studies that have shown an unacceptably high rate of missed injuries with selected CT compared to pan-scanning were poorly designed. It may be reasonable to employ a strategy where all intubated patients are pan-scanned, and do selective x-rays and CT scans for non-intubated patients.

Case Continued: This patient undergoes a CXR, which reveals no abnormality.

Q: Which patients who have suffered multiple injuries require a CT chest?

A: While several decision rules have been derived to determine who requires a CT chest, they have not been externally validated.

Case Continued: The team caring for this patient decides to order a CT chest, which reveals no aortic or thoracic spine injury. There is, however, a small pneumothorax, which was not seen on the CXR.

Q: What is the appropriate management of this occult pneumothorax?

A: An occult hemothorax is one that is not seen on CXR but is seen on CT. Traditionally, these patients would receive a chest tube. In a 2012 study of 81 patients with occult hemothorax who were followed clinically, 83% were managed without a chest tube. As such, there may be a role for observation without chest tube insertion in these patients.



A CT chest is really only indicated if there is suspicion of an aortic injury or T-spine injury, as CXR will be sensitive to most clinically significant chest injuries – including clinically significant hemothorax and pneumothorax.

CASE 7: BLUNT CHEST TRAUMA

A 45-year-old male is brought to your ED following losing control of his automobile and striking a brick wall. He is not certain how fast he was going. He was not wearing a seat belt. He is complaining of severe chest pain. You complete your primary and secondary survey, which is essentially unremarkable. A CXR reveals a sternal fracture. C-spine x-ray and pelvic x-ray are all normal.

Q: When would you consider working up a possible thoracic aortic injury?

A: While most trauma patients with thoracic aortic injury die at the scene, there are a subset who survive to hospital admission. The mechanism of injury is the most important consideration. High-energy mechanisms, including lateral impact pelvic fractures, fall from height and anterior-posterior deceleration, should all trigger a consideration for thoracic aortic injury.

Q: What role does the CXR play in the assessment of a possible aortic injury?

A: While a CXR had a negative predictive value in one study of 98%, it should not be used to rule out aortic injury if there is a concerning mechanism.



Sternal fracture on lateral CXR



In patients with a low clinical suspicion, a CXR can be used as a screening test for aortic injury but should not be used as the sole diagnostic tool in high-risk patients, as these patients require a CT chest.

Q: What is the management of confirmed traumatic aortic injury?

A: While most patients with blunt aortic injuries do not survive to hospital, those that make it to CT are inherently more stable and so are repaired in a delayed fashion. Initial management focuses on lowering the blood pressure if the patient is hypertensive as well as addressing coincident coagulopathy and hypothermia. Surgical treatment occurs once the patient has been stabilized.

Case Continued: This patient went on to have a CT chest, which confirmed the sternal fracture but did not reveal any other abnormality.

Q: When should we suspect blunt cardiac injury in patients with chest trauma?

A: Blunt cardiac injury encompasses a broad spectrum of injury, including myocardial contusion, free wall rupture, valvular injury and pericardial injury. Most of these injuries will be clinically suspected based on the findings of a new murmur or unexplained hypotension once more common causes of hemorrhage have been accounted for. However, myocardial contusion is a more occult injury and it should be suspected in any high mechanism blunt, crush or deceleration injury to the chest.

Q: What should be the initial investigations for blunt cardiac injury?

A: This is an area of controversy. In general, the work up for blunt cardiac injury should include a CXR, FAST exam for pericardial effusion and an ECG. With a normal ECG the risk of complications from myocardial contusion is low. These patients likely require at least an interval of telemetry monitoring for arrhythmias in the ED and can likely be discharged home if they have a normal ECG, are clinically stable and have no arrhythmias.

While newer guidelines suggest ordering a troponin in suspected blunt cardiac injury patients, there is no consensus on timing of troponin or what to do with a positive troponin in a patient that looks well and has a normal ECG and whom you would otherwise send home. This is especially problematic as more and more high sensitivity troponin assays are used. If a troponin is positive, however, these patients are usually admitted and have an echocardiogram.

