SCROTUM AND PROSTATE

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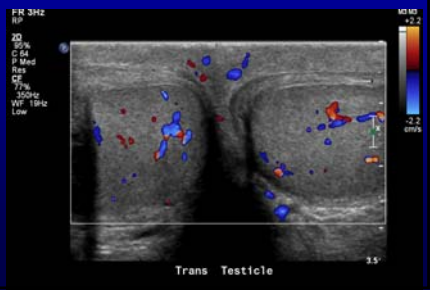
OUTLINE

- Review of differential diagnosis of scrotal pain, swelling, and mass
  - Testicular disease
  - Extra-testicular disease: scrotal wall, epididymis, spermatic cord
- Review of Prostate MRI
  - Current status of Prostate MRI
  - Tips for interpretation of multi-parametric MRI
  - Pitfalls

IMAGING SCROTUM

- Primary modality: Ultrasound
  - Readily accessible and available
  - Easy to perform (no prep, relatively short exam time)
  - High resolution, high diagnostic accuracy
  - No ionizing radiation
- MRI:
  - Details of lesion extent
  - Problem solver



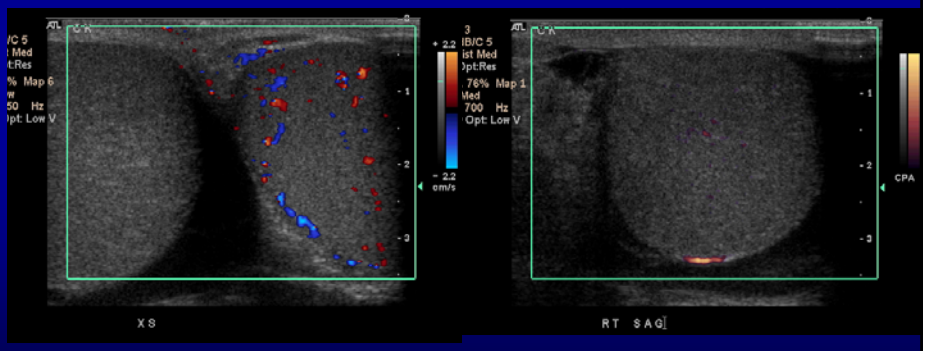
Tips for US technique

- Look for symmetry in size and echogenicity
- Use low flow velocity settings in color Doppler or power Doppler
- Compare to/scan asymptomatic side to optimize color Doppler gain settings
- Carefully scan area of clinical concern
- Other techniques – Valsalva for varicoceles

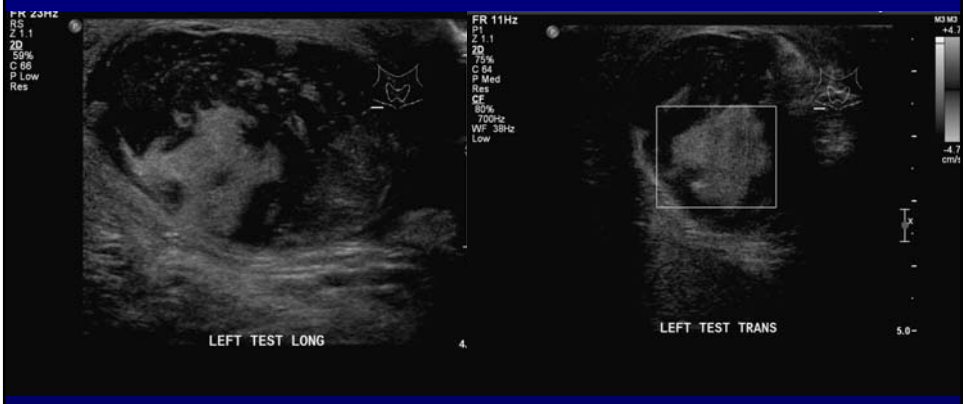
TESTIS

- Acute Conditions
  - Testicular Torsion
    - Intravaginal – within tunica vaginalis(often associated with Bell-Clapper deformity)
    - Extravaginal – outside tunica vaginalis, strictly newborns
  - Orchitis-Mumps
  - Abscess
  - Trauma - hematoma

Which side is abnormal?

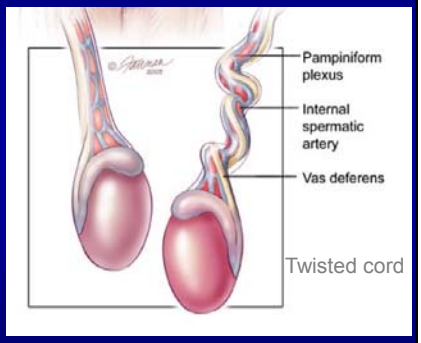


Testicular Infarct



Testicular Torsion

- Acute testicular pain, SURGICAL EMERGENCY
  - U/S=Important in differentiating b/w torsion vs. epididymo-orchitis
    - Color/Doppler-Essential
- Extravaginal-Strictly newborns
  - Outside of tunica vaginalis when testis and gubernaculum are not fixed
- Intravaginal (Bell Clapper Deformity)
  - Tunica vaginalis encircles entire epididymis, distal spermatic cord and testis except posterolateral aspect
  - Complete, Incomplete, and Transient (Bilateral usually)
  - ?Exclude torsion with presence of Color/Doppler signal: No
  - Asymmetry in RI's and decrease in diastolic flow: Inconclusive for partial torsion



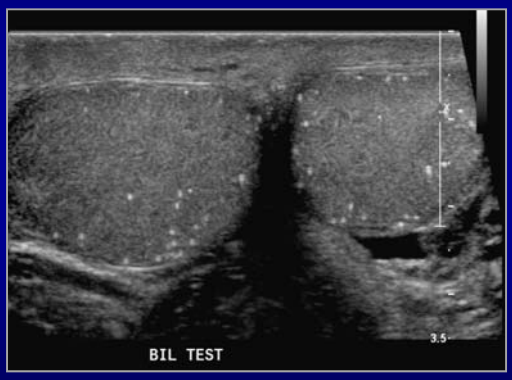
Benign Testicular Masses

- Testicular Microlithiasis
  - Microlithiasis
  - Macrolithiasis
    - Post-traumatic, burned out-GCT, large cell calcifying Sertoli cell tumor
- Trauma
  - Hematoma, rupture
- Benign
  - Testicular Cyst
  - Epidermoid Cyst
  - Intratesticular Varicocele
  - Tubular Ectasia of the Rete Testis
  - Infarct
  - Abscess, TB
  - Leydig cell hyperplasia
  - Fibrosis
  - Adrenal rest cell tumor

Malignant Testicular Masses

- Germ cell tumors -95%
  - Seminomas, 50%
  - Non-seminomatous mixed germ cell tumors (Embryonal,Yolk Sac,Teratoma, choriocarcinoma) germ cell tumorGerm cell tumors -95%
- Sex cord stromal tumor
  - Leydig cell tumors
  - Sertoli cell tumors
- Lymphoma/leukemia
- Metastasis (GI origin)

49 y/o male with remote history of trauma



Testicular Microlithiasis

- 5 or more microliths present per transducer field for diagnosis.
- U/S-punctate nonshadowing, hyperechoic foci within a homogeneous testicle, 2-3mm.
- Microcalcifications-laminated concretions within lumen of seminiferous tubules.
- Bilateral and symmetric. Can be asymmetric, unilateral, or clustered
- Prevalence of 0.6 – 3.7%.
- Association with Intratubular germ cell neoplasia (↑ risk) 60-70%, not proven to be a direct cause.
- Annual follow-up recommended for at least several years after the diagnosis – no consensus.

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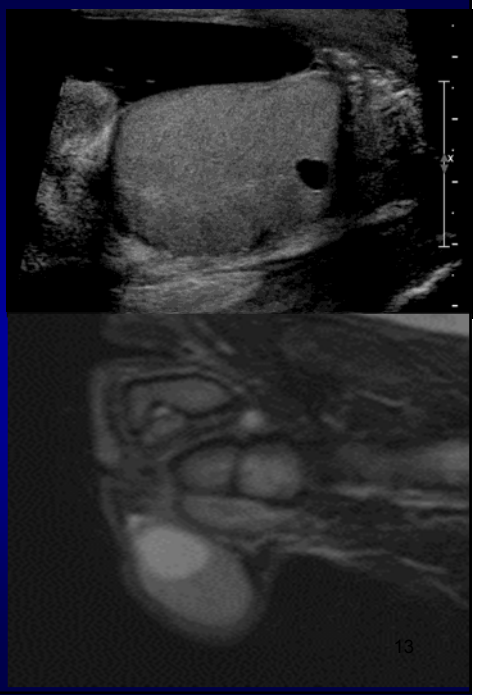
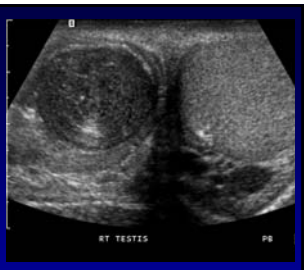
Testicular Cyst

- Benign
- Leave me alone lesion if it is simple and non-palpable.



Epidermoid cyst



- benign tumor of germ cell origin
- 1-3 cm, nontender, usually palpable
- Age: 20- 40
- US finding: vary with maturation, compactness, and quantity of keratin
- characteristic "onion ring" configuration with alternating layers of hyper- and hypoechogenicity
- do not show blood flow at Doppler US.

