

GENITOURINARY TRACT TRAUMA

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I have no conflicts of interest

RENAL TRAUMA

- Epidemiology & general information in renal trauma
- Imaging evaluation and grading (case based review using AAST guidelines)
- Principles of management and follow-up in renal trauma

Epidemiology of Renal Trauma

- Renal injury occurs in 5% of trauma cases; up to 95% are blunt trauma
- Associated multi-organ injury is present in 80-95% of blunt and penetrating renal trauma
- 95% of blunt renal trauma is managed conservatively
- Grade 1-3 traumas can be managed non-operatively (>95%)
- Grades 4-5 injuries can be managed non-operatively in hemodynamically stable patients but there may be higher rates of infection
- Patients with urinary extravasation can be managed without major intervention in over 90% of cases
- Non-operative management for penetrating and high grade renal injuries is still debatable

Indications for Imaging Evaluation & Grading Injury

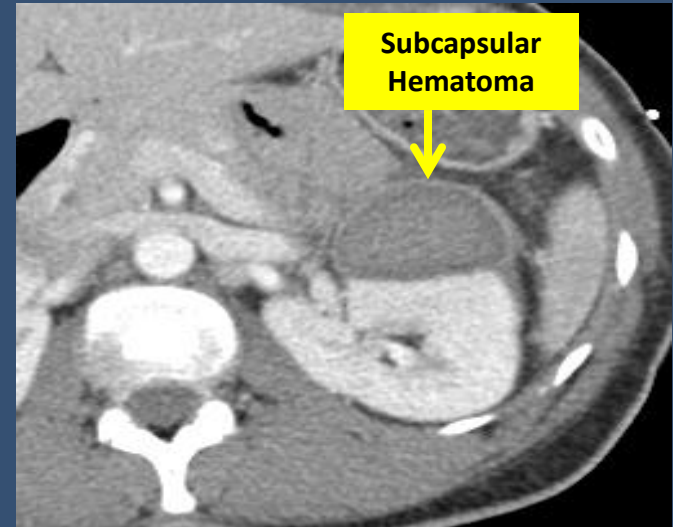
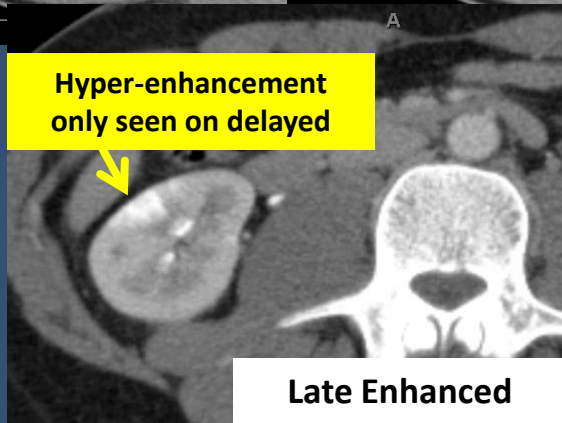
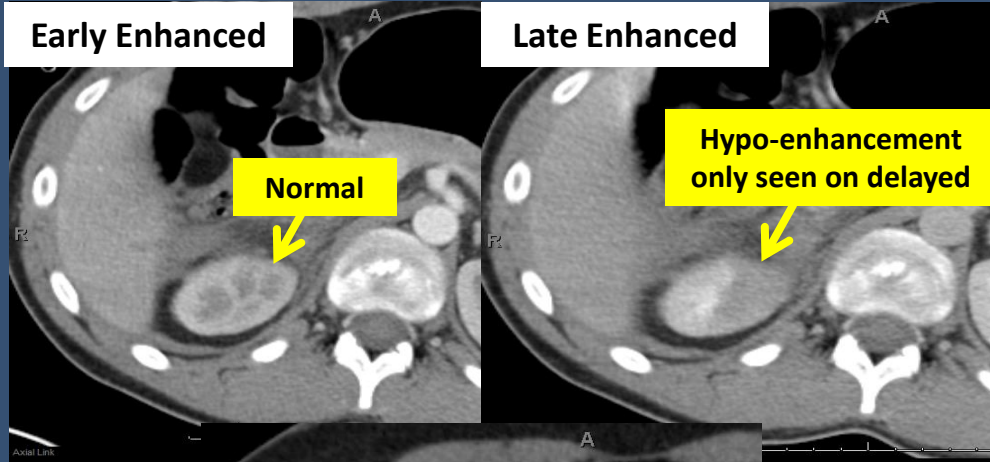
- Blunt trauma patients, hemodynamically stable
 - Gross hematuria
 - Microscopic hematuria with BP < 90mm Hg
- Trauma patients with mechanism of injury (high speed deceleration, falls) or penetrating injury (GSW, knife wounds)
 - Up to 34% of multisystem trauma patients will have renal injury in the absence of hematuria or hemodynamic instability
- The American Association of Surgery for Trauma (AAST) renal injury scale used to grade renal trauma. Validated as predictive of morbidity and the need for intervention to treat higher grade renal injuries.
 - Ambiguity in staging high grade injuries separating grade IV from V
 - No component accounting for contrast extravasation (bleeding) on CT nor size of perirenal hematoma

AAST Renal Injury Scale

Grade	Type	Description	Management (<i>guided imaging and patient signs/symptoms</i>)
I	Contusion	<ul style="list-style-type: none"> Segmental hypo- or hyper-enhancement 	<ul style="list-style-type: none"> ➤ Non-operative ➤ No follow-up needed
	Hematoma	<ul style="list-style-type: none"> Subcapsular & non-expanding hematoma w/o laceration 	<ul style="list-style-type: none"> ➤ Non-operative ➤ No follow-up needed
II	Hematoma	<ul style="list-style-type: none"> Nonexpanding perirenal hematoma confined to retroperitoneum 	<ul style="list-style-type: none"> ➤ Non-operative ➤ No follow-up needed
	Laceration	<ul style="list-style-type: none"> < 1.0 cm parenchymal depth w/o urine extravasation 	<ul style="list-style-type: none"> ➤ Non-operative ➤ No follow-up needed
III	Laceration	<ul style="list-style-type: none"> > 1.0 cm parenchymal depth w/o urine extravasation 	<ul style="list-style-type: none"> ➤ Non-operative ➤ No follow-up needed if clinically stable and no devitalized segments*
IV	Laceration	<ul style="list-style-type: none"> Deep laceration with urine extravasation 	<ul style="list-style-type: none"> ➤ May be non-operatively managed. F/U imaging at 48 hrs
	Vascular	<ul style="list-style-type: none"> Main renal artery/vein injury with contained hemorrhage or injury to segmental renal vessels 	<ul style="list-style-type: none"> ➤ May be non-operatively managed. F/U imaging at 48 hrs
V	Laceration	<ul style="list-style-type: none"> Shattered kidney with dispersion of avulsed segments UPJ avulsion (no connection to ureter) 	<ul style="list-style-type: none"> ➤ Surgical management ➤ Conservative, non-operative management in selected, stable patients. F/U imaging at 48 hours
	Vascular	<ul style="list-style-type: none"> Avulsion/laceration/thrombosis of main renal vessels with devascularized kidney 	<ul style="list-style-type: none"> ➤ Surgical management ➤ Conservative, non-operative management in selected, stable patients. F/U imaging at 48 hours

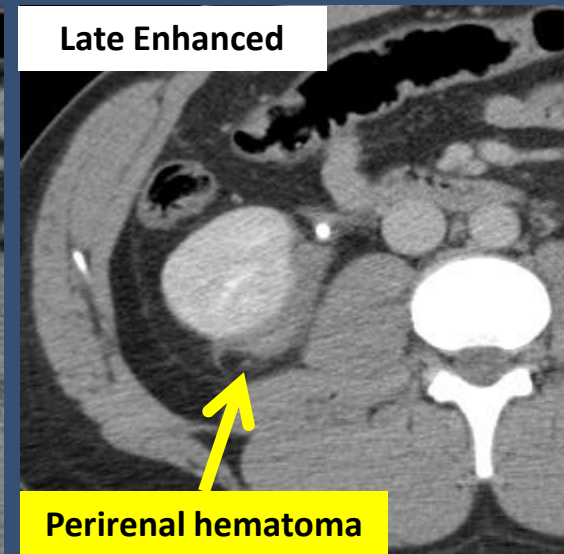
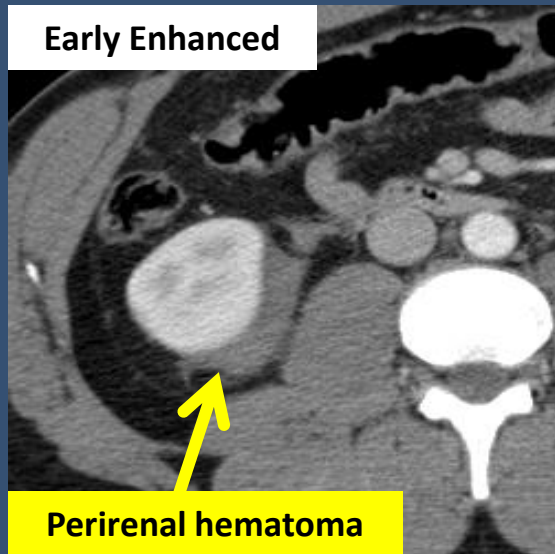
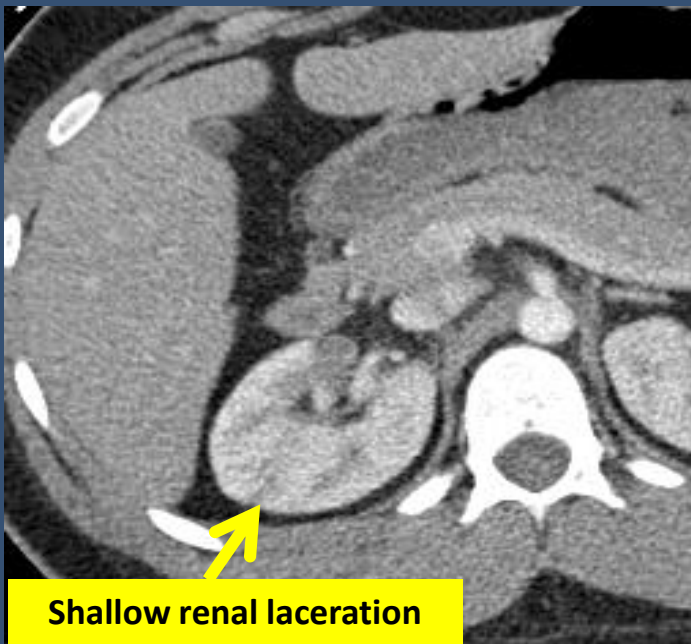
Grade I Renal Injury

