42nd Annual
Post Graduate Radiology Course

Hotel Del Coronado • Coronado, California

Friday, October 20, 2017
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**SAVE THE DATE** - 2018 Fall Symposia
Bloody Mess: Evaluation of Hematuria in the ER Patient

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Bloody Mess: Evaluation of Hematuria in the ER Patient

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Hematuria is defined as the presence of red blood cells in the urine. When visible to the patient, it is termed gross hematuria and is usually alarming to patients. Microscopic hematuria is that detected by the dipstick method or microscopic examination of the urinary sediment.

American Urologic Association

Microscopic Hematuria

The recommended definition of microscopic hematuria is three or more red blood cells per high-power field on microscopic evaluation of urinary sediment from two of three properly collected urinalysis specimens.

Microscopic vs Macroscopic Hematuria

In patients with microscopic hematuria neoplasm is uncommon and in the largest study upper urinary tract TCC was found in 0.2%, RCC in 1% and bladder cancer in 3.7% (exact frequency depends on age of population studied).

In patients with macroscopic hematuria the risk for malignancy is high and can be found in 10-28% of cases overall and in up to 10% of patients younger than 40 years of age (exact frequency depends on age of population studied).

“In men aged >60 years, the positive predictive value of macroscopic haematuria for urological malignancy is 22.1%, and in women of the same age it is 8.3%. In terms of the need for follow-up investigation, a single episode of haematuria is equally important as recurrent episodes.”

Management of macroscopic haematuria in the emergency department
Hicks D, Li CY

Differential diagnoses in macroscopic haematuria

- Urinary tract malignancy: kidney, renal pelvis, ureter, bladder, prostate, urethra
- Urinary calculi
- Infections: urinary tract infection, schistosomiasis
- Trauma: penetrating or blunt
- Benign prostatic hyperplasia
- Haemorrhagic cystitis
- Endometriosis
- Nephrological disease: IgA nephropathy, glomerulonephritis
- Postprocedural bleeding—for example, transurethral surgery
- Bleeding disorders, anticoagulation therapy above therapeutic range
- Arteriovenous malformation angiomyolipoma
The most common diagnoses were renal colic (119/584, 20.4%) and intestinal obstruction (80/584, 13.7%). CT altered the leading diagnosis in 49% of the patients (284/584) and increased mean physician diagnostic certainty from 70.5% to 92.2%. The management plan was changed by CT in 42% (244/583). Surgery was planned for 79 patients before CT, whereas hospital discharge was planned for 25.3% of these patients (20/79) after CT.

Abdominopelvic CT Increases Diagnostic Certainty and Guides Management Decisions: A Prospective Investigation of 584 Patients in a Large Academic Center
Abujudeh HH, Thrall JH et al
AJR 2011; 196:238-243

"The worldwide prevalence and incidence of urolithiasis have been increasing, with the number of new cases having nearly doubled in the United States over the past 3 decades. Acute urolithiasis is diagnosed in about 1% of all yearly ambulatory care visits in both U.S. and European emergency departments." Can Unenhanced CT Findings Predict Interventional Versus Conservative Treatment in Acute Renal Colic? Lotan E et al. AJR 2016; 207:1016–1021

"The lifetime risk for a urinary calculus disease is 12% for men and 6% for women. Risk factors include a personal or family history of stones, urinary tract anatomic abnormality, obesity, and metabolic disorders. The incidence for stone disease is highest in warm regions and during the summer months because of an increased rate of dehydration." Acute Urinary Tract Disorders Gool RH, Unnikrishnan R, Remer EM Radiol Clin N Am 53 (2015) 1273–1292

Nephrolithiasis: What does the referring clinician need to know?
- Presence or absence of calculus
- Location of calculus (kidney, ureter, bladder)
- Number of stones
- Stone diameter
- Presence of additional findings (i.e. acute pyelonephritis)

Nephrolithiasis: What Surgeons Need to Know
Eisner BH et al. AJR 2011; 196:1274-1278

"Not only does this study enable the detection of stones of all sizes, but in its area of examination from above the kidneys to below the bladder base, it enables the evaluation of other urinary and extraurinary abnormalities that may be contributing to symptoms of acute flank pain."