Epidermoid cyst/Keratocyst

- U/S – 4 appearances
    1. Target appearance
    2. Rim of calcification
    3. ‘Onion skin’ pattern
    4. Solid mass with echogenic rim
- Doppler – No flow
- Negative tumor-markers and avascularity
- Enucleation or testis sparing surgery

Trauma

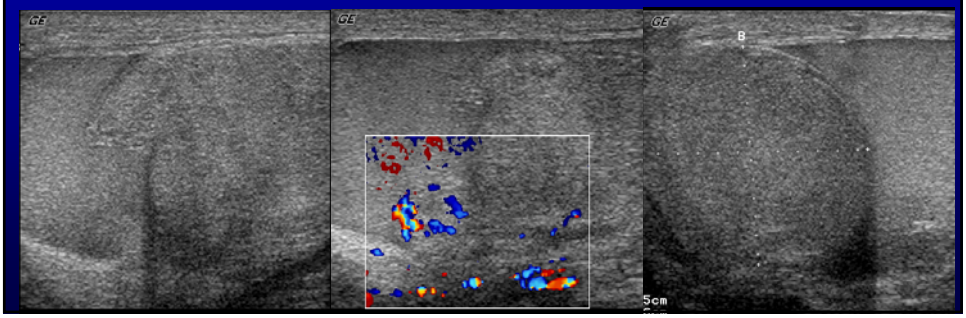
- Testicular Rupture:

- disruption of tunica albuginea, contour abnormality, heterogeneous echotexture, absence of vascularity

- Testicular Fracture

- discontinuity or breakage of normal parenchyma, hypoechoic band with corresponding avascular portion

- often associated with rupture

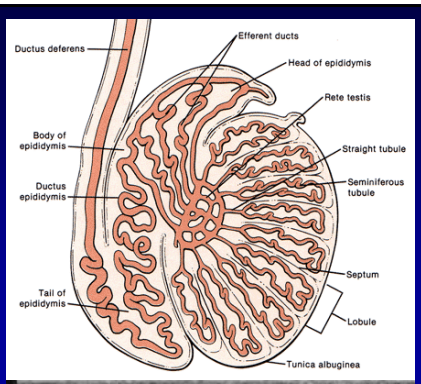


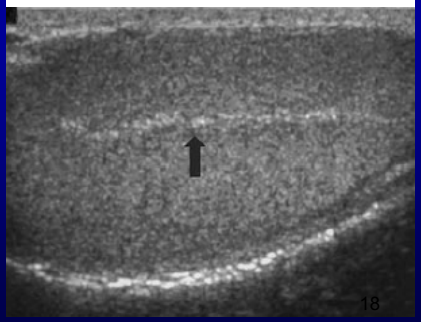
Tubular ectasia of rete testis

- Benign condition-partial or complete obliteration of the rete testis
  - Can be mistaken for a neoplasm (especially in cross-section)
- ? Secondary to obstruction in the epididymis or efferent ductules.
- Cystic dilatation within or adjacent to the mediastinum.
- Typically >55 yrs of age, usually bilateral.
- Frequently associated with spermatocele / epididymal cysts.

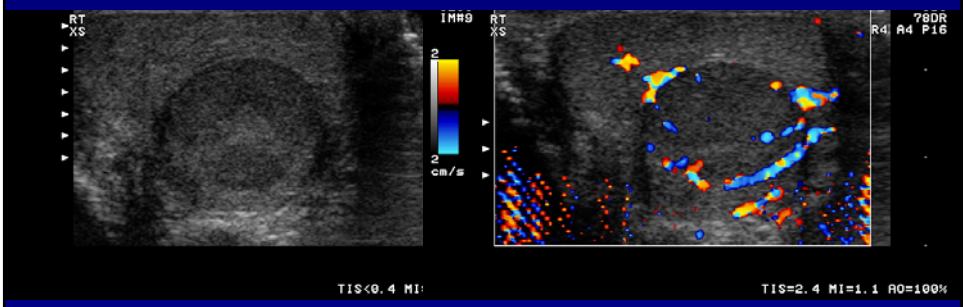
Rete Testis

- Network of epithelial-lined spaces embedded in the fibrous stroma of the mediastinum.
- Drains into the epididymis through 10-15 efferent ductules.
- Hypoechoic with a striated configuration adjacent to the mediastinum testis.
- Seen in up to 18% of the population .
- Tubular ectasia – fluid-filled dilated tubular structures.





Seminoma



34 y/o male pre-op for vasectomy

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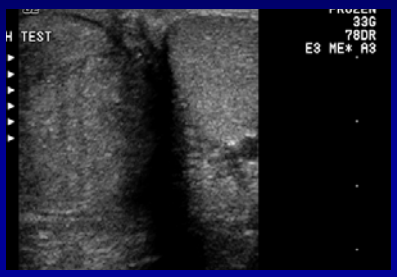
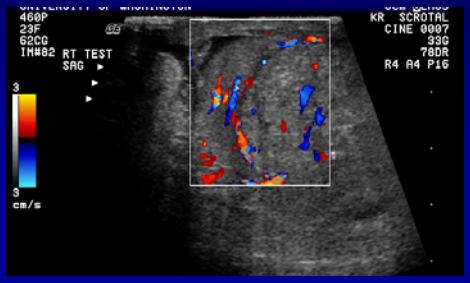
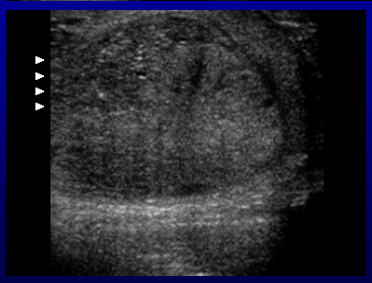
Mixed Germ Cell Tumor







23 y/o male with right testicular mass and pain

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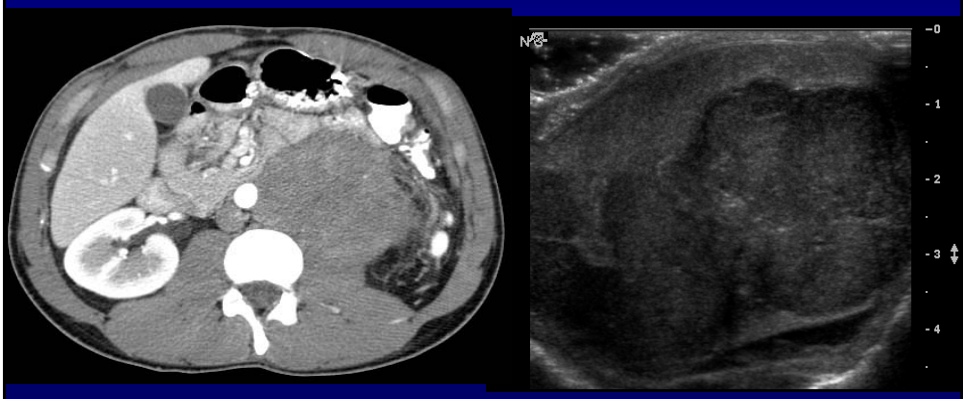
Non seminomatous GCT



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Seminoma Vs. Non-Seminomatous GCT

- Most common GCT
  - 35-50%
  - Best prognosis
- U/S
  - Typically uniformly hypoechoic
  - Can replace whole testis
    - Compare both testes
  - Rarely cystic (10%)
- MR
  - Hypointense on T2

- Multiple histologic patterns(Mixed GCTs)
  - Yolk Sac, teratoma, embryonal, choriocarcinoma
- U/S
  - Heterogeneous echotexture
  - Cystic
  - Echogenic foci (Ca++,fibrosis, hemorrhage)

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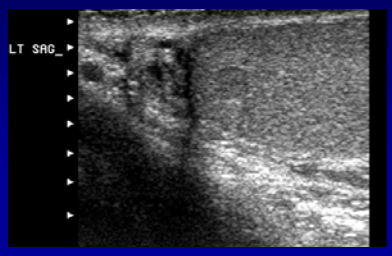
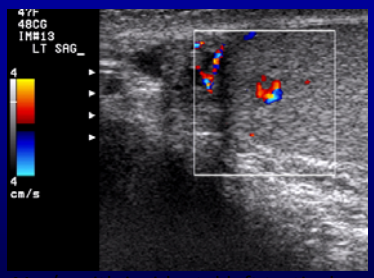
Leydig Cell Tumor

- Most common Sex Cord/Stromal Tumor
  - ~90% Benign – although no radiological criteria allows for differentiation of benignity
- Occur in any age group
- 30% have endocrinopathy
- U/S appearance-variable
  - Indistinguishable with that of germ cell tumor
- Sertoli Cell Tumor-less common
  - Subtype-large cell calcifying Sertoli tumor, bilateral