Grade	Type	Description
I	Contusion	▪ Segmental hypo- or hyper-enhancement
	Hematoma	▪ Subcapsular & non-expanding hematoma w/o laceration



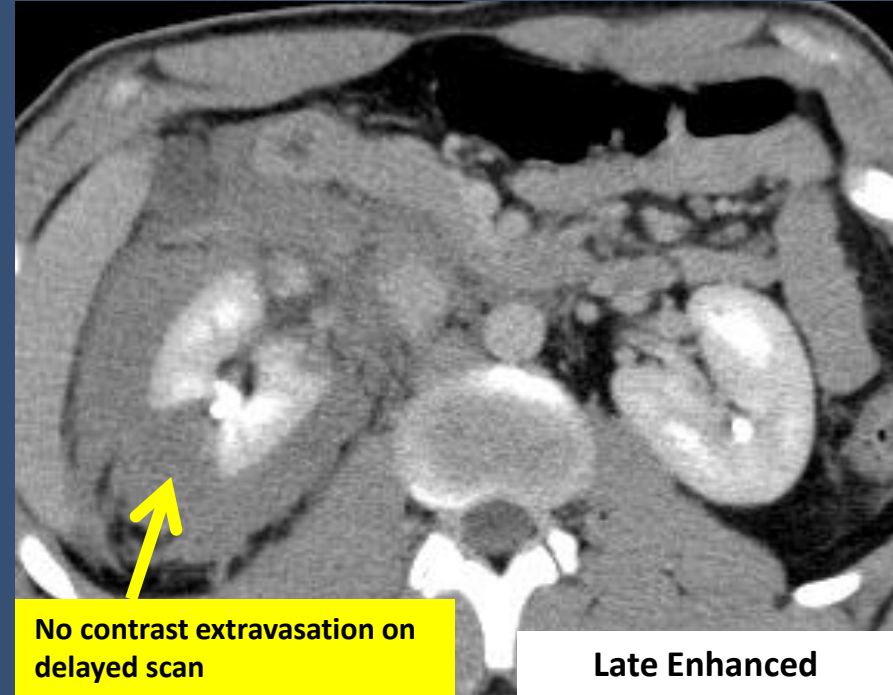
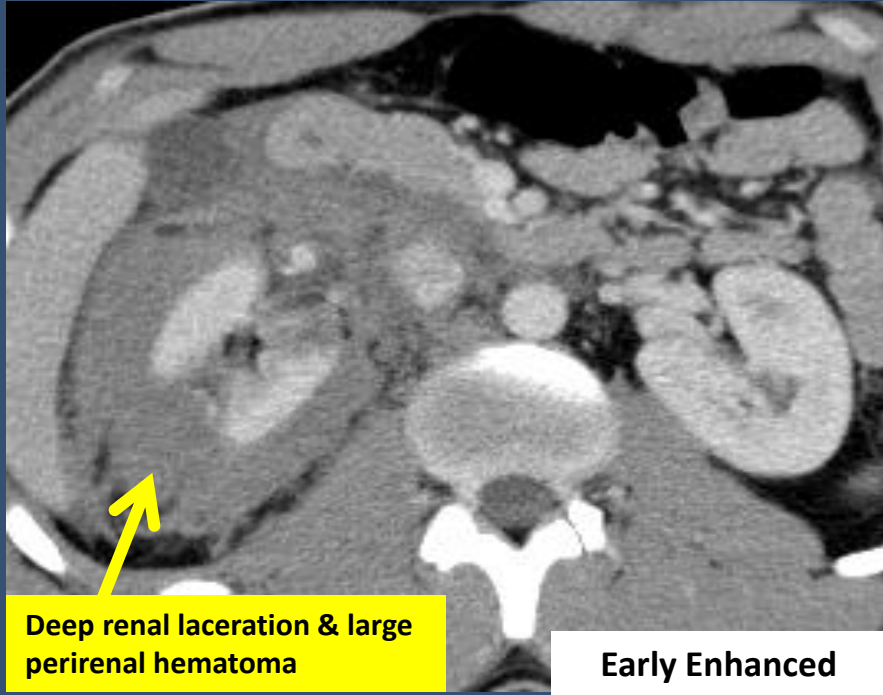
Grade II Renal Injury

Grade	Type	Description
II	Hematoma	▪ Nonexpanding perirenal hematoma confined to retroperitoneum
	Laceration	▪ < 1.0 cm parenchymal depth w/o urine extravasation



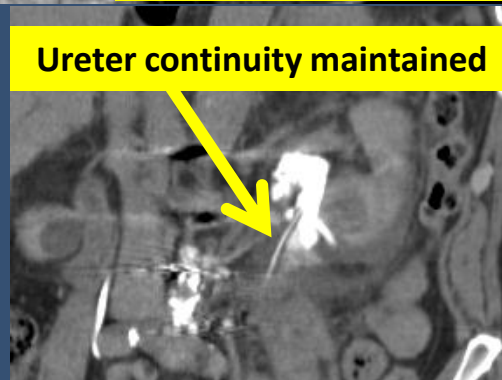
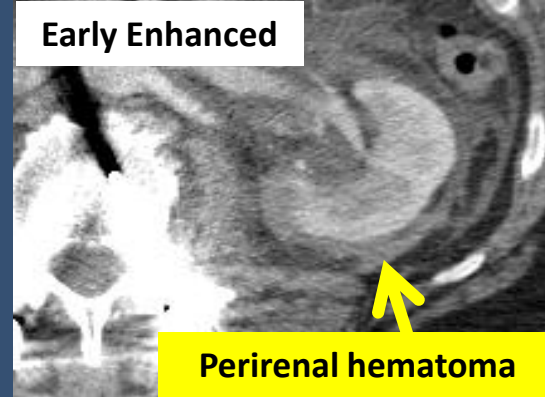
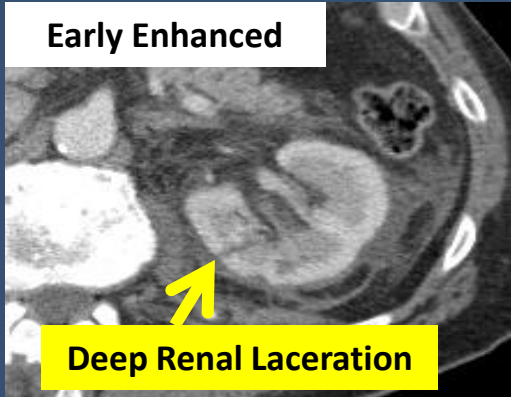
Grade III Renal Injury

Grade	Type	Description
III	Laceration	<ul style="list-style-type: none">> 1.0 cm parenchymal depth w/o urine extravasation



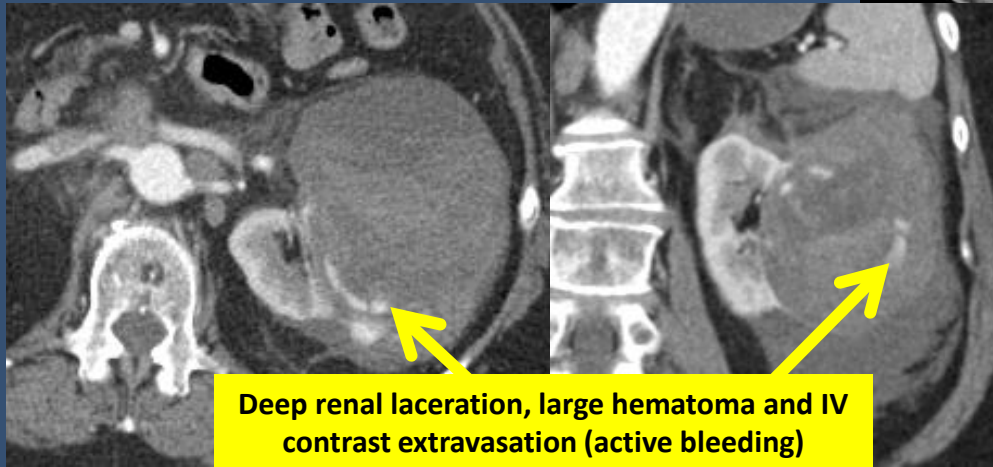
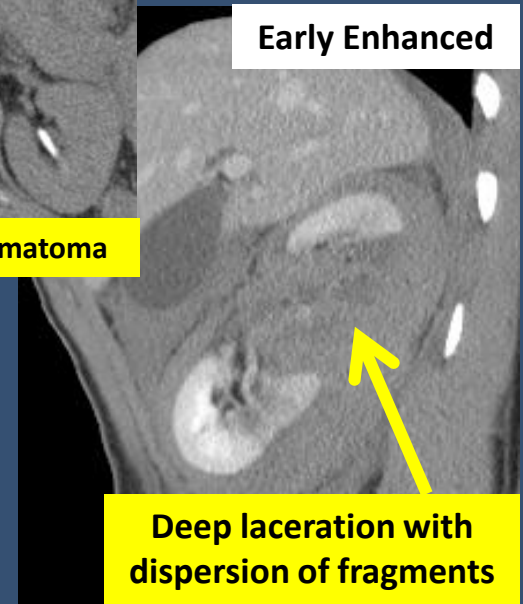
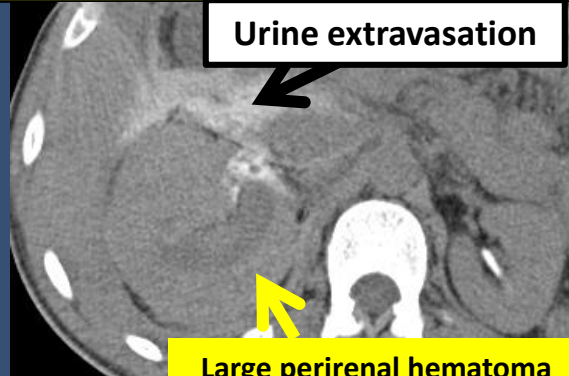
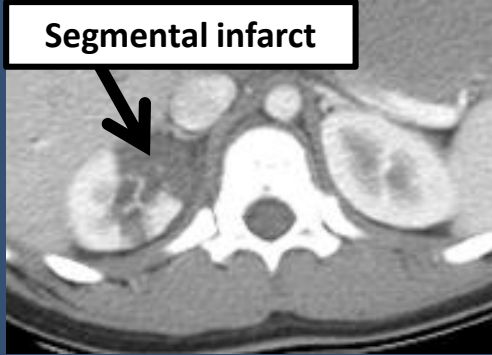
Grade IV Renal Injury