Nephrolithiasis: What Surgeons Need to Know
Eisner BH et al. AJR 2011; 196:1274-1278
"The American Urological Association and the American College of Radiology (ACR) recommend low-dose (for body mass index [BMI] <30) noncontrast CT for the initial presentation of flank pain."

Acute Urinary Tract Disorders
Goel RH, Unnikrishnan R, Remer EM

When will a stone pass?
- Passage of a ureteral calculus depends on size and location, with a spontaneous passage rate of 48% for proximal versus 75% for distal ureteral calculi and 76%, 60%, 48%, and 25% for 2 to 4, 5 to 7, 7 to 9, and greater than 9 mm diameter, respectively.

Acute Urinary Tract Disorders
Goel RH, Unnikrishnan R, Remer EM

"ROC curves that were constructed for stone size and attenuation revealed that stones larger than 6.5 mm and stones with an attenuation value greater than 1100 HU were more likely to require interventional treatment, with an AUC of 0.74 and 0.68, respectively."

Can Unenhanced CT Findings Predict Interventional Versus Conservative Treatment in Acute Renal Colic?
Lotan E et al.
AJR 2016; 207:1016–1021

"Our results showed that larger stone size, higher density, and proximal location are significantly associated with the selection of interventional over conservative management for patients with acute renal colic. Complaints of shivering, fever, and leukocytosis also strongly correlate with the selection for interventional treatment. Other clinical and radiologic information may be useful as supportive findings, but they were not predictive for the purposes of choosing suitable patient management."

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Can renal calculi be missed on CT?
- 98 percent of stones can be detected ranging from calcium based stones to radiolucent stones like uric acid, xanthine, or cystine.
- The one percent of stones that can be missed are pure matrix stones or stones composed of protease inhibitor, indinavir.
Stone in Ureter

Renal Cell Carcinoma: Presentation
- Hematuria (40%)
- Flank pain (40%)
- Palpable mass in flank or abdomen (25%)
- Weight loss (33%)
- Fever (20%)
- Hypercalcemia (5%)

“In current practice, most renal masses are discovered serendipitously. As the size of these newly discovered renal lesions decreases, the proportion of benign lesions increases. However, while great strides have been made in lesion detection, lesion characterization has lagged.”

Simplified Imaging Approach for Evaluation of the Solid Renal Mass in Adults
Dyer R et al.
Radiology 2008;247:331-343

Functional MDCT Imaging of the Kidneys
- corticomedullary phase (25-45 seconds)
- parenchymal or nephrographic phase (60-90 seconds)
- excretory phase (240-300 seconds)

Corticomedullary Phase
- typically between 20-45 seconds after injection
- cortex is maximally enhanced (147 +/- 41HU)
- medulla enhancement is low (56 +/- 25HU)

Corticomedullary Phase (25-50sec) : Optimal Phase For Detection of
- Evaluate arterial structures
- Preoperative planning for nephron sparing surgery
- Define tumor vascularity
- Changes in perfusion
- Tumor detection

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Renal Cell Carcinoma Invades the Renal Veins and IVC

In the corticomedullary phase, attenuation values of renal clear cell carcinoma were significantly higher than those of renal papillary carcinoma. The accuracy was 95.7%; the sensitivity 98.3% and the specificity, 92% when using 100HU as the cutoff value.

Differentiation of Renal Clear Cell Carcinoma and Renal Papillary Carcinoma Using Quantitative CT Enhancement Parameters
Ruppert-Kohlmayr AJ et al.
AJR 2004; 183:1387-1391

Papillary Renal Cell Carcinoma: Facts
- Small
- Low stage and low grade tumors
- Usually hypovascular
- May be multifocal or bilateral
- Better prognosis than other RCC’s
- Ideal for nephron sparing surgery
Papillary renal cell carcinomas are typically hypovascular and homogeneous. A high tumor to parenchyma enhancement ratio (≥ 25%) essentially excludes the possibility of a tumor being a papillary renal cell carcinoma. A low tumor-to-aorta enhancement ratio or tumor to normal renal parenchymal enhancement ratio is more likely to indicate papillary renal cell carcinoma.