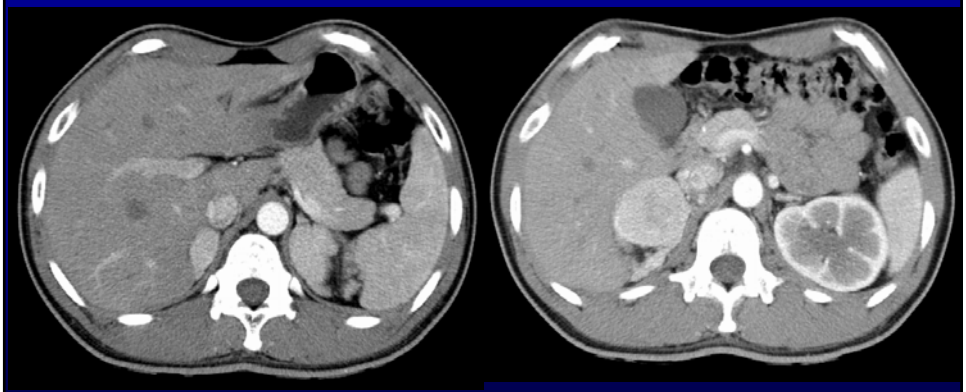


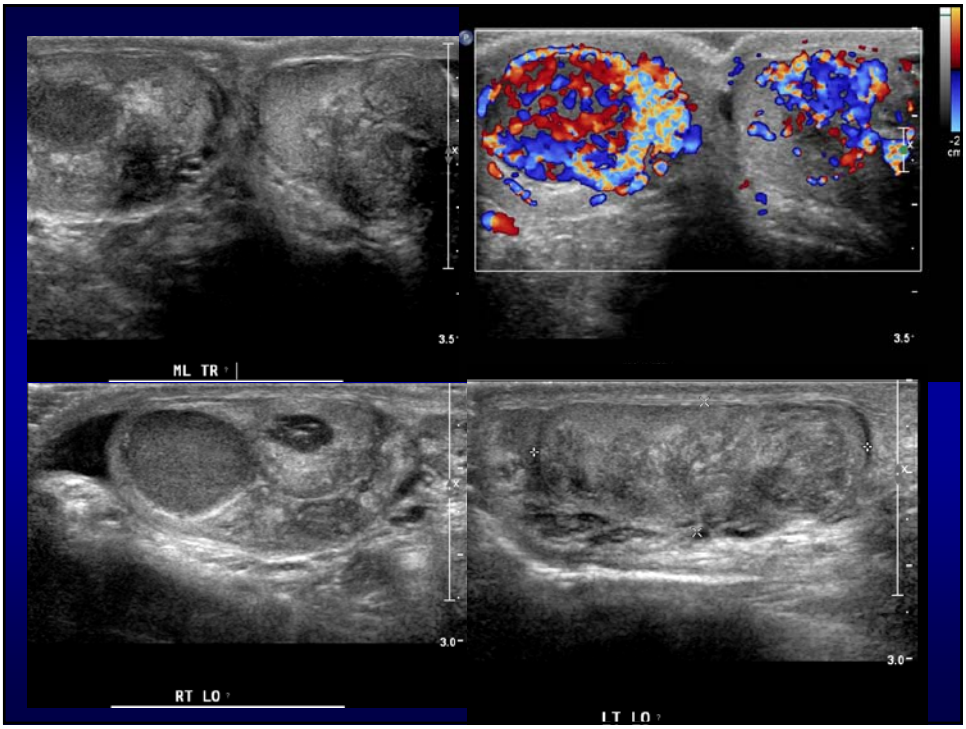
41 y/o with incidental left testicular mass found on US

Lymphoma

28 y/o with progressive bilateral lower extremity weakness

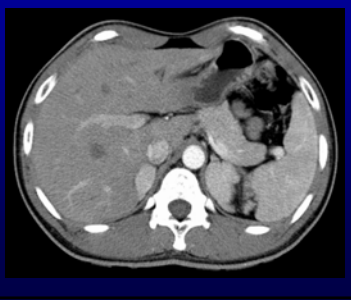
20 yo male with incidental bilateral adrenal masses. Clinician ordered scrotal ultrasound due to abnormal lab findings.



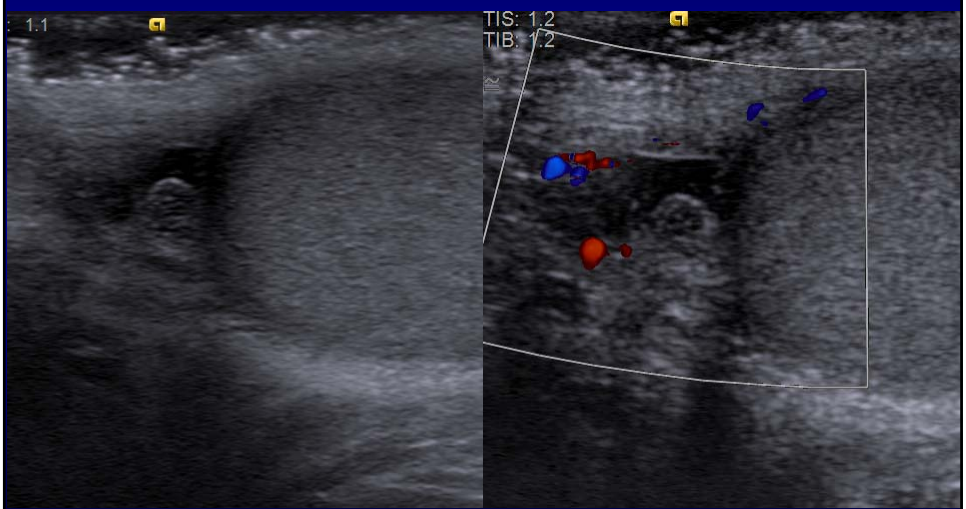


Congenital nodular adrenal hyperplasia associated with testicular adrenal rest tumors

- Congenital adrenal hyperplasia caused by inherent deficiency of adrenocortical enzyme (21-hydroxylase)
- Increased corticotropin levels prevent involution of aberrant adrenal cortical cells that migrate in gonadal tissue in fetal life. This ectopic tissue may develop into adrenal rest tumors



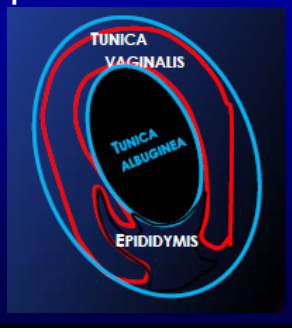
Acute pain, ? Diagnosis



Testicular appendiceal torsion

SCROTAL WALL

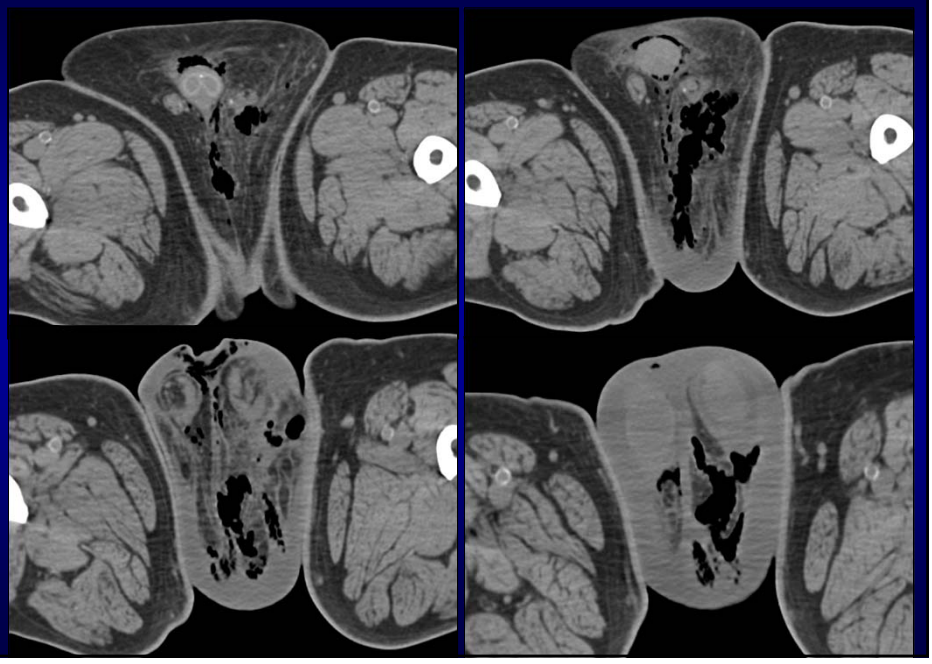
- Skin, superficial fascia, dartos muscle
- External spermatic, cremasteric and internal spermatic fascia
- Tunica vaginalis (visceral and parietal layers)
- Wall thickness: 2-8 mm



Scrotal Wall Thickening

- Inflammatory
  - Cellulitis
  - Fournier's gangrene
- Noninflammatory scrotal edema
  - Heart failure
  - Idiopathic lymphedema
  - Liver failure
  - Lymphatic and venous obstruction
- Malignant lesions
  - Primary solid neoplasms are rare
  - Mets from melanoma, anal carcinoma, and lung carcinoma

43 yo male, scrotal swelling



Fournier's Gangrene

- Jean Alfred Fournier (1832-1914) French dermatologist
- Rapidly progressive necrotizing fasciitis of the perineum
- Risk factors include diabetes, alcoholism, immunodeficiency
- Urologic emergency
- Radiographic hallmark is soft tissue gas