Grade	Type	Description
IV	Laceration	▪ Deep laceration with urine extravasation
	Vascular	▪ Main renal artery/vein injury with contained hemorrhage or injury to segmental renal vessels



Grade IV Renal Injury

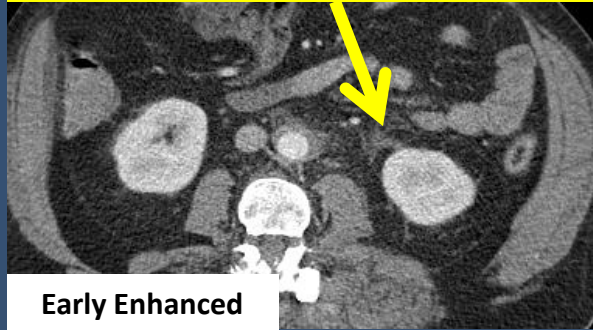
Grade	Type	Description
IV	Laceration	▪ Deep laceration with urine extravasation
	Vascular	▪ Main renal artery/vein injury with contained hemorrhage or injury to segmental renal vessels



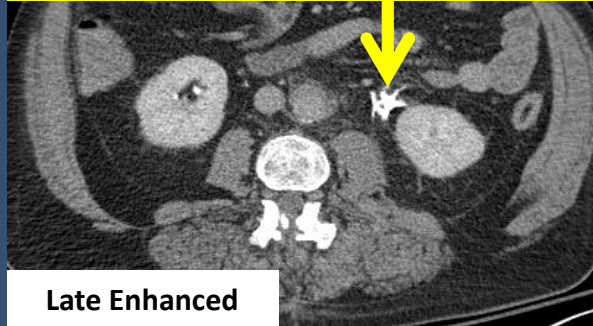
Grade V Renal Injury – UPJ Disruption

Grade	Type	Description
V	Laceration	<ul style="list-style-type: none">Shattered kidney with dispersion of avulsed segmentsUPJ avulsion (no connection to ureter)
	Vascular	<ul style="list-style-type: none">Avulsion/laceration/thrombosis of main renal vessels with devascularized kidney

Subtle stranding around proximal ureter



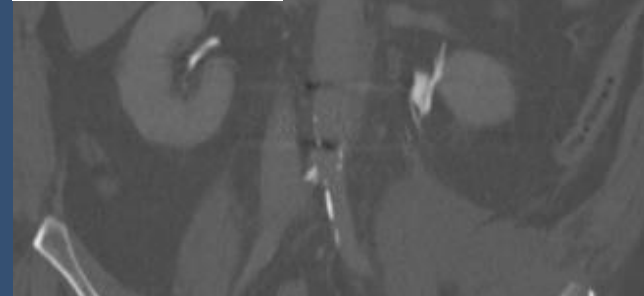
Extravasation confirmed on delayed scan



Late Enhanced

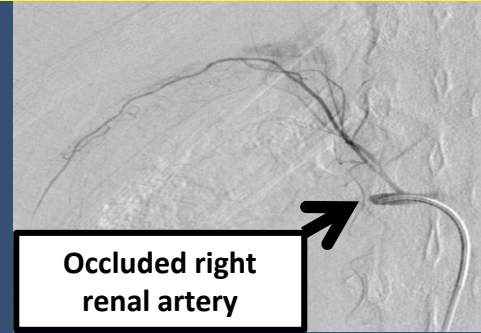
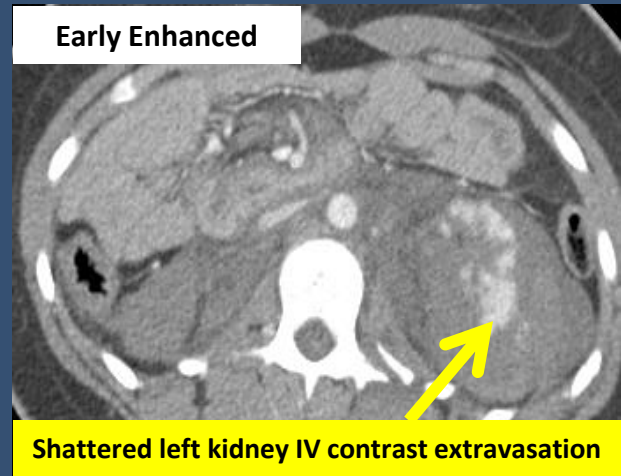
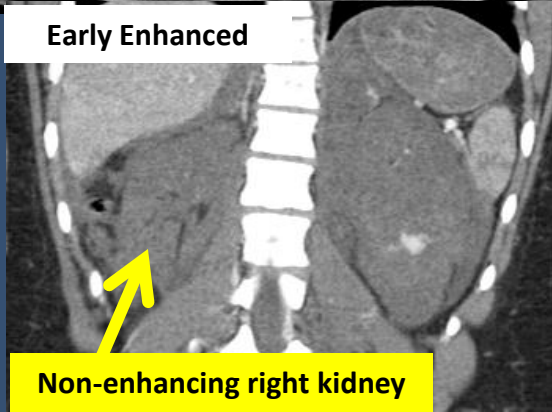
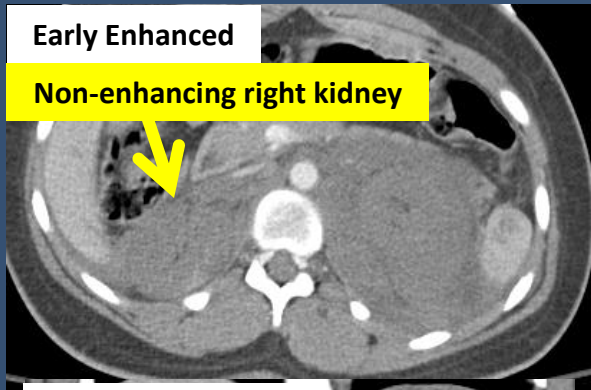


Late Enhanced



Grade V Renal Injury – RA avulsion & Shattered Kidney

Grade	Type	Description
V	Laceration	<ul style="list-style-type: none"> Shattered kidney with dispersion of avulsed segments UPJ avulsion (no connection to ureter)
	Vascular	<ul style="list-style-type: none"> Avulsion/laceration/thrombosis of main renal vessels with devascularized kidney



Additional Considerations

- Radiographic findings that predict higher risk for renal hemorrhage*
 - Intravascular contrast extravasation (**not part of the AAST grading scheme**)
 - Complex laceration (involves both the medial and lateral aspects of the kidney)
 - Perinephric hematoma larger than 3.5 cm (measured from the renal capsule to the margin of the hematoma)
 - 0 - 1 → 7% risk of hemorrhage requiring intervention
 - 2 -3 → 67% risk of hemorrhage requiring intervention
- 162 trauma related renal injuries from 2006-2013**
 - Active extravasation (25 patients); only 28% of these required operative repair
 - 12/25 patients had AAST grades 1-3 (48%): **3 required surgery**
 - 13/25 patients had AAST grades 4-5 (52%): 4 required surgery
 - 9 managed conservatively
 - **No contrast extravasation: no patients required operative management**
 - Collecting system (CS) injury (22 patients)
 - 50% were not identified on initial CT (identified on f/u exams 2-18 days after initial imaging)
 - Perinephric hematoma > 2.0cm had significant correlation with collecting system injury

*High-grade Renal Injuries. Radiographic Findings Correlated with Intervention for Renal Hemorrhage. Urol Clin N Am (2013), 335-341

**Utility of MDCT findings in predicting patient management outcomes in renal trauma. Emerg Radiol (2017) 24:263-272

Management

- Changing trends in management of renal trauma recognizing that surgical exploration for renal trauma often results in nephrectomy with halving of residual renal functional status.
- Broad definition of non-operative management including angioembolization and endoscopic/percutaneous control of urine leak within 24 hours of admission
 - 83.4% of all renal trauma managed successfully with only rest/observation
 - 16.6% required additional intervention; surgical intervention required in 5.9% of those cases
- Independent predictors for failing non-operative management
 - Penetrating injury (thought to be due to frequent disruption of Gerota's fascia losing the tamponade effect and injury to renal vascular system)
 - Highest abdominal injury grade for non-renal organs (> grade III); pancreatic and bowel injury commonly require surgical management
 - Highest renal grade injury
- 90% of patients that fail non operative management occur within 24 hours; mean of 17.6 hours
- **Using a more traditional, narrow definition of non-operative failure (renal surgery), the failure rate is 0.8%.**

Management

	2002	2012
Blunt trauma		
➤ Nephrectomy	8.2%	2.1%
➤ Endovascular	1.4%	53.3%
Penetrating trauma		
➤ Nephrectomy	19.3%	4.4%
➤ Laceration repair	75.4%	70.9%
➤ Endovascular	0%	11.3%

- Grades 1-3 overwhelmingly managed conservatively
- Grades 4 and 5 injuries may be effectively managed by observation
 - 2013 study showed 6.5% of grade 4/5 renal injuries failed conservative management.
- Absolute indications for renal exploration**
 - Life threatening hemorrhage from renovascular injury
 - UPJ avulsion
 - Urinoma unresponsive to minimally invasive procedures