FOAMed Link: [*The Trauma Professional's Blog algorithm for Blunt Cardiac Trauma*](#)

Case Continued: A troponin and ECG were ordered, which were both normal.

Q: What is the management of isolated sternal fractures?

A: Patients with isolated sternal fractures, a normal ECG and CXR and normal vital signs are at low risk for requiring intervention, and can be safely discharged provided you provide adequate pain management and you have ruled out associated injuries.

FOAMed Link: [*Best Bets bottom line recommendations for uncomplicated sternal fractures*](#)



Remember:

In unstable patients with blunt chest trauma, remember hemorrhage is still by far the most common cause of instability.

CASE 8: GERIATRIC TRAUMA

A 78-year-old woman presents to your ED along with 4 other passengers who were on a public bus that had to stop suddenly to avoid a crash. She reports having hit the right side of her chest on the seat in front of her. Her initial vital signs are normal and a CXR reveals 2 rib fractures. Her abdominal exam is benign, she has a negative FAST, and she has no other injuries.

Q: How would you manage this patient, and how would you manage this patient any differently compared to a 25-year-old patient?

A: In those over 65 years old, mortality associated with multiple rib fractures has been shown to be 5 times higher compared to patients under 65. These patients require a period of observation in the emergency department and possibly a repeat CXR. Even a single rib fracture in the elderly can cause atelectasis and pneumonia if pain is not well managed and instruction for periodic deep breathing not given. Elderly patients with multiple rib fractures may require admission for this reason.

Q: What else could you use to help guide your disposition decision in this patient?

A: Consider using bedside ultrasound for detection of pneumothoraces, as the sensitivity for detection has shown to be higher than supine CXR (98% versus 75%) when compared to a gold standard of CT scan.



In this patient in particular, the presence of an occult pneumothorax with multiple rib fractures may make an admission the more reasonable choice.