Enhancement Characteristics of Papillary Renal Neoplasms Revealed on Triphasic Helical CT of the Kidneys
Herts BR et al. 
AJR 2002; 178:367-378

CT Urography is essentially defined as a CT examination of the urinary tract before and after the administration of intravenous contrast material that includes excretory phase images.”

What is the Current Role of CT Urography and MR Urography in the Evaluation of the Urinary Tract
Silverman SS, Leyendecker JR, Amis Jr ES
Radiology 2009; 250:309-323

MDCT Urography: JHU Technique
- 1000 cc water 15-20 minutes prior to the study
- Inject 100-120 cc of Iohexol-350 at 4-5 cc/sec
- 5-8 minute delay
- Occasionally more delayed scans will be necessary in event of total obstruction
“Excretory phase CT with oral hydration opacified the calyx/infundibulum completely in 57% and nearly completely in 38%, opacified the renal pelvis completely in 94.5% and nearly completely in 3.5%.”

Opacification of the Collecting System and Ureters on Excretory-Phase CT Using Oral Water as Contrast Medium
Kawamoto S, Horton KM, Fishman EK
AJR 2006; 186:136-140

What are the advantage of a 4-5 minute delay for CT Urography?
- The contrast in the pelvis and collecting systems is not too “dense/bright” causing artifact on 3D images which limit analysis of the calyces
- In a busy practice saving 5 minutes a case can provide improved throughput adding 5-10 extra slots in a 10 hour shift on a single scanner depending on study mix

“Familiarity with the unusual radiologic features of urothelial cancer of the renal pelvicaliceal system will facilitate making the correct diagnosis as well as developing adequate treatment options.”
Urothelial Cancer of the Renal Pelvicaliceal System: Unusual Imaging Manifestations
Prando A et al.
RadioGraphics 2010; 30:1553-1566

Urothelial Cancers: facts
- Make up 10-15% of all renal tumors
- 90% are transitional cell carcinomas, 9% are squamous cell carcinoma and 1% are mucinous adenocarcinoma
- Average age is 6-7th decade of life
- Male to female ratio is 3-1
- 40% of patients with upper tract TCC will develop metachronous TCC of the lower urinary tract

Urothelial Cancers: CT Findings
- Single or multiple sessile filling defects that compress the renal sinus fat
- Pelvicaliceal irregularities (stricture like)
- Focal or diffuse mural thickening
- Caliceal amputation
- Tumor filled distended calices
CT of the Ureter: CT Findings

- Urothelial thickening is most common finding
- Urothelial enhancement
- Ureteral calcification
- Periureteral fat stranding
- Filling defect or mass
- Hydronephrosis and hydroureter
“In our experience, proper utilization of a 3D technique can be incredibly useful in the diagnosis of subtle tumors that are barely perceptible on the source axial images and that may be missed otherwise.”

MDCT Evaluation of Ureteral Tumors: Advantages of 3D Reconstruction and Volume Visualization
Raman SP, Horton KM, Fishman EK
AJR 2013; 201;1239-1247

TCC Proximal Ureter

Acute Pyelonephritis: Facts
- More common in woman
- Usually due to e.coli infection
- In most cases initial CT imaging is not necessary unless complications expected like in diabetic, elderly, or immunocompromised or have a history of stone disease and congenital GU abnormalities.

Acute Pyelonephritis- Clinical Presentation
- chills
- fever
- dysuria
- flank pain
- microscopic hematuria
- pyuria
- bacteriuria (usually E. coli)

CT Findings in Renal Infection
- alteration in renal contour
- alteration in parenchymal attenuation (decreased)
- alteration in contrast enhancement (decreased)
- decreased rate of contrast excretion
- perinephric abnormalities
Phase of Acquisition:
Non-Contrast CT

- Non-contrast CT will miss
- Small renal tumors especially when not changing renal contour
- Acute pyelonephritis
- Vascular pathology including AVM

Acute Pyelonephritis
Renal Abscess: CT Findings
- focal low density mass
- often cystic with thickened irregular walls
- thickening of Gerota’s fascia
- perinephric extension
- may be single or multiple
- usually unilateral in location

Renal Abscess Simulates a Cystic Renal Cell Carcinoma
Renal Abscess Simulates a Tumor