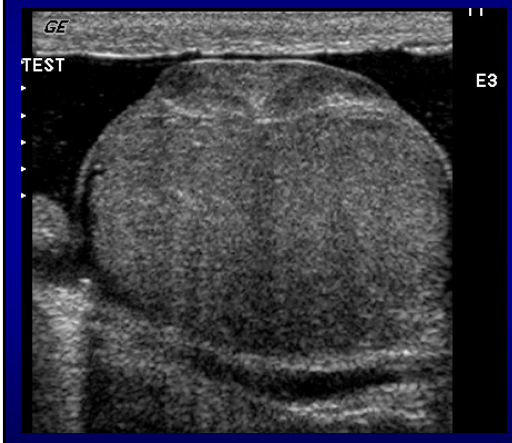
Scrotal Space masses

- Hydrocele, pyocele, hematocele
- Hernia
- Fibrous pseudotumor
- Scrotolith (scrotal pearl)

Hematocele

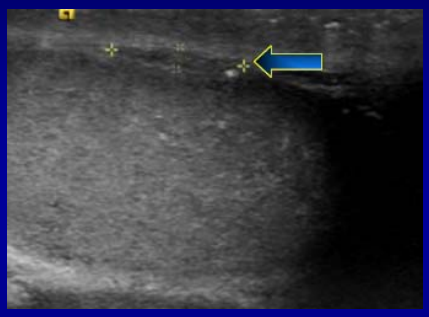
59 y/o who sat on right testicle with worsening testicular pain

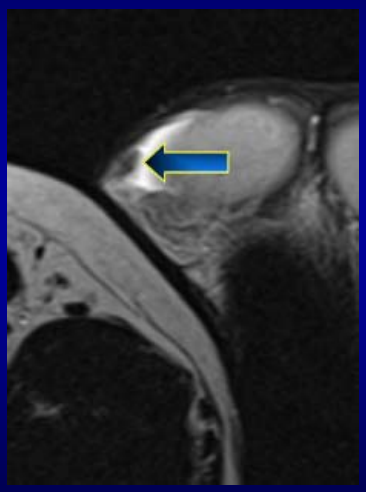
Fibrous Pseudotumor



- Benign fibroinflammatory reaction
- Reactive fibrous proliferation
- Mass or plaque-like process of the testicular capsule
- Involves the tunica vaginalis or albuginea
- U/S - variable appearance
- MRI can be useful
  - Low T1, low T2 & no enhancement

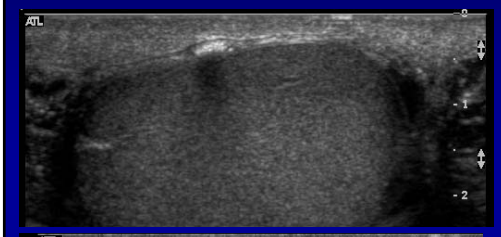
Fibrous Pseudotumor





- MRI
- Attached to Capsule
- Solid mass
- Fibrous=hypointense on T2

Scrotal Pearl

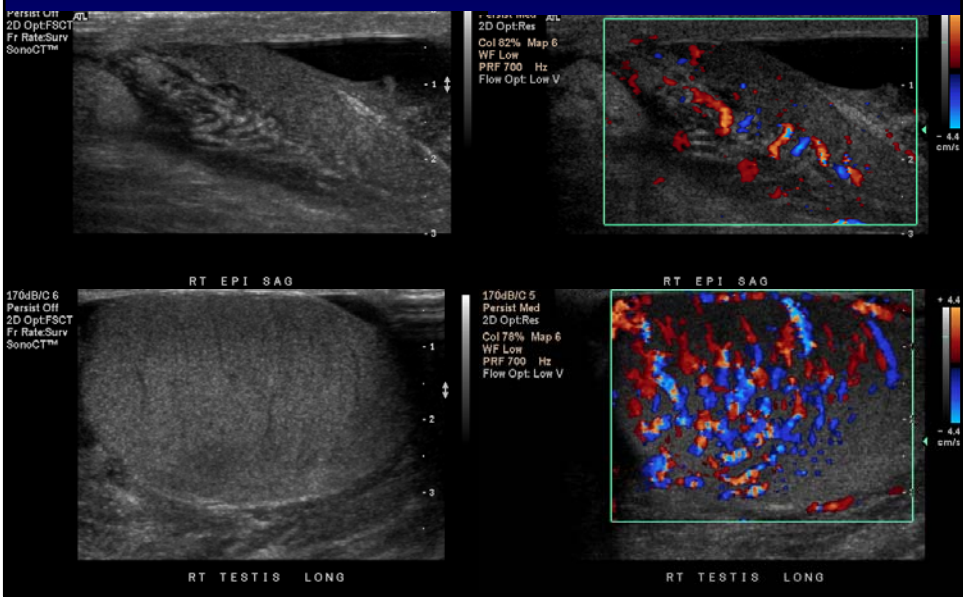


- Scrotolith/Scrotal Calculi
- Result of trauma, torsion of appendix of testis/epididymis or inflammatory deposits
- Microtrauma:
  - Mountain bikers(81%)
- Free-floating Ca within tunica vaginalis

EPIDIDYMIS

- Inflammatory- Epididymitis (acute/chronic, granulomatous infection)
- Cysts/spermatocele
- Sperm granuloma
- Tumors (Rare)
  - Adenomatoid (Benign)
  - Papillary cystadenoma associated with VHL
  - Leiomyoma, lipoma, rhabdomyoma/sarcoma, lymphoma and lymphangioma

Epididymo-orchitis



Epididymo-orchitis: US Findings

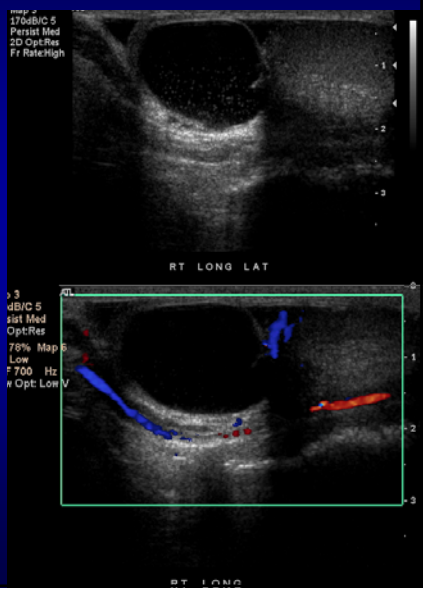
- Enlarged heterogeneous epididymis
  - Reactive hydrocele and scrotal thickening
- Testicular enlargement and heterogeneous echotexture, initially involves tail
- Color/Power Doppler - Hyperemic
  - High flow, Low resistance
  - PSV threshold >15 cm/s has a diagnostic accuracy of 90% for orchitis and 93% for epididymitis
  - Reversal of diastolic flow is suggestive of venous infarction

Epididymo-orchitis

- Most common cause of acute scrotum - STD's
- Chronic-Can be mass-like with persistent pain
  - Seen with granulomatous diseases-TB, sarcoid
- Infection - Believed to direct extension of pathogens retrograde
- 20% extend and cause associated orchitis

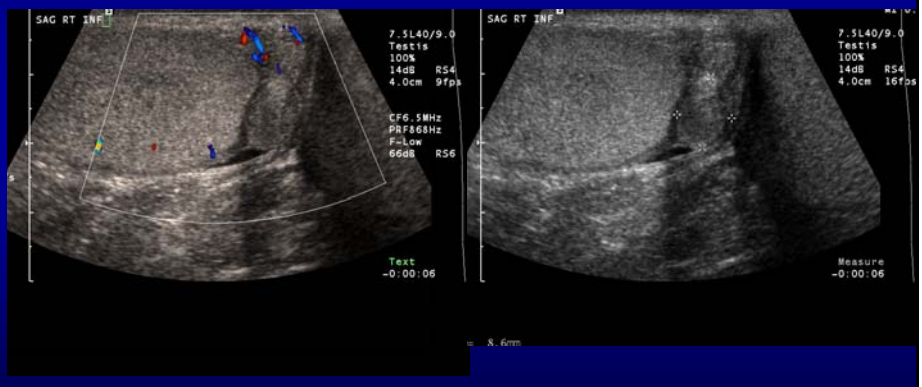
Epididymal Cyst

- Common
- Usually unilocular anechoic cyst
- DDX spermatocele
- Clinically not important



58 y/o with firm mass near right testicle

History of previous vasectomy Diagnosis?