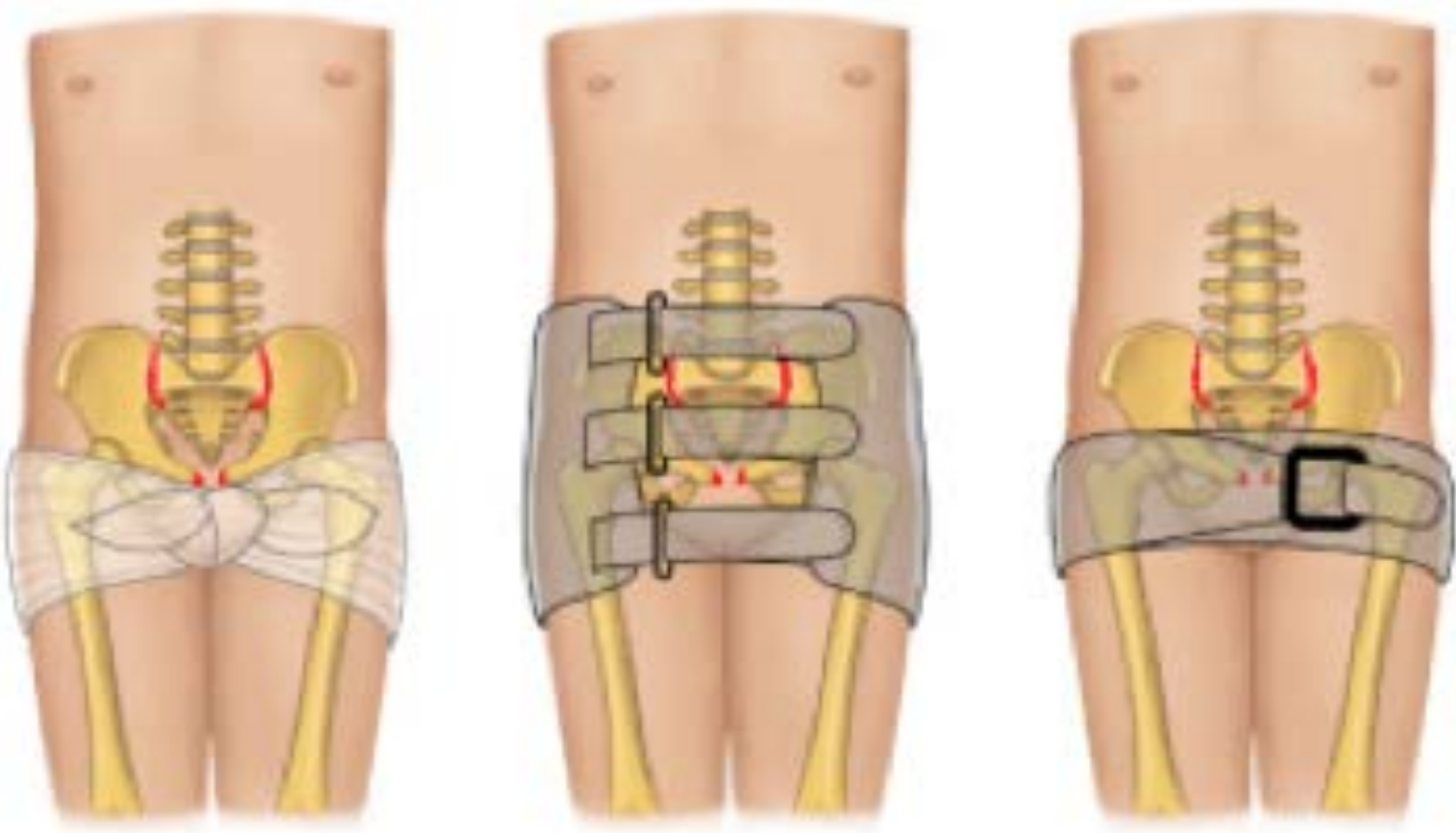
CASE 9: BLUNT PELVIC TRAUMA

You are the ED doc in a small community hospital and a 25-year-old woman who was the front passenger in an MVC arrives in severe hemorrhagic shock with decreased level of consciousness. When you get to the examination of the bony pelvis, you put gentle compression on the iliac crests and they seem mobile.

Q: What should be your immediate next step?

A: If gentle inward pressure of the bony pelvis causes movement, DO NOT LET GO. Instead, have an assistant wrap the pelvis in a sheet or pelvic binder at the level of the greater trochanters (which is lower than the intuitive location of the iliac crest). Be sure that there are no wrinkles in the sheet, to minimize pressure ulcers.

Video: [Watch a Video Demonstrating How to Use a Sheet as a Pelvic Binder Here](#)



Examples of Pelvic Binders

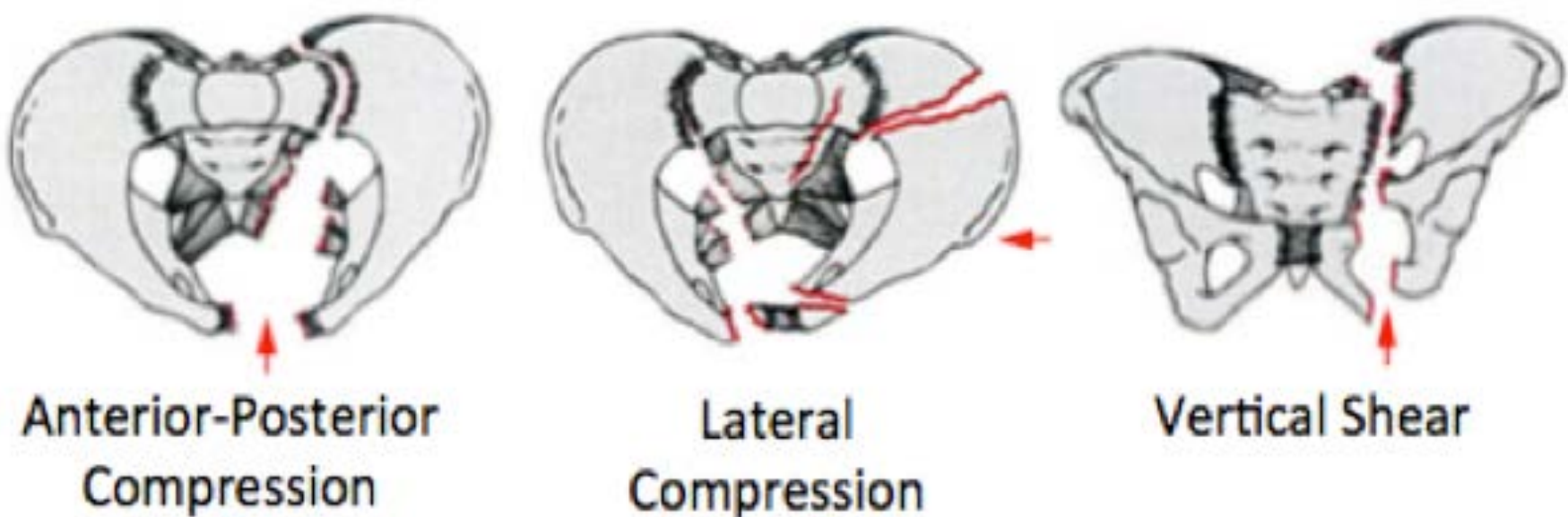
Q: What are some other physical examination clues that this patient might have an unstable pelvic fracture?