*Nationwide Procedural Trends for Renal Trauma Management. *Annals of Surgery*, 2017, vol 10, no. 20

**High-grade Renal Injuries. Radiographic Findings Correlated with Intervention for Renal Hemorrhage. *Urol Clin N Am* (2013), 335-341

REFERENCES

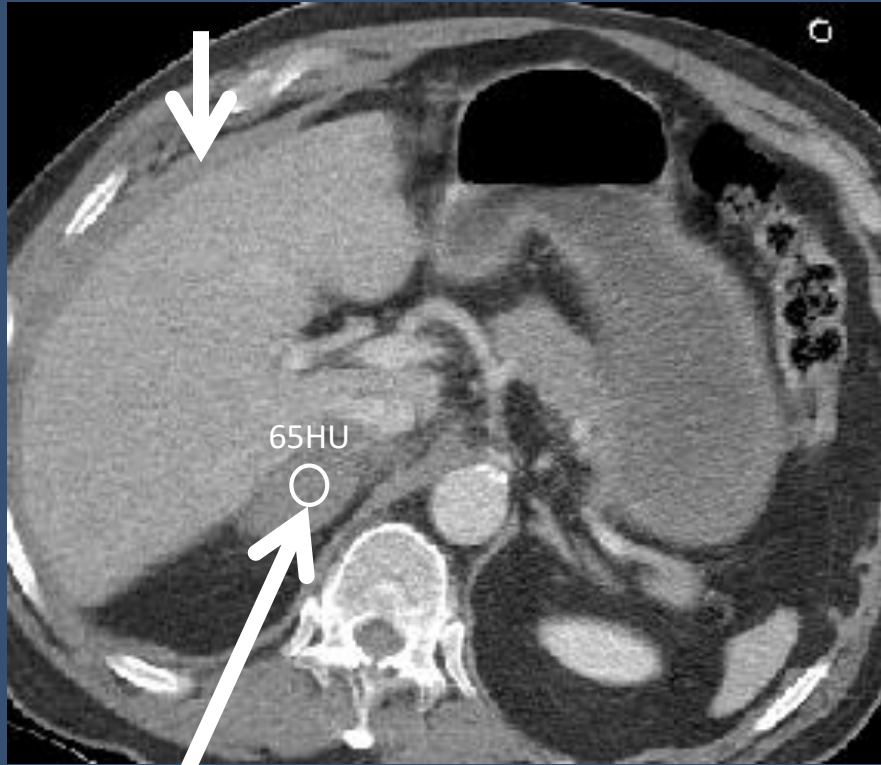
- Urotrauma: AUA Guideline. [http://www.auanet.org/guidelines/urotrauma-\(2014-amended-2017\)](http://www.auanet.org/guidelines/urotrauma-(2014-amended-2017))
- Colaco M et al. Nationwide Procedural Trends for Renal Trauma Management. *Annals of Surgery*. Vol 20, No 20. 2017
- Bjurlin MA et al. Comparison of nonoperative and surgical management of renal trauma: Can we predict when nonoperative management fails? *J Trauma Acute Care Surg*, Vol 82, No. 2, pg 356-361
- Baghdanian AH et al. Utility of MDCT findings in predicting patient management outcomes in renal trauma. *Emerg Radiol* (2017) 24:263-272
- Veeratterapliay R et al. Renal Trauma. *Journal of Clinical Urology* 2017. Vol 10(4) 379-390
- Myers JB et al. High-grade Renal Injuries. Radiographic Findings Correlated with Intervention for Renal Hemorrhage. *Urol Clin N Am* 40 (2013) 335-341
- Dugi DD et al. American Association for the Surgery of Trauma Grade 4 Renal Injury Substratification Into Grades 4a (Low Risk) and 4b (High Risk). *The Journal of Urology* Vol 183, 592-597, February 2010
- Ramchandani P, Buckler PM. Imaging of Genitourinary Trauma. *AJR*:192, June 2009, pages 1514-1523

ADRENAL TRAUMA

- Epidemiology & general information in renal trauma
- Imaging evaluation and grading (case based review using AAST guidelines)
- Principles of management and follow-up in renal trauma

History: Motor vehicle accident

Hemoperitoneum



Adrenal mass

June 1, 2001

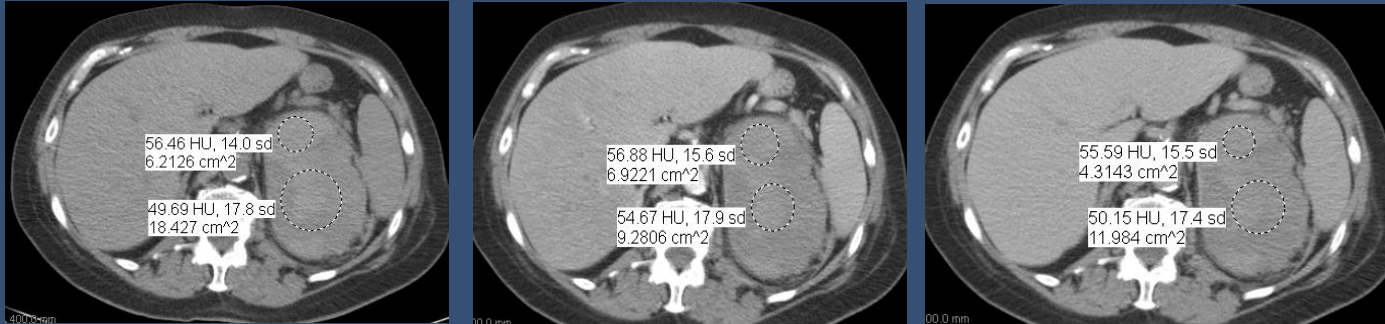


Decreased size and density of the mass on CT 3 weeks later

History: Anticoagulated and incidental mass identified on CT



Findings: Large, heterogeneous but non-enhancing mass in the left upper quadrant. What is your differential diagnosis?



Diagnosis: Spontaneous adrenal hemorrhage

Adrenal Trauma

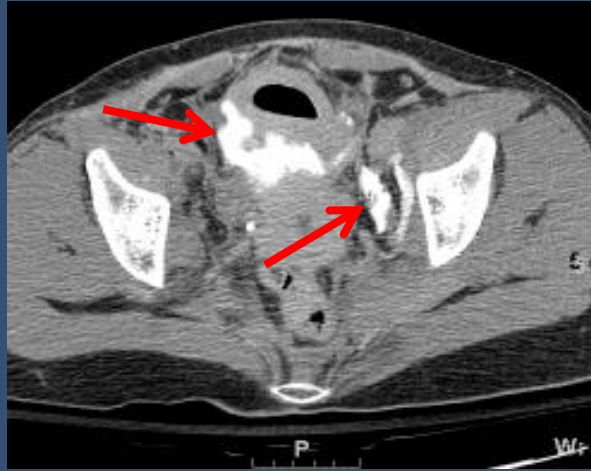
- Traumatic more common than spontaneous
 - 80% are unilateral
 - 85% right
 - 15% left
- Non-traumatic – often bilateral
 - Stress
 - Bleeding disorder or anticoagulation
 - Underlying tumor
 - Unknown
- Adrenal insufficiency occurs when $> 90\%$ of the gland is destroyed

BLADDER TRAUMA

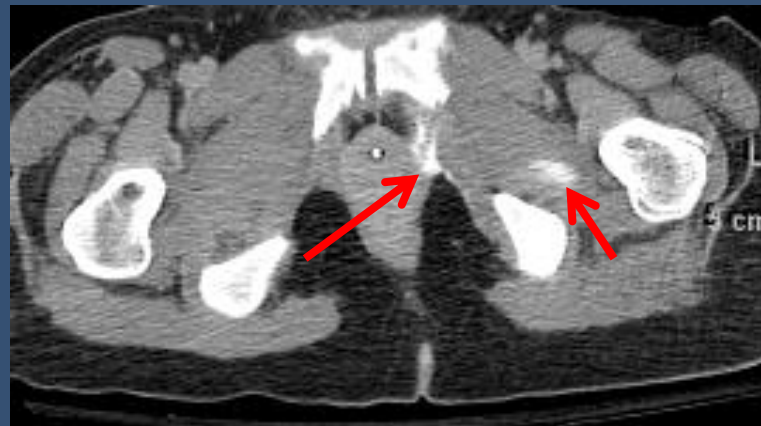
- Epidemiology & general information in renal trauma
- Imaging evaluation and grading (case based review using AAST guidelines)
- Principles of management and follow-up in renal trauma

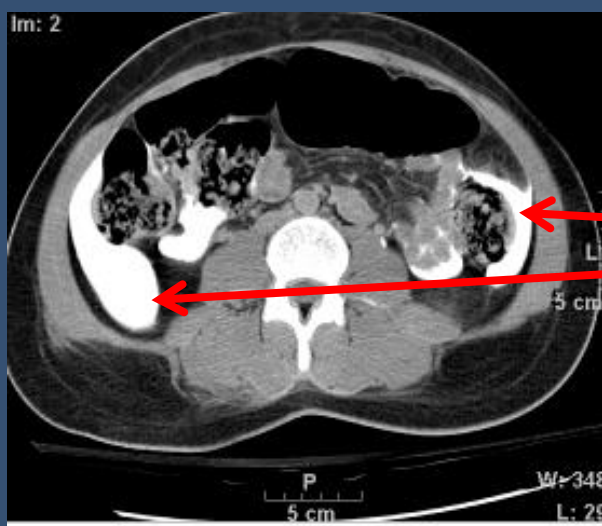
History: Motor vehicle accident.