Sperm Granuloma

- Epididymitis nodosa
- Occur most commonly post-vasectomy: 42% - Autopsy series
- Foreign body reaction from extravasated sperms
- U/S: Well demarcated hypoechoic intraepididymal lesion
- Other Post Vasectomy changes: spermatocele

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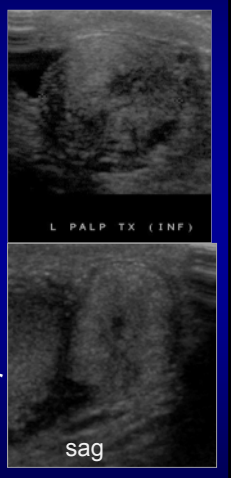
Adenomatoid Tumor

- Most common tumor of the epididymis (Benign)
  - One-third of all paratesticular neoplasms
- Men - 20yrs and older(20-50yrs)
- Predominantly epididymal tail (4x more frequently) - few mm to 5cm
  - Also seen tunica albuginea and spermatic cord
- Variable U/S appearance
  - Majority are isoechoic relative to testicular parenchyma
- Indistinguishable from testicular neoplasm (location)

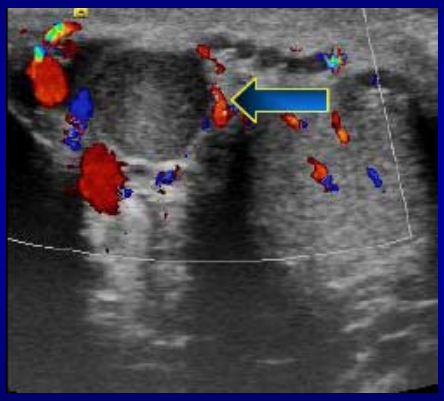


30 year old with palpable mass

Lipoma

- Nonspecific
- Homogeneous hyperechoic
- Confirm with CT or MRI

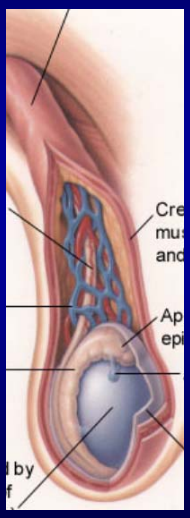
Leiomyoma



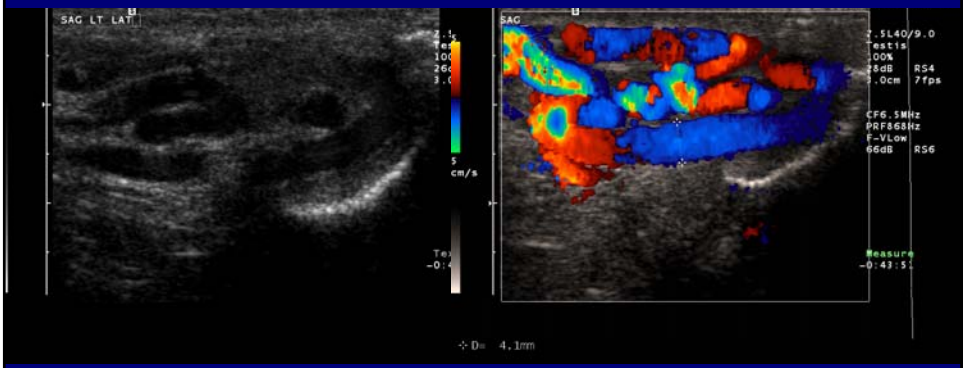
- Nonspecific
- Solid or cystic
- +/- Ca ++

SPERMATIC CORD

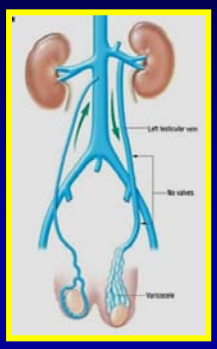
- ***Spermatic Cord***
  - Vas deferens, testicular ,deferential and cremasteric arteries
  - Pampiniform plexus, lymphatics , nerves
- ***Varicocele***
- ***Tumors***
  - Most benign tumors are lipomas
  - 25% are malignant.
    - Rhabdomyosarcomas (Pediatric age group)
    - Leiomyomas and leiomyosarcomas
    - Others include liposarcomas, fibrosarcomas, myxochondrosarcomas, and MFH



Varicocele



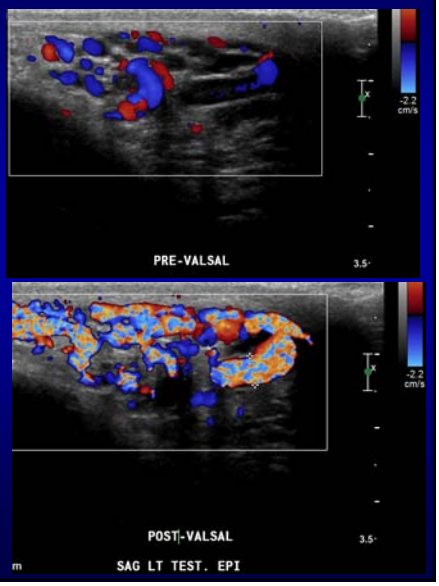
Varicocele



- Abnormal dilatation of the veins of the spermatic cord.
- Caused by incompetent valves in the internal spermatic veins.
- Impaired drainage of blood in upright and during Valsalva.
- US size > 3 mm
- More common on the left – left testicular vein is longer, enters the left renal vein at a right angle, can arch over the vein compressing it, and may be compressed by a distended descending colon .
- Noncompressible varicocele or unilateral right sided varicocele should prompt evaluation of retroperitoneal mass or left renal vein

Varicocle and infertility

- Relationship with infertility is controversial
- 1/3 men with infertility have varicocele on US
- Only 60% have palpable varicocele
- Treatment improves sperm quality in 53%



Prostate

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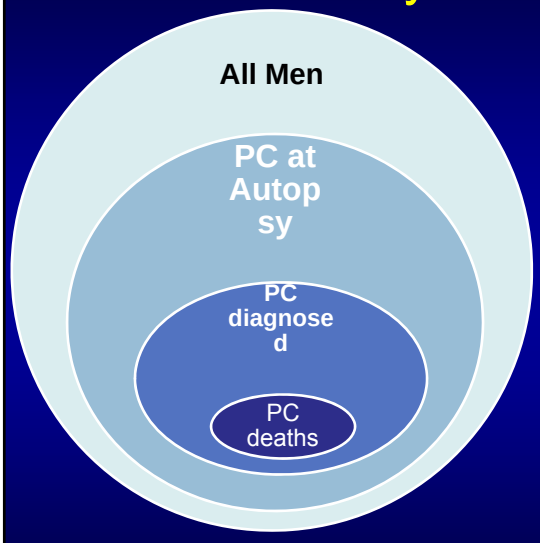
Natural History of Prostate Cancer



- Poorly understood
- Multifocal, heterogeneous.
- Low grade tumor-> indolent
- High grade tumor-> rapidly progress

Damber JE, Lancet 2008

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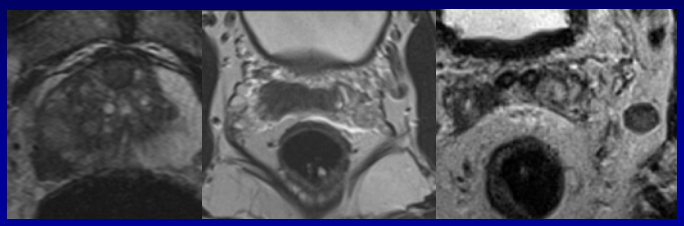
Limitation of Prostate Cancer Screening

- Prostate cancer is the only malignancy that is diagnosed using a non-specific screening test that precipitates a random tissue sampling of the organ
- The overwhelming majority of prostate cancers are not lethal cancers.
- Therefore, the non-specific screening test and random biopsy technique risks the detection and treatment of indolent cancers and failure to detect clinically significant cancers.
- Need a better screening tool.
- Negative predictive value of mpMRI for “clinically significant” disease almost 100%
  - Do not need to biopsy most men with negative mpMRI

Definition of Clinically Significant Prostate Cancer

- A clinically significant cancer is one that if untreated would cause significant morbidity and mortality.
- The clinical significance of a prostate cancer is dependent on the life expectancy of the individual and the propensity of the cancer to metastasize.
- Clinical significance
  - Tumor volume
  - Tumor grade
  - Serum PSA level
- European Consensus of clinical significant disease
  - Any lesion > 0.5 cc (10 mm diameter)
  - Gleason > 6

Current Status of Prostate MRI

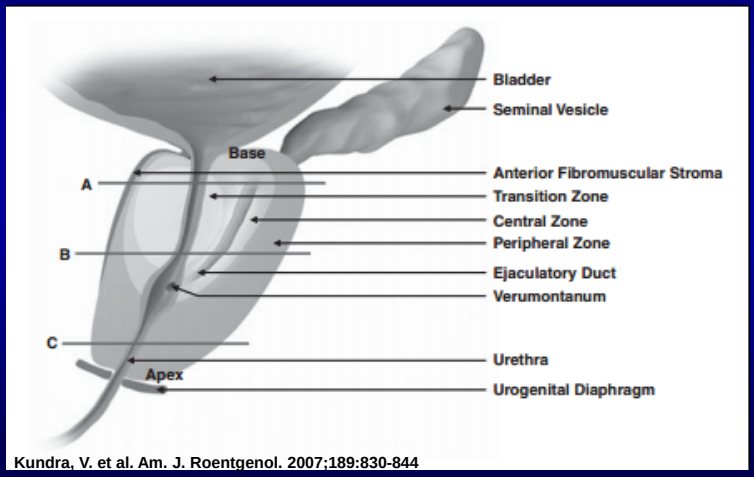


- Significant improvements in ability to localize dominant tumors in the prostate using MRI, related to:
  - Hardware optimization
  - Advances in radiologic-pathologic correlations
  - Evolution of multi-parametric imaging techniques