A: Signs of pelvic injury include:

- Groin/scrotal or suprapubic swelling or hematoma
- Tenderness at or palpable defect of the symphysis pubis
- Blood at the urethral meatus
- Distal peripheral neuropathy
- Pelvic fluid on FAST exam

Q: How does the mechanism of injury influence the injury pattern in pelvic fractures?

A: The Young-Burgess classification is used to classify pelvic fractures based on the mechanism of injury: Anterior-posterior compression, lateral compression and vertical shear. Anterior-posterior compression fractures, also called the “open book” fracture based on the widened pubic symphysis on pelvic x-ray, are associated with more neurovascular complications if the posterior pelvic structures, such as the sacro-iliac joint, are involved. Vertical shear fractures are prognostically the worst fractures and are characterized by hemi-pelvis dislocation as a result from a fall from height onto an extended limb.



Young-Burgess classification of pelvic ring fractures

Q: Why is it important to recognize pelvic injuries early?

A: Pelvic fractures are high-velocity injuries associated with a mortality rate as high as 50%. These injuries have the potential for significant hemorrhage, which requires prompt recognition and hemostasis. Bleeding can occur from injury to the venous plexus (the most common site of bleeding), the cancellous bone itself, or from arterial injury. Arterial bleeding carries the highest mortality and is often effectively treated with embolization with greater success than laparotomy.



Keep a high index of suspicion for pelvic hemorrhage, as the initial trauma pelvic x-ray does not always correlate well with the level of bleeding – i.e. a seemingly small fracture may hemorrhage extensively if arterial structures are affected nearby.

CASE 10: PENETRATING EXTREMITY INJURY

A young man was “minding his own business” when he was stabbed in the thigh with a switchblade. His friends immediately drove him to the hospital and he walks in to your triage limping. His vitals are normal. On his lower extremity exam you find a 2cm long laceration in the lateral thigh with blood slowly oozing out of the wound. His neurovascular exam is normal with pedal pulses present. A handheld Doppler revealed equal pulses bilaterally

Q: What are the signs of vascular injury to look for on physical examination?

A: Signs of vascular injury in penetrating trauma can be divided into hard and soft signs. Hard signs have a 100% positive predictive value (PPV) for vascular injury and include severe arterial bleeding, shock, large pulsatile and expanding hematoma, new palpable thrill or audible bruit and distal ischemia based on the 6 Ps (pallor, poikilothermia, pain, paresthesia, paralysis, pulselessness). Soft signs of vascular injury have a lesser PPV but still must be investigated. They include minor bleeding, small and stable hematoma, injury to nerve, and proximity of tract to major vessel.

Q: What should be the next step in the investigation of this patient's injury?