Space of Retzius

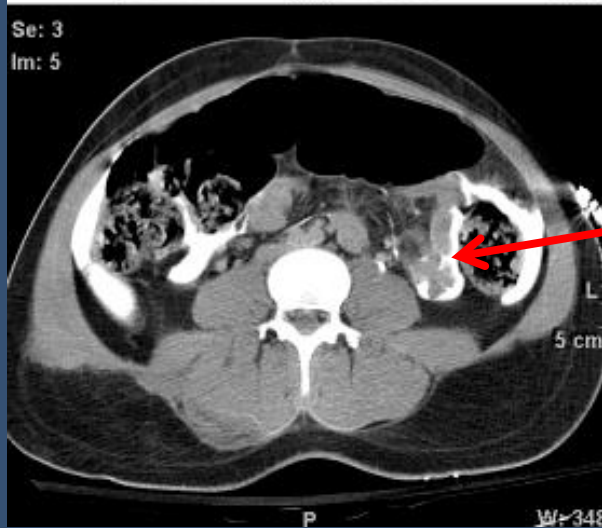


Extravasated Contrast





Paracolic gutters

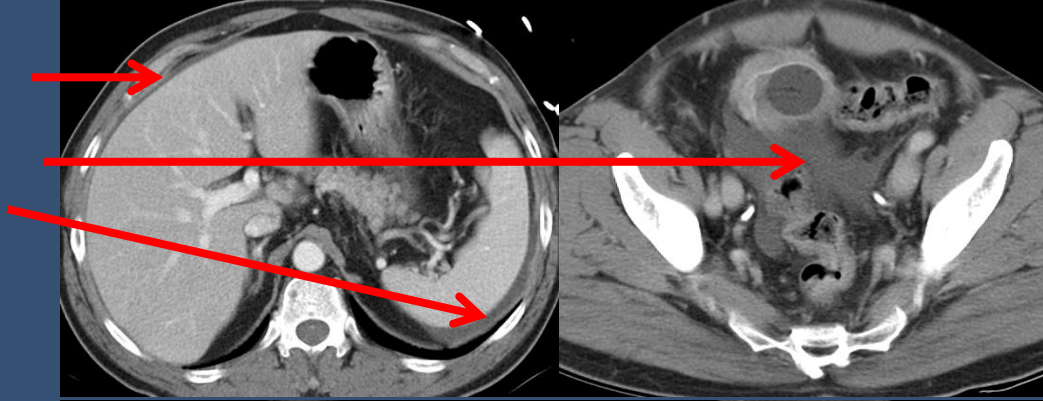


Small bowel mesentery

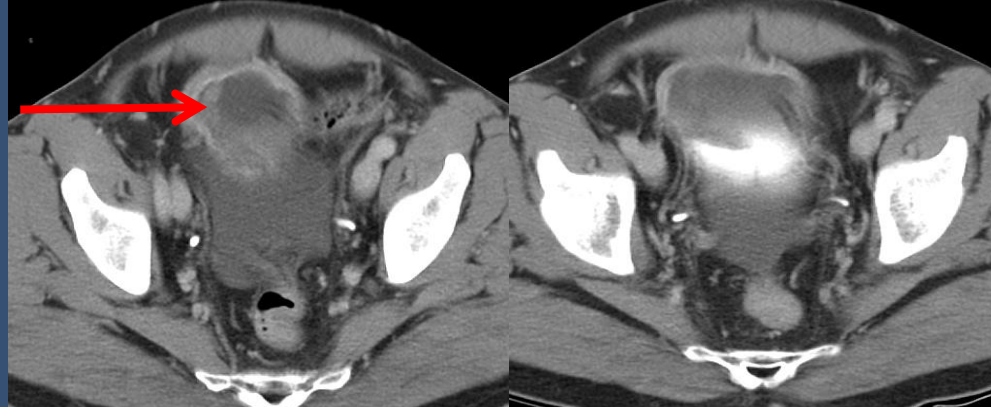
Diagnosis: Intraperitoneal and Extraperitoneal
Bladder rupture. Requires surgical repair

History: Motor vehicle accident.

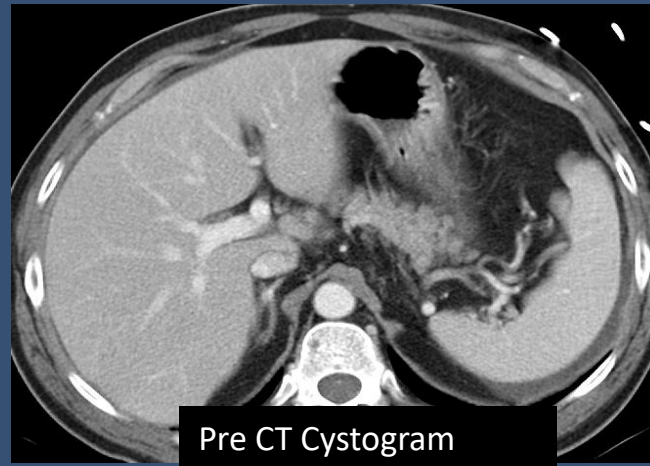
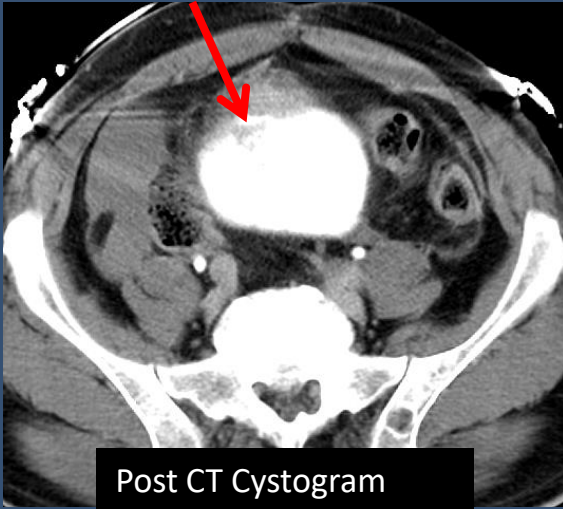
Free fluid in the
pelvis and
around the
liver/spleen



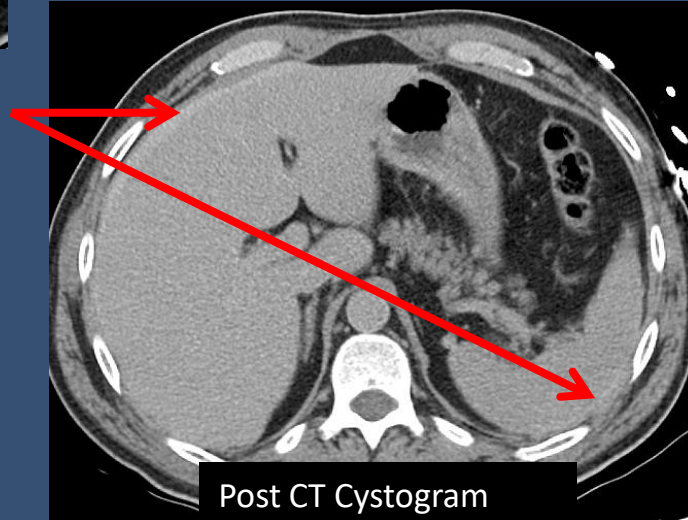
Blood clot in bladder



Bladder hematoma



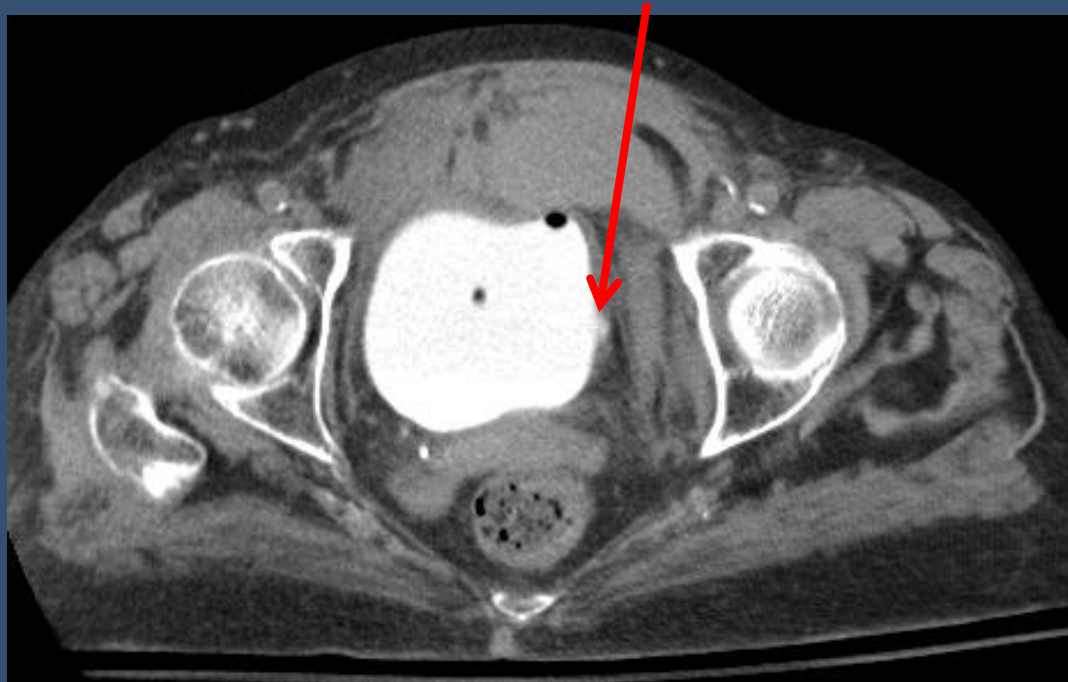
Contrast around liver/spleen



Diagnosis: Intraperitoneal bladder injury.
Requires surgical repair

History: Motor vehicle accident.