Current Status of Prostate MRI

- Traditionally, MRI is performed predominantly for local staging
- Ordered in limited subsets of patients with intermediate risk for locally advanced disease
- **Tumor localization** is currently the most compelling clinical role of multi-parametric MRI in daily practice

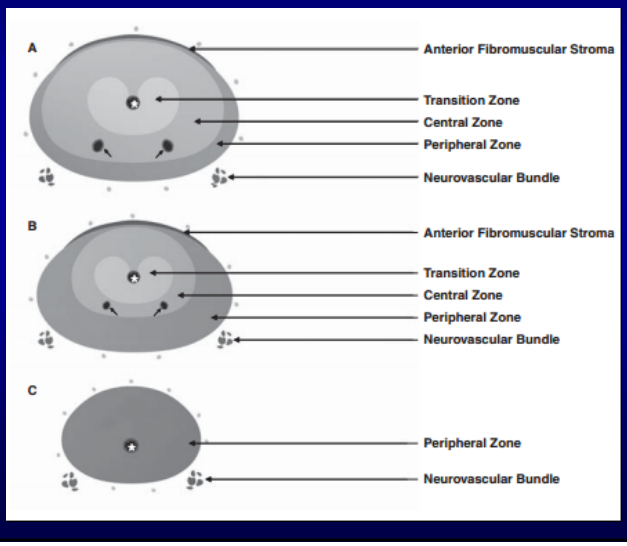
Anatomy



Kundra, V. et al. Am. J. Roentgenol. 2007;189:830-844

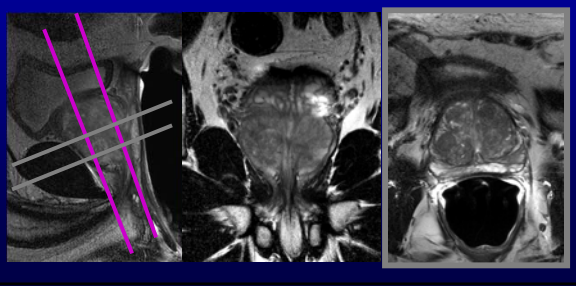
Anatomy

Central gland = central zone + Transition zone

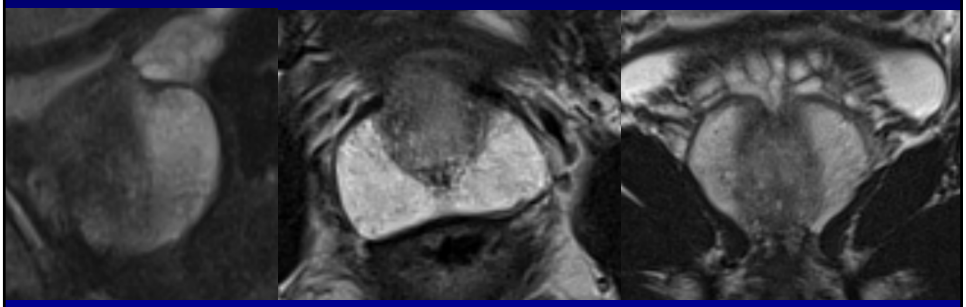


T2WI

- Anatomic sequence reflecting water content of tissues
- "Work-house sequence" of prostate MRI
  - Performed in 3 separate plants through prostate



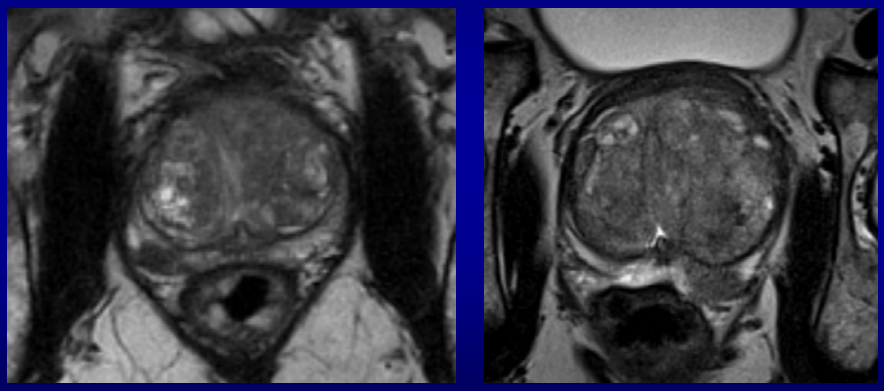
T2WI: Anatomy



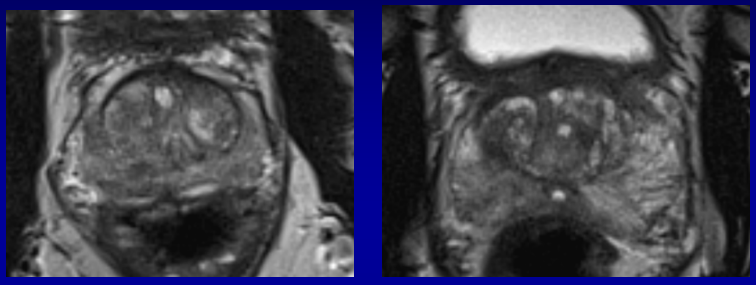
Sag T2 Ax T2 Cor T2

- Peripheral zone (PZ): high T2 signal
- Transition zone (TZ): heterogeneous low T2 signal; BPH nodules

Tumor on T2WI



Limitation of T2WI Alone



- Often, heterogeneous PZ on T2WI
- Numerous benign causes of decreased T2 signal:
  - Inflammation
  - Atrophy
  - Hemorrhage
  - post-treatment change

Multi-parametric Approach

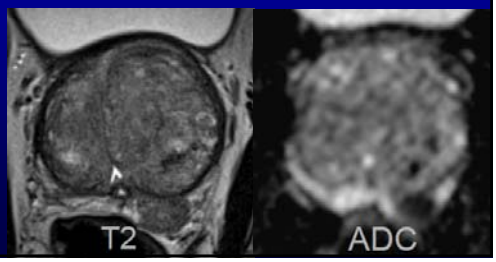
- Term generally refers to combination of T2WI and at least two “functional” sequences
- Generally accepted that combination of parameters achieves significantly improved accuracy compared with T2WI along

DWI

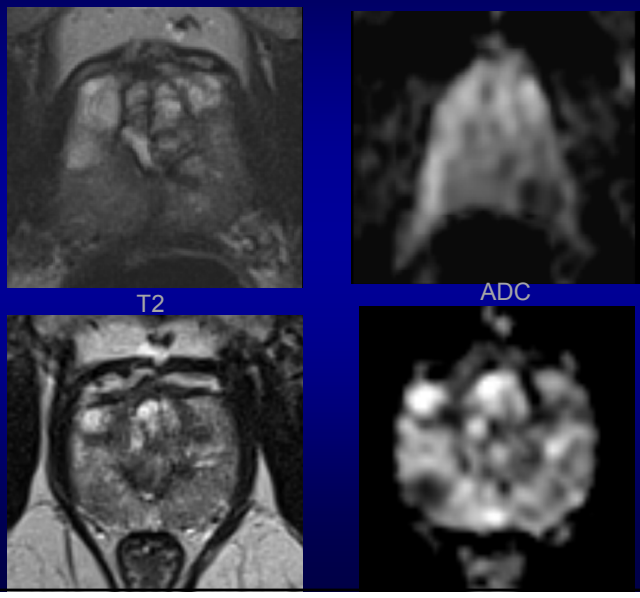
- Non-contrast techniques that can be easily performed using modern equipment
- Reflects tissue cellularity
  - Increased in setting of neoplasia
- Considered to be an essential sequence for tumor localization and characterization
- Typical maximal b-value of 800-1000 sec/mm^2 in much of literature

DWI

- Automatic reconstruction by scanner of "apparent diffusion coefficient" (ADC) map
- Tumor foci dark on ADC map
  - Decreased ADC due to greater cellularity
- Improved accuracy by combining T2WI and ADC maps



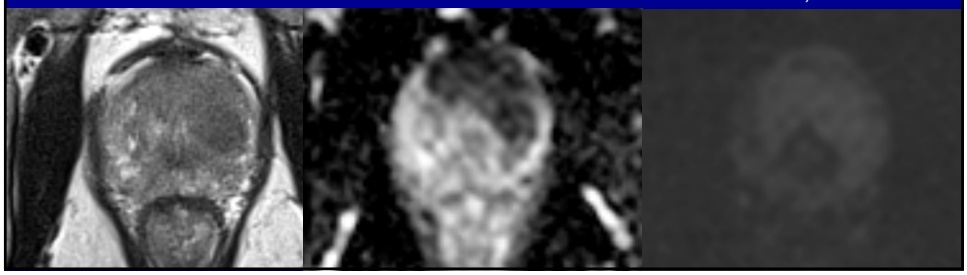
Added Value of ADC Maps



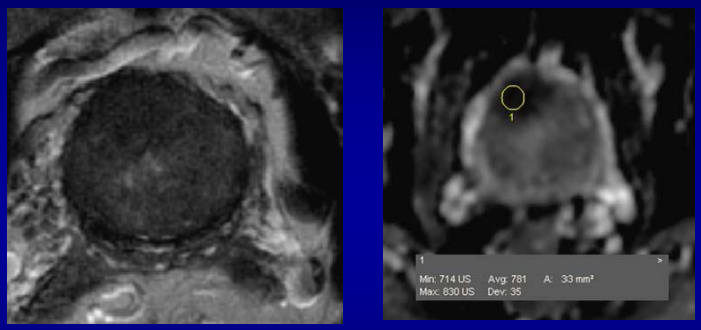
ADC Map Vs. High b-value Image

- Tumor visibility is greater on ADC map than on trace DWI images
- Due to persistent high signal within the normal PZ on high b-value DWI
- T2 80.3% (106/132), b500 26.5% (35/132) b1000 46.2% (61/132), ADC map 62.1 %(82/132)