A: The presence of any hard signs warrants immediate exploration in the operating room. However, this patient has no hard signs. The presence of soft signs warrants CT angiography to rule out vascular injury. If the patient had persistent bleeding or if the wound was felt to approximate the path of the femoral artery then a CT angiogram would be the next appropriate investigation. One could choose to perform an ankle-brachial index (ABI), which, if found to be greater than 90-95%, would significantly reduce the likelihood of an arterial injury. However, a normal ABI would likely not be sufficient to rule out an arterial injury.



Clinical Pearl:

The femoral artery is the most commonly injured vessel in the lower extremity. The presence of a distal pulse does not exclude proximal arterial injury.

CASE 11: THE TRANSFER OF THE TRAUMA PATIENT

A 55-year-old male pedestrian was struck by a car and brought to your community emergency department in shock with major chest, pelvic and lower extremity injuries. His GCS is 13. You decide that this patient requires transfer to a trauma centre.

Q: What investigations are required prior to initiating transfer to a trauma center?

A: If the decision to transfer is made early (based on serious mechanism or poor patient condition), “less is more” when it comes to investigations prior to transfer to a trauma centre. Chest and pelvic x-rays are likely the only imaging studies required prior to transfer as they can guide the placement of a chest tube or pelvic binder prior to transfer. Obtaining CT scans will often delay transfer and will unlikely change management for a patient that will require transfer regardless of the result. Also, CT scans will usually be repeated at the trauma centre and so will not save time upon arrival.

Q: What interventions should you consider doing prior to transfer?

A:

1. Good IV access with two large-bore IVs is important for administration of fluids and/or blood products both prior to and during transfer.
2. Plain radiographs or clinical suspicion for a significant pelvic injury should guide chest tube and pelvic binder placement prior to transfer.
3. Reduce badly displaced fractures and dislocations.
4. Close (either with sutures or staples) large lacerations to reduce blood loss during transfer.
5. Have a slightly lower threshold for intubation, as conditions on the road or in the air are unpredictable and the clinical situation may deteriorate quickly.

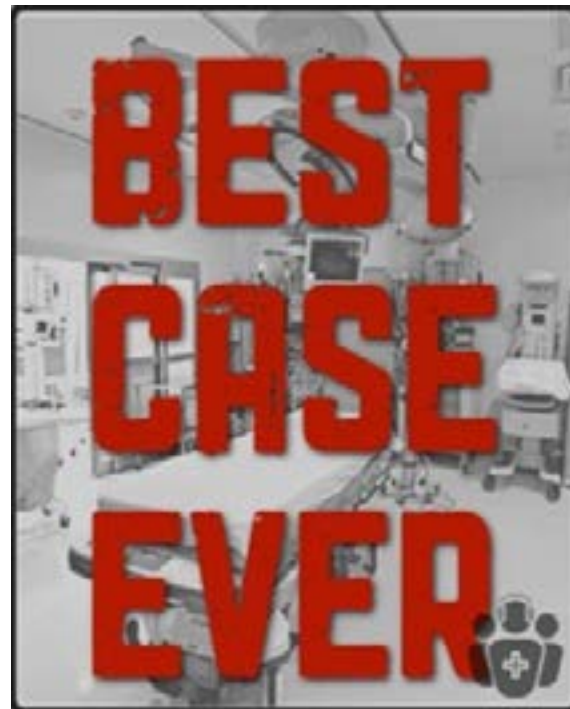
6. Insertion of Foley catheter and NG or OG tube (if the patient is intubated) is also recommended, if possible.
7. Remove the spine board for a patient awaiting transfer and place them on a soft bed to reduce the rate of pressure ulcers. Use spine boards only for the actual physical transferring of the patient.

In rare situations, with a hemodynamically unstable patient and a positive FAST scan, the local general surgeon might elect to perform a damage-control trauma laparotomy in order to prevent death from intra-abdominal solid organ exsanguination. Consider discussing this possibility with your surgical group prior to your next trauma.



Clinical Pearl:

When deciding over land or air transfer, consider the 90-minute rule of thumb: only if land transport will take more than 90 minutes should you consider using air transport.



[What are your thoughts on CPR in the trauma patient? Take a listen to Dr. MacKinnon's best case ever!](#)



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