Contrast in a laceration of the bladder wall



Diagnosis: Interstitial bladder injury. Managed conservatively

Bladder Injuries

- Contusion (I)
 - Most common minor injury
 - Incomplete or partial tear of bladder mucosa; ecchymosis of a localized portion of the bladder wall
 - Diagnosis of exclusion of more serious injuries

Bladder Injuries

- Intraperitoneal (II)
 - 25% of major bladder injuries
 - Direct blow to a distended bladder
 - Tear along bladder wall at the dome covered by peritoneum
 - Requires surgical repair

Bladder Injuries

- Interstitial (III)
 - Rare
 - Partial thickness laceration with intact serosa

Bladder Injuries

- Extraperitoneal (IV)
 - 62% of major bladder injuries; most common
 - Often with pelvic fractures and lacerations of the anterolateral bladder wall by the spicules but can be associated with blunt trauma without fractures
 - Sub types
 - Simple: Confined to the pelvis
 - Complex: Disruption of the fascial planes allowing contrast to track into the thighs, scrotum, perineum
 - Managed with drainage and conservative

Bladder Injuries

- Combined intra- and extraperitoneal (V)
 - 12% of major bladder injuries
 - Requires surgical repair

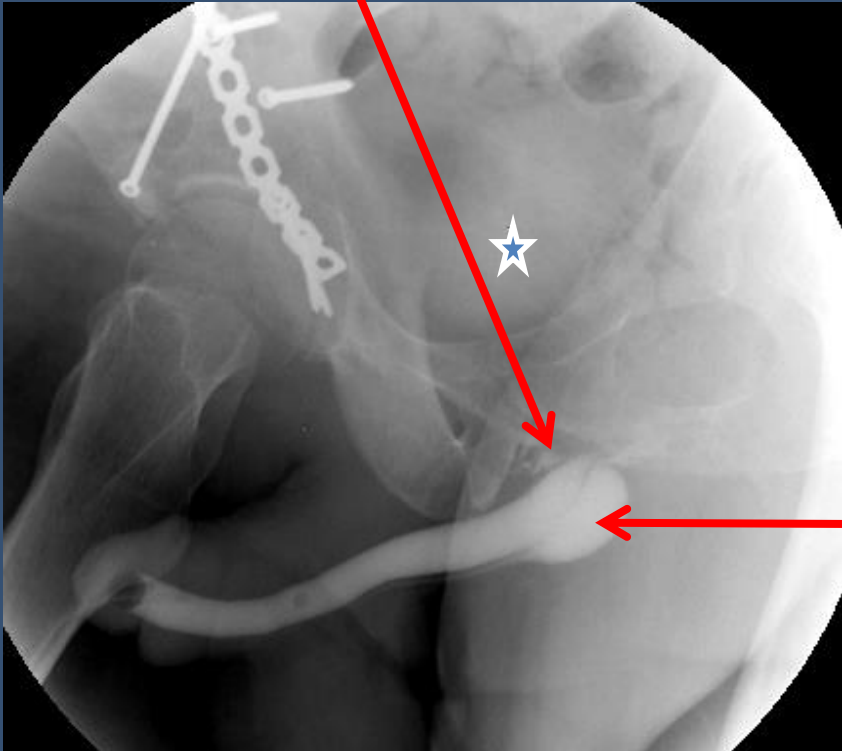
CT Cystogram Technique

- Delayed IV enhanced CT NOT adequate to exclude a bladder injury
- Exclude urethral injury first
- 300 mL dilute contrast passively instilled into the bladder through Foley
 - 10 mL Omnipaque 300 in 300 mL saline
- Scan pelvis with bladder full. Scan abdomen and pelvis with bladder empty
- 95-100% sensitivity detecting injury

External Genitalia Trauma

History: Blood at the urethral meatus noticed after ORIF of pelvis fracture.

Laceration and extravasation at urogenital diaphragm



Posterior (contrast contained above the UG diaphragm)

Partial; contrast in the bladder

Extravasation into corpus cavernosum

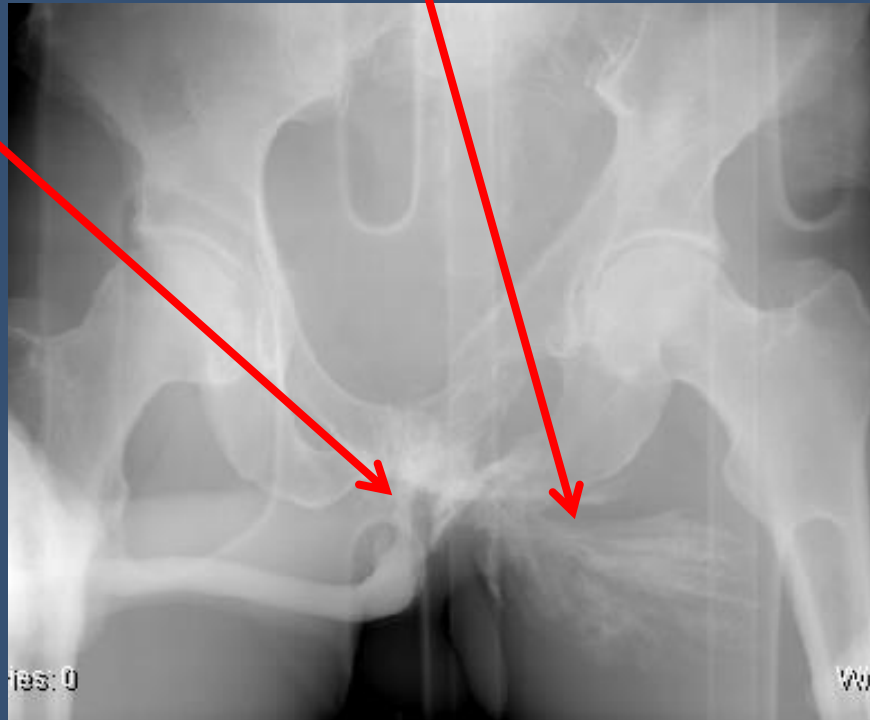
History: Porsche fell off the jacks onto patient. Blood at the urethral meatus

Laceration and
extravasation at
urogenital diaphragm

Combined posterior & anterior (contrast
above and below the UG diaphragm

Complete; No contrast in the bladder

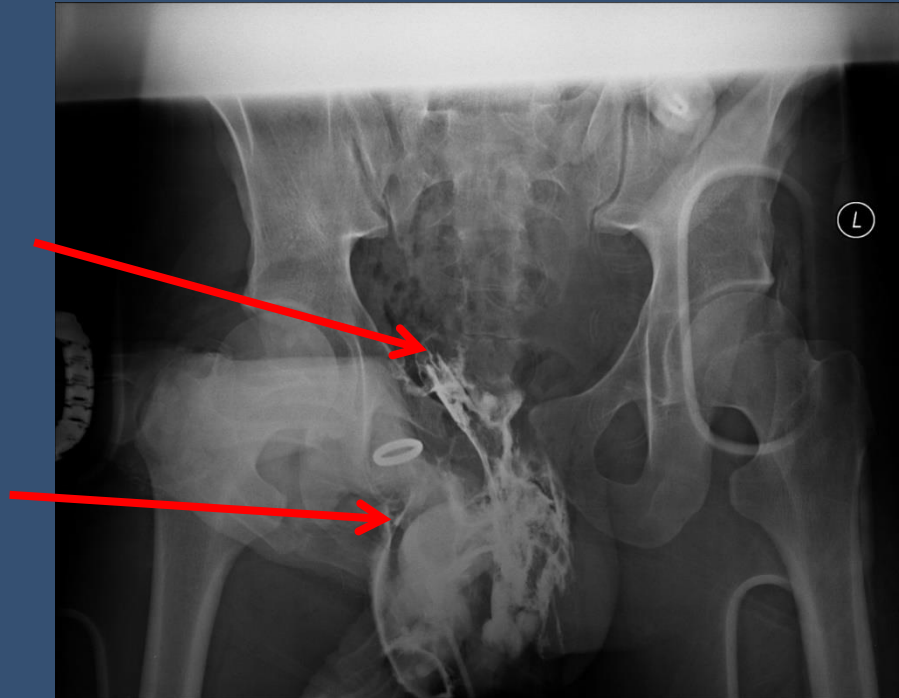
Contrast extravasating
into the thigh soft
tissues