Rosenkrantz AB. AJR 2011;196:123-129



ADC as Marker of Tumor Aggressiveness



- Significant correlation of ADC values with Gleason score of tumor in numerous publications

Woodfield CA, et al. AJR, 2010
Park SU, et al. Eur Rad, 2010
Van AS NJ, et al. Eur Urol, 2009

DCE: Perfusion Imaging

- Rapid acquisitions after contrast injection
- High Temporal resolution
  - Approximately 5 sec or less
- Lower spatial resolution than T2WI
- Variable acquisition duration

  ≥ 5 minutes to detect delayed washout from tumors

DCE

- Visual analysis of raw post-contrast images can be difficult
- Benign vs. malignant distinguished by difference in enhancement kinetics
- Commercially available software to integrate generation of parametric perfusion maps into clinical workflow
  - Semi-quantitative (wash-in and wash-out rates)
  - Quantitative Tofts model (k_{trans}, V_e)

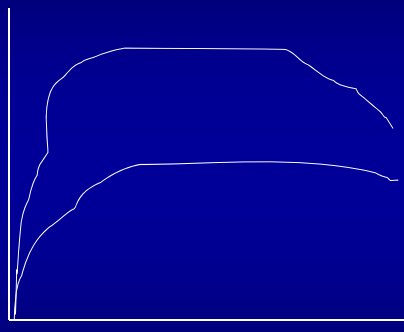
DCE

- MRI can measure
  - tissue perfusion and blood volume (T2* methods)
  - permeability (K trans)
  - extracellular leakage space (T1 method) – ***currently used***
- Prostate cancer shows faster and brighter than normal peripheral zone tissue

Jager et al. 1997 Radiology

DCE

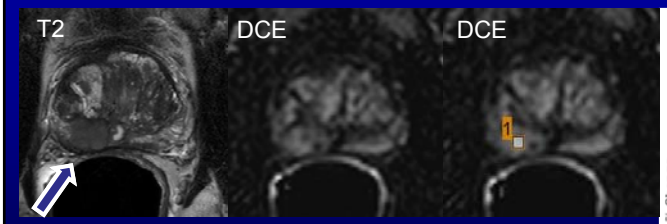
Early enhancement with early wash-out

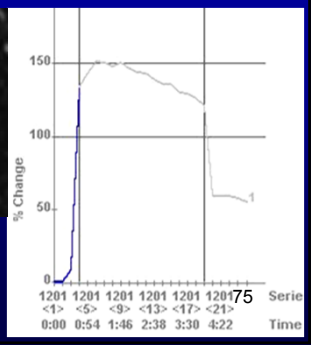


From USCF

DCE Clinical Utility

- Cancer-> **Rapid enhancement with washout**
- Time-intensity (TI) curve is useful since it provides additional diagnostic confidence and kinetic information.





This T2 low signal lesion is not conspicuous on DCE images, but TI curve clearly demonstrates rapid enhancement with washout, consistent with prostate cancer kinetic.

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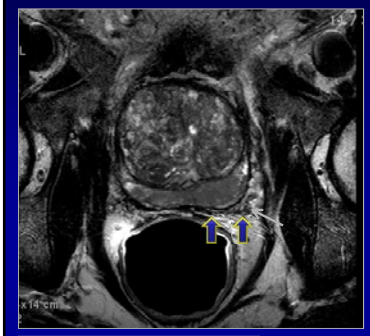
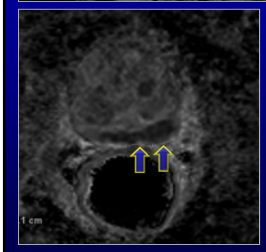
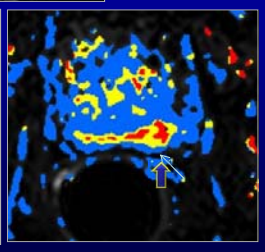
DCE Clinical Utility



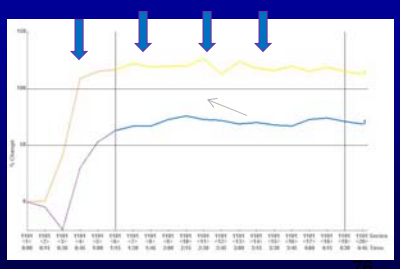
Classical PZ cancer with T2 hypointensity.



Low ADC



Early arterial enhancement



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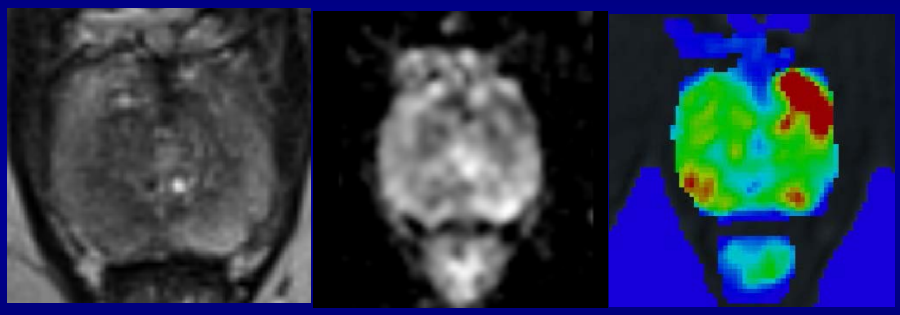
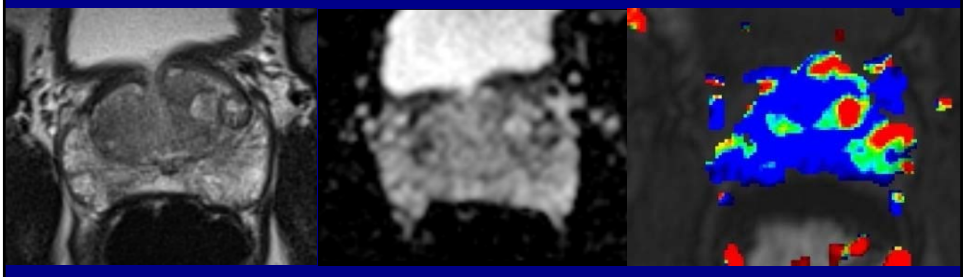
DCE Clinical Utility



T2 ADC Perfusion

DCE: False Positive



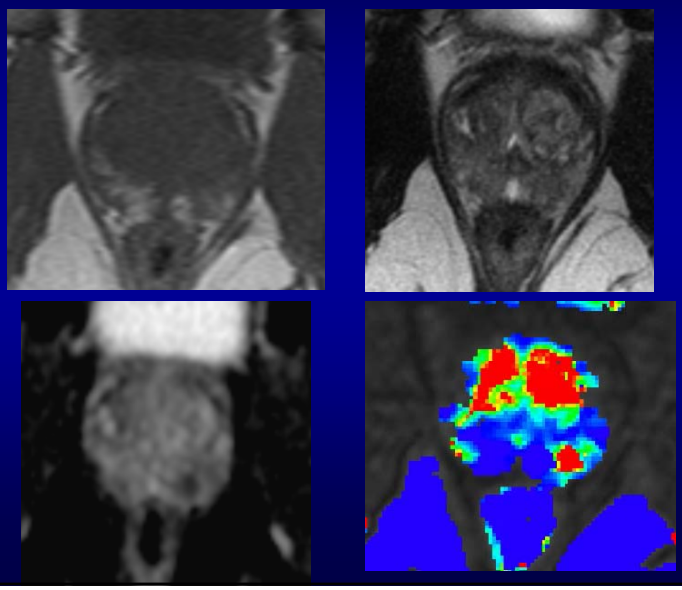
T2 ADC Perfusion

-BPH nodules
-Be cautious of abnormalities identified only on DCE:
May be inflammatory in nature

T1WI

- Depicts hemorrhage from prior biopsy
  - Increased signal on T1WI in PZ
  - Improves slowly with time since prior biopsy
- Recommendation for ≥8 week delay after biopsy for hemorrhage to resolve
  - Hemorrhage can persist despite lengthy delay
- Although more challenging, still possible to render interpretation in setting of hemorrhage:
  - Use of functional sequences
  - Dominant tumors spared from hemorrhage