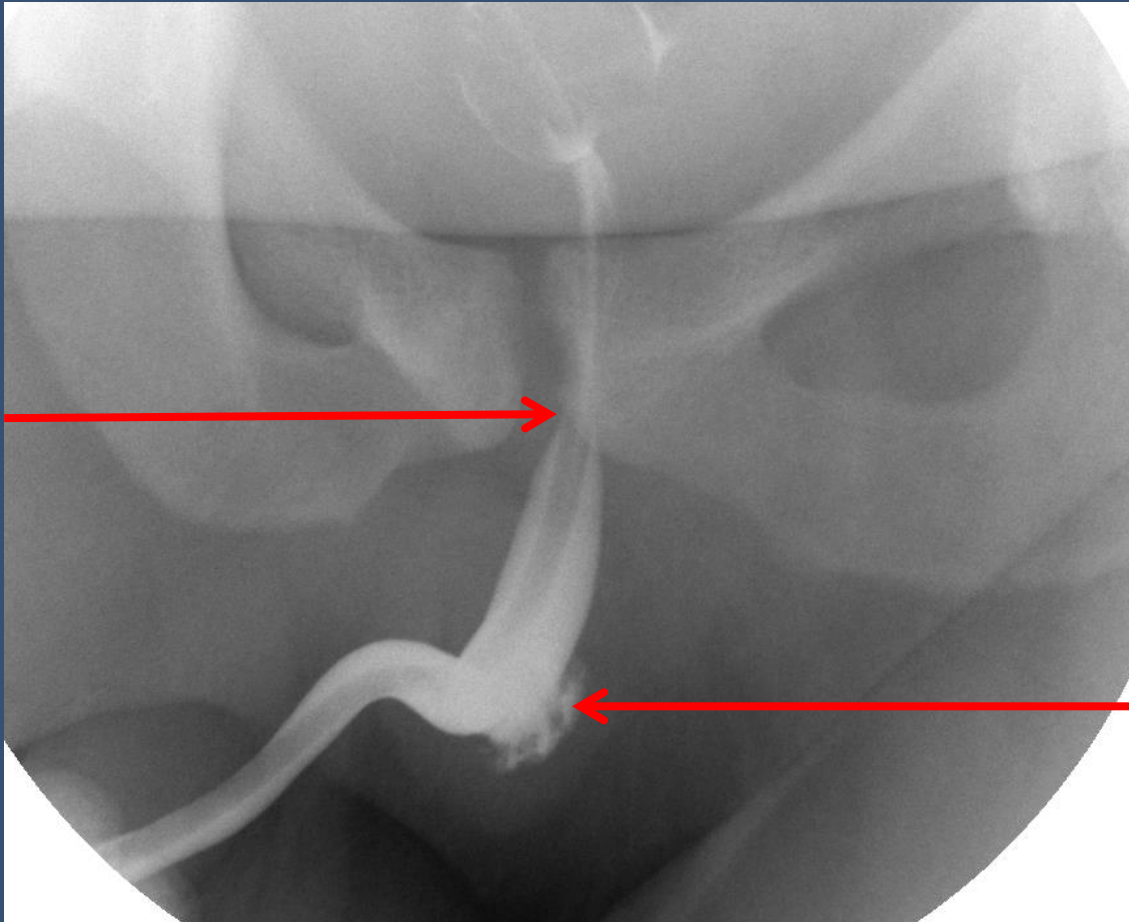
History: Motor vehicle accident

Contrast extravasation
into the pelvic
extraperitoneal space

Contrast extravasation
into the scrotum and
perineum



Urogenital
diaphragm

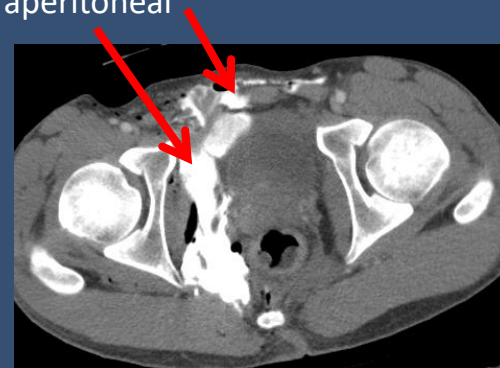


Anterior urethra
laceration

Contrast extravasation into
scrotum and perinum



Contrast extravasation
into pelvic
extraperitoneal



Bladder neck with extension
into the posterior urethra and
extraperitoneal space



Contrast extravasation
into peritoneum

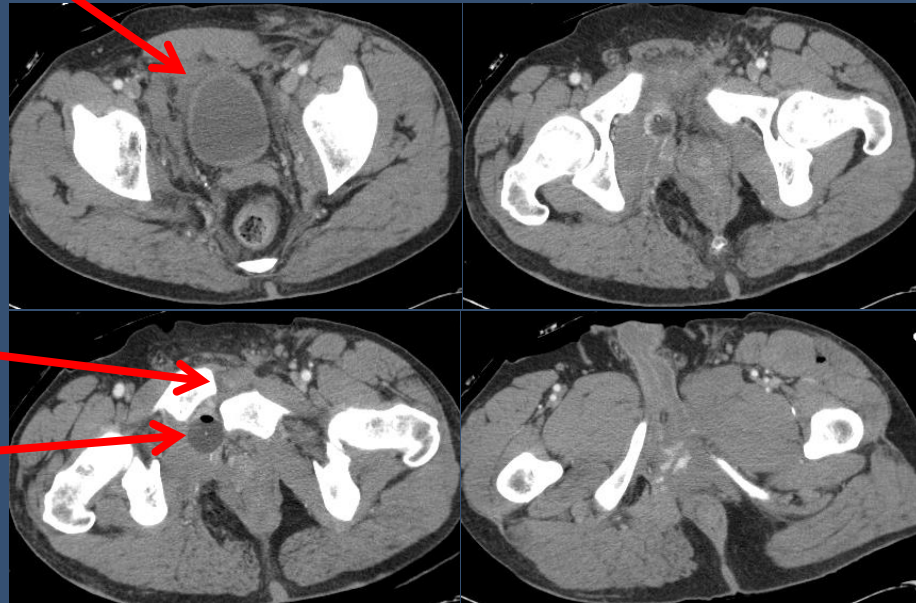
Urethral Injury

- Type I: Posterior urethra is stretched but no extravasation
- Type II: Pure posterior urethra laceration with extravasated contrast above the UG diaphragm
- Type III: Combined anterior and posterior urethra laceration with extravasated contrast above and below the UG diaphragm
 - Most common type of injury
- Type IV: Bladder neck injury with extension into the proximal urethra
- Type V: Anterior urethra laceration

History: Motor vehicle accident.

Diagnosis: Urethral laceration with Foley catheter outside of the urethra/bladder

Blood in the space of Retzius



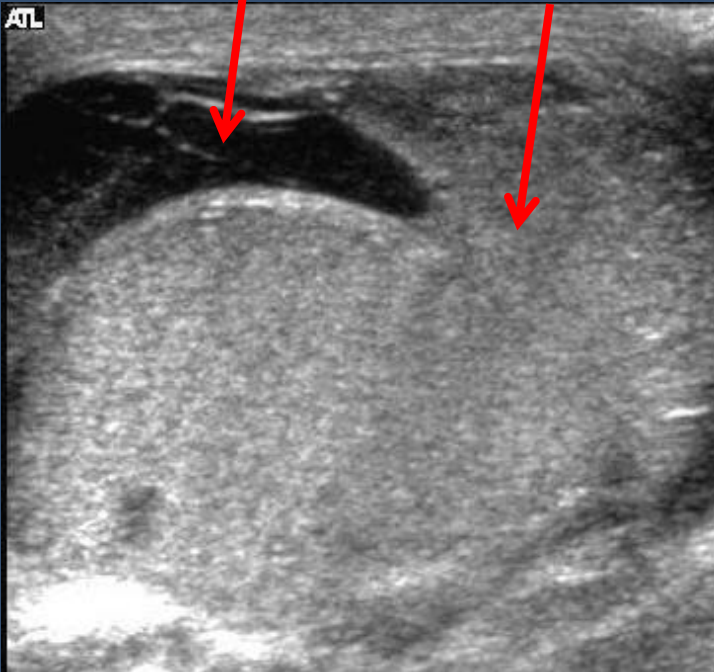
Diastasis of symphysis pubis

Foley catheter off midline

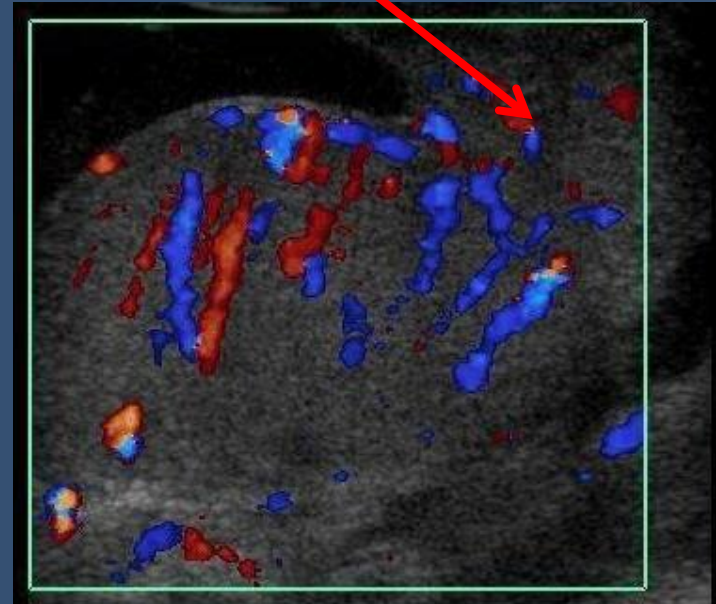
History: Zamboni driver hit by a hockey puck in the groin.

Hematocoele

Discontinuity of the tunica albuginea

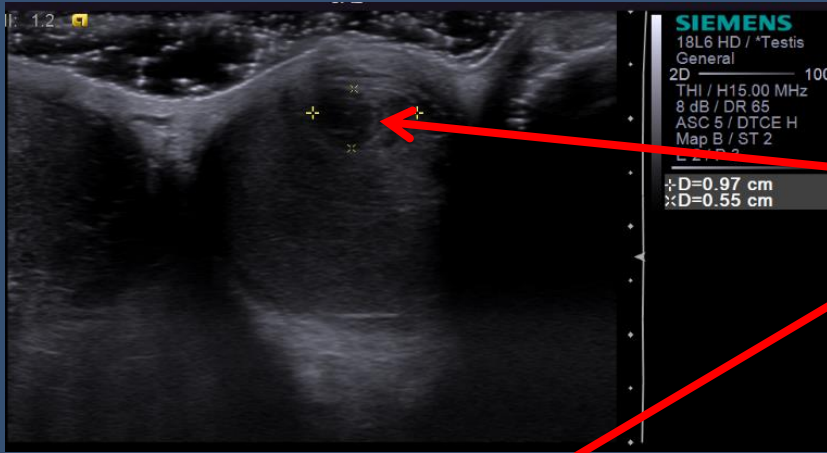


Testicular blood flow shown extending into the extra-testicular soft tissues

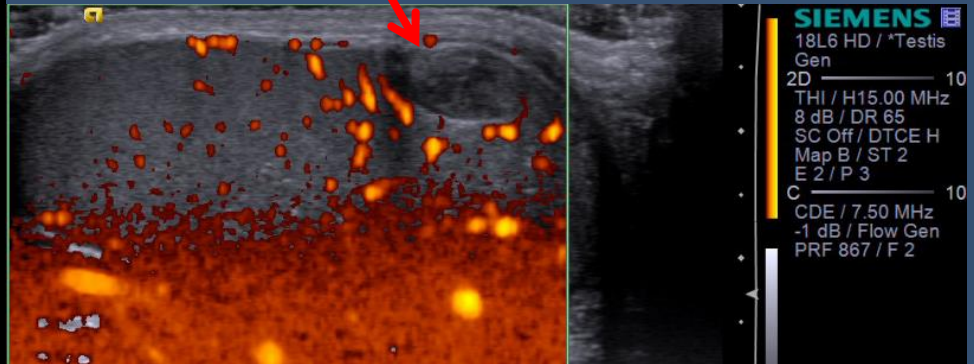
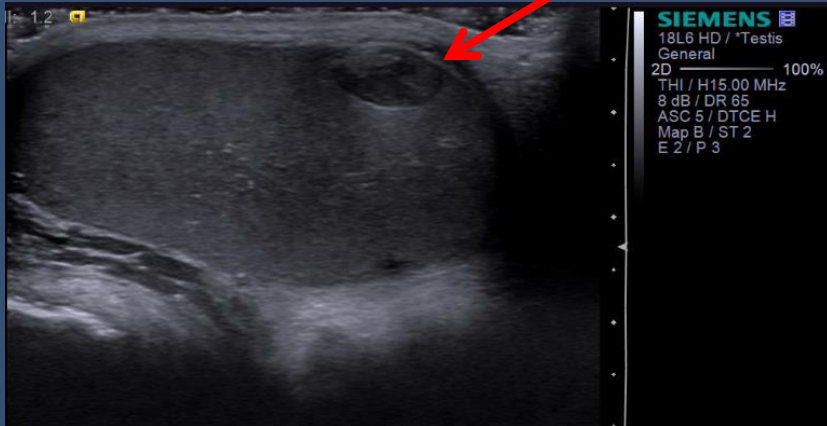