Post-Biopsy Hemorrhage

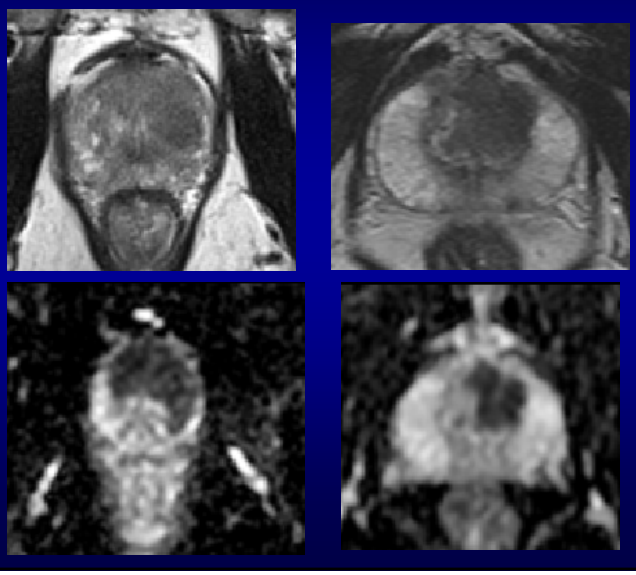


Transition Zone Tumors

- Traditionally considered difficult to identify on MRI
  - Masked by BPH nodules in TZ
- Morphology is critical
  - May be best assessed on T2WI
  - Homogeneous
  - Lack discrete margins
  - Elliptical shape
- Lower ADC than other BPH nodules
- Enhancement patterns overlap BPH

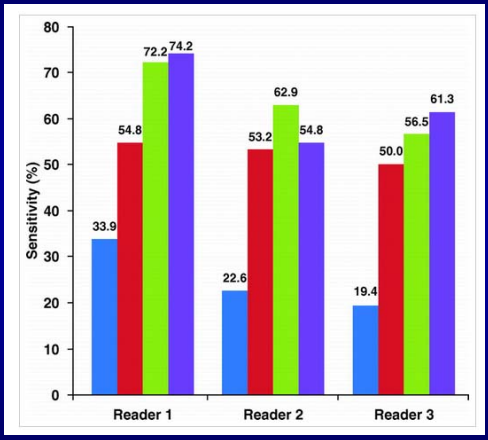
Oto A, et al. Radiology 2006, 2010

Transition Zone Tumors



Transition Zone Tumors

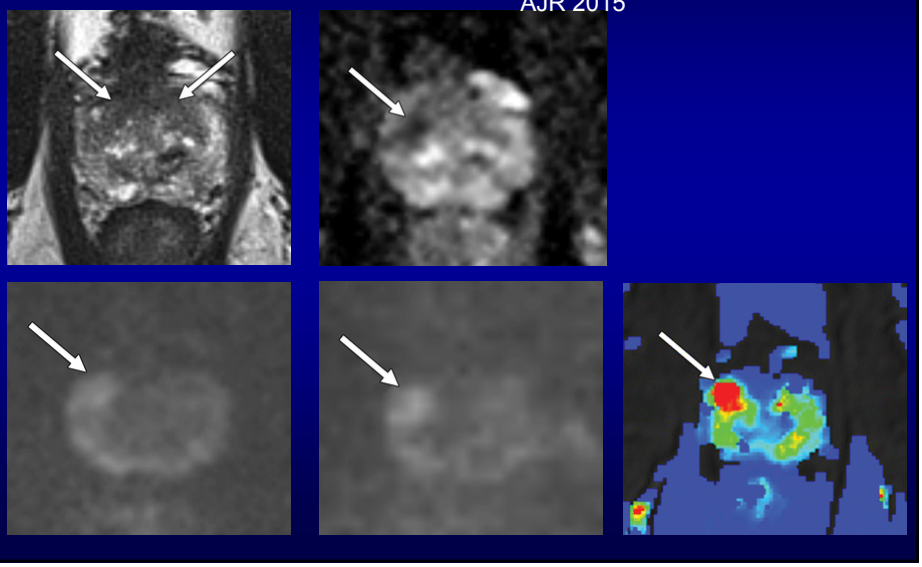
Rosenkrantz AB, et al. AJR 2015



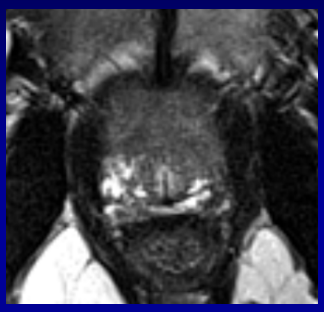
Blue: T2WI alone
Red: T2WI plus ADC and b1000
Green: T2WI plus ADC and b1000 plus b2000
Purple: T2WI plus ADC and b1000 plus b2000 plus DCE

Transition Zone Tumors

Images from Rosenkrantz AB, et al. AJR 2015



Evasive Anterior Tumor

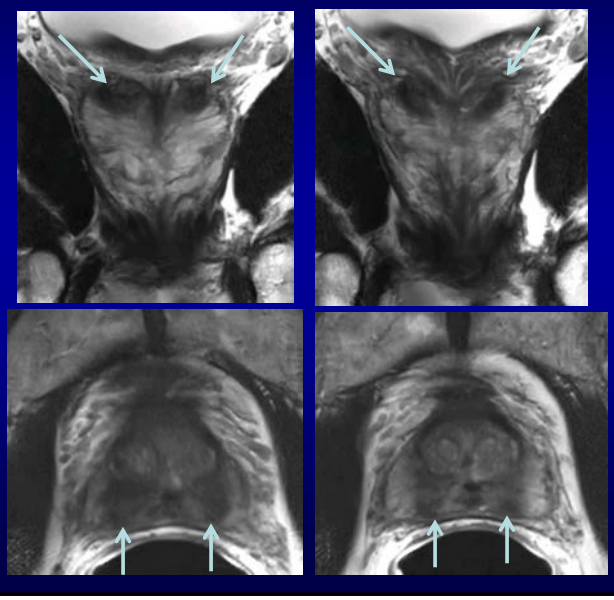


- 65 year old male with PSA 18
- 6 previous negative prostate biopsies
- MRI: equivocal lesion in distal apical TZ
- Targeted biopsy using MRI/ultrasound fusion software: Gleason 3+4 tumor in 100% of 1 core

Diagnostic Pitfalls to Review

- Normal Central zone mimicking tumor
- Peri-prostatic vessel mimicking tumor
- Neurovascular bundle mimicking tumor
- Use of ultra high b-vlue DWI to better detect tumor
- Optimal windowing of ADC map to better detect tumor
- Optimization of DWI acquisition to better detect tumor

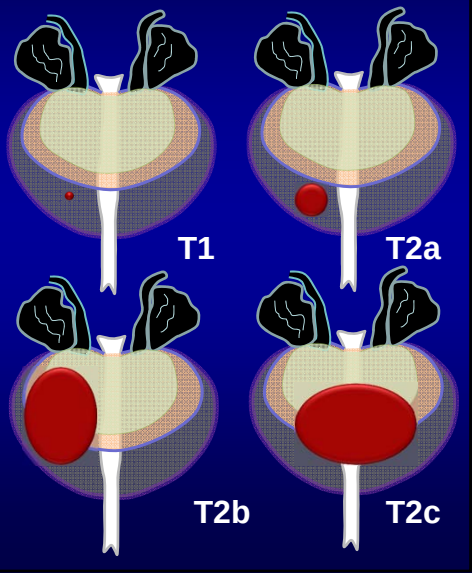
Pitfall: Central Zone



TNM staging

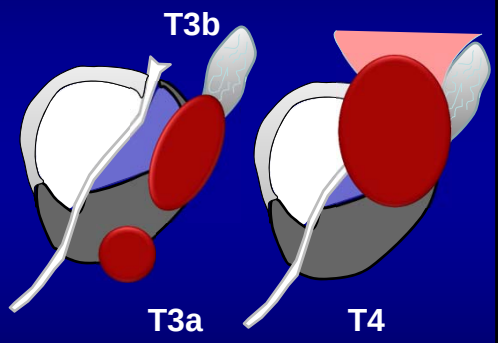
T Staging

- **TX** - Primary tumor cannot be assessed
- **T0** - No evidence of primary tumor
- **T1** - Clinically inapparent tumor not palpable or visible by imaging
- **T2** - Tumor confined within prostate
  - T2a - Tumor involving less than half a lobe
  - T2b - Tumor involving less than or equal to half a lobe
  - T2c - Tumor involving both lobes



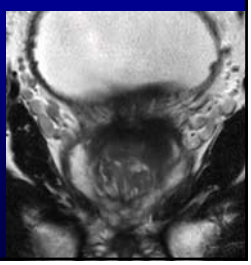
T Staging

- **T3** - Tumor extending through the prostatic capsule
  - T3a - Extracapsular extension
  - T3b - Tumor invading seminal vesicle(s)
- **T4** - Tumor fixed or invading adjacent structures other than seminal vesicles.



Extracapsular Extension

- MR findings (>90% specific)
  - Asymmetry of neurovascular bundle
  - Blunting of the rectoprostatic angle
  - Direct tumor extension outside of capsule
  - Focal bulging, focal capsular thickening, irregular bulge are not specific.
- Axial plane: KEY plane!!
- Sagittal and coronal planes: adjunctive tools: helpful for seminal vesicle invasion, superior extension



Summary

- Ultrasound is the best imaging modality in the evaluation of scrotal disease
- Imaging findings of common scrotal disease reviewed
- Current role of multi-parametric Prostate MRI: in addition to local staging, MRI improves detection and localization of clinically significant tumors in the prostate

Thank you!

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