Diagnosis: Testicular Fracture

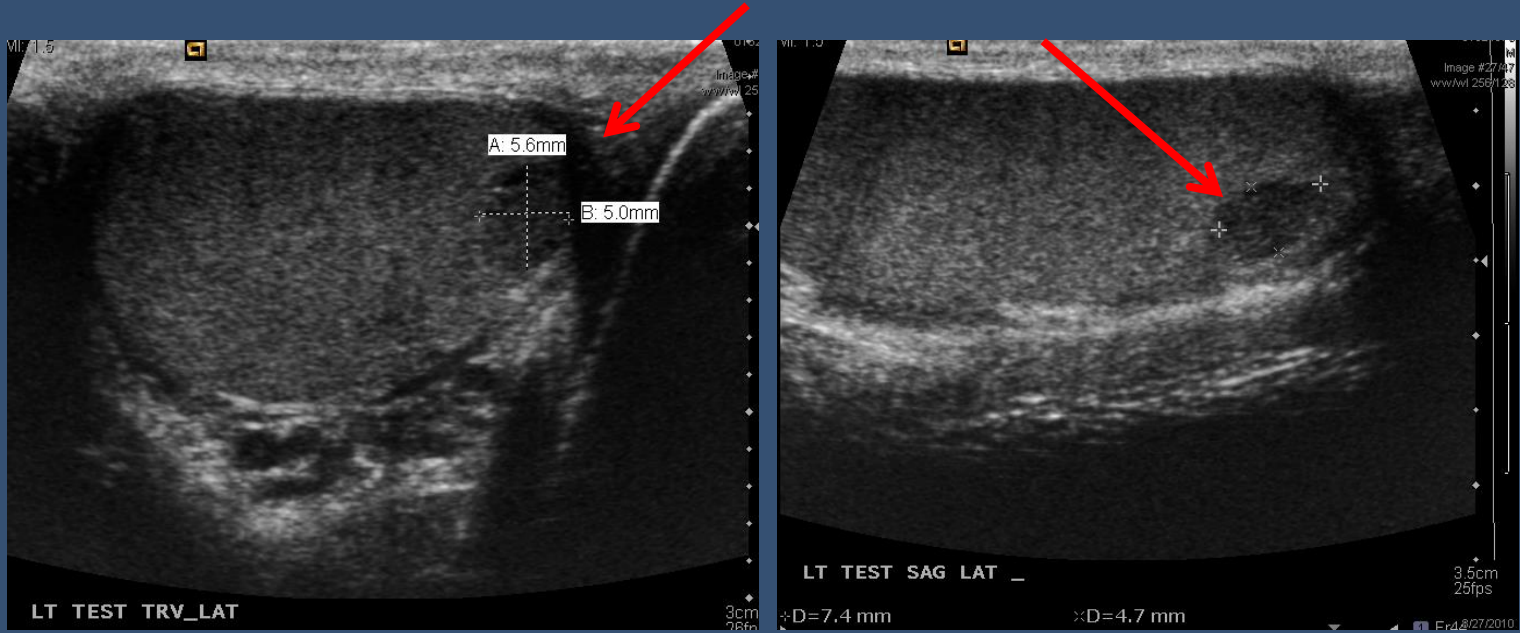
History: Hit by a baseball in the groin.



Hypoechoic avascular intra-testicular nodule



3 weeks later the nodule has decreased in size. Tumor markers negative



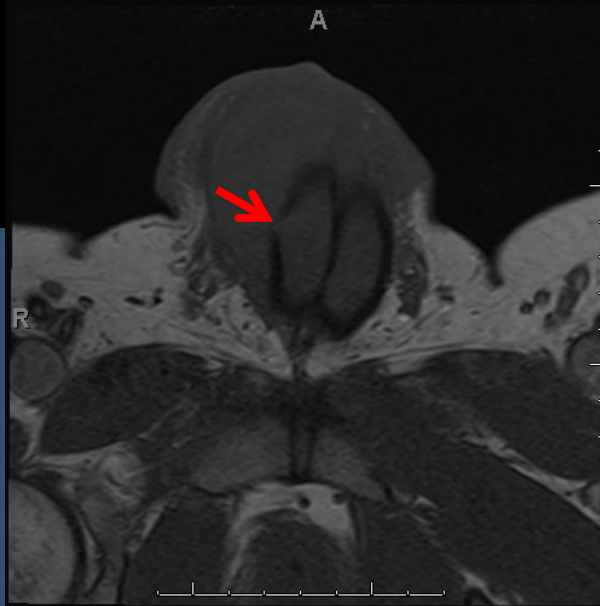
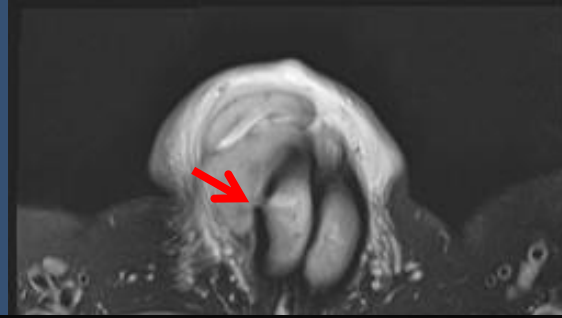
Diagnosis: Testicular hematoma

Testicular Trauma

- Testicular fracture
 - Irregular testicular contour with disruption of tunica albuginea
 - Heterogeneous parenchymal echogenicity
 - Distorted vascularity
 - Associated epididymal enlargement and hematocele
 - Discrete fracture plane seen in only 17% of cases
 - Surgery necessary
 - 90% salvage rate if done within 3 days; drops to 55% after that
- Testicular hematoma
 - Avascular intra-testicular nodule
 - May be hyperechoic or hypoechoic depending on age

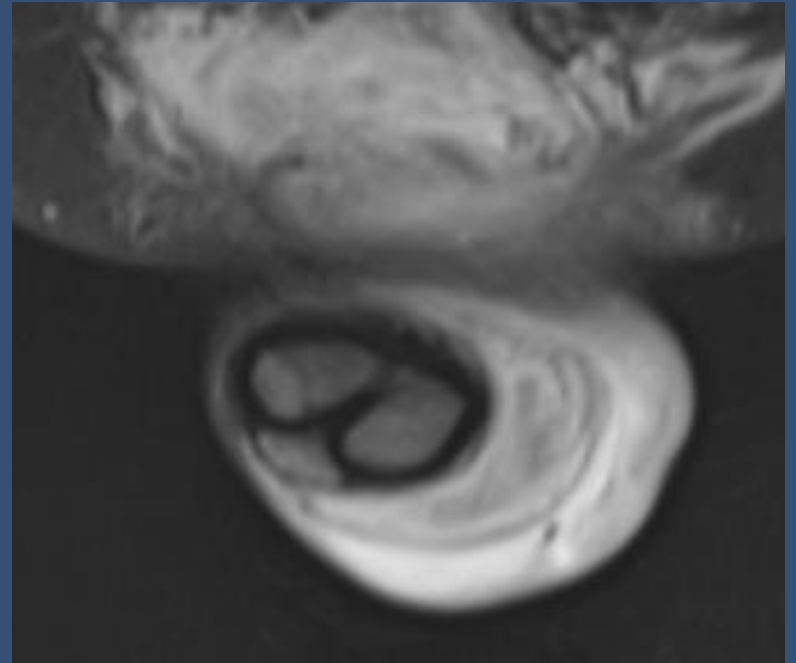
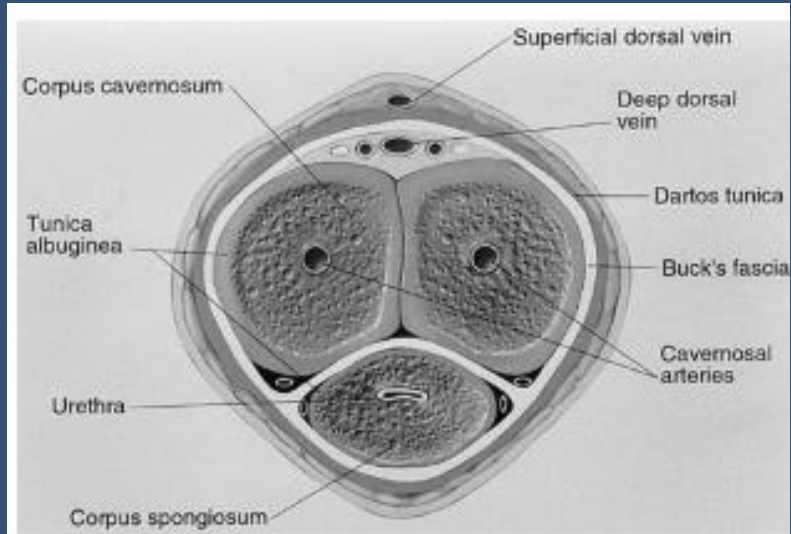
The Worst

History: penile and scrotal swelling. Pain during intercourse.



Penile fracture

- Penile fracture is a disruption of the tunica albuginea and appears on US as a disruption of the echogenic line.
- Hematoma in 100%. If Buck's fascia is intact then the hematoma is confined to the penis shaft. If Buck's fascia is disrupted then the hematoma will spread out into the scrotum/perineum
- Urethral injury in 10% of cases of penis fracture
- Emergent surgery is indicated
- Occurs during strenuous sexual activity.





4 years old. It's a long road and you can't start too soon.