XGP with Staghorn Calculus
Xanthogranulomatous Pyelonephritis: Facts

- Chronic destructive granulomatous process
- Results from atypical incomplete immune response to a subacute bacterial infection
- Parenchyma replaced by lipid-laden macrophages
- Diabetes in only 10%
- F>M, more common in middle age
- 90% pyuria, 60% + cultures, hematuria 18%

Xanthogranulomatous Pyelonephritis: Facts

- Large staghorn calculus in most, but not all cases with contracted pelvis
- Extensive inflammatory process
- Decreased renal function
- Enlarged kidneys
- Severe hydronephrosis, expansion of calices
- Can be associated with extrarenal disease
- Psoas involvement

Presenting signs and symptoms included pain (66%), urinary frequency (66%), dysuria (66%), nocturia (66%), palpable mass (56%), leukocytosis (50%), and fever (50%). The duration of symptoms was usually relatively short (less than 6 months), considering the extent of the pathologic process.

CT of xanthogranulomatous pyelonephritis: radiologic-pathologic correlation.
Xanthogranulomatous Pyelonephritis

Emphysematous Pyelonephritis
- Life-threatening necrotizing infection of the kidneys characterized by gas formation within or surrounding the kidneys
- 90% of patients have poorly controlled diabetes
- Nondiabetic patients are typically immunosuppressed or have associated urinary tract obstruction
- Most common organisms: E.coli, Klebsiella pneumonia, Proteus mirabilis

Emphysematous Pyelonephritis
- CT is the modality of choice
- Parenchymal enlargement and destruction
- Small bubbly or linear streak of gas
- Fluid collections
- Air-fluid levels
- Tissue necrosis

Emphysematous Pyelo
Emphysematous Pyelo

Clinical Presentation: Hematuria

Renal AVM

Emphysematous Pyelonephritis

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Renal arteriovenous malformations (AVMs) are rare lesions and may be acquired or congenital. Acquired renal AVMs (arteriovenous fistulas [AVFs]) are relatively rare, accounting for 3% to 5% of all renal AVMs. Hematuria is the major and most common symptom; other clinical manifestations, such as hypertension, left ventricular hypertrophy, cardiac failure, and abdominal pain are also usually associated with AVMs.

Gross hematuria caused by a congenital intrarenal arteriovenous malformation: a case report
Carrafiello G et al.
J Med Case Reports 2011;5: 510
Renal Infarction: Causes
- Trauma
- Embolism from heart
- Embolism from catheters
- Sickle cell disease
- Vasculitis
- Acute renal vein thrombosis (rare)

Renal Infarction: Facts
- Can be segmental or global in extent
- Can be an isolated process or part of multisystem disease involvement
- Acute and chronic renal infarction due occur
- Symptoms may range from acute flank pain, to FUO to hematuria

Renal Infarction: CT Findings
- Focal vs global involvement
- Usually due to arterial occlusion sudden in onset
- May be unilateral or bilateral depending on the etiology
- Cortical rim sign may be seen with global infarction
- Chronic renal infarction may be seen as a small kidney
Atrial Thrombus and Renal Infarct

Renal Infarct due to Renal Artery Occlusion
Estimates of 72,570 new cases and 15,210 deaths in the US in 2013

Most cancers are transitional cell carcinoma while others are squamous cell carcinoma and adenocarcinoma

Data from NCI (National Cancer Institute)

"The overall sensitivity, specificity, accuracy, positive predictive value, and negative predictive value (NPV) for bladder cancer detection were 78% (117 of 149), 94% (649 of 689), 91% (785 of 838), 75% (117 of 157), and 95% (649 of 681) for CT urography and 95% (142 of 149), 92% (634 of 689), 93% (776 of 838), 72% (142 of 197), and 99% (634 of 641) for cystoscopy. The NPV of CT urography was higher in patients evaluated for hematuria alone (98%, 589 of 603)."

Bladder cancer detection with CT urography in an Academic Medical Center.
Sadow CA et al
"The presence of a discrete bladder mass or nodule should be considered suspicious for malignancy. In many cases, such lesions may be better appreciated on early phase images when surrounded by low-attenuation urine, particularly when the lesion is avidly enhancing, although a discrete filling defect may not be difficult to appreciate on delayed images when the nodule is large."

Bladder Malignancies on CT: The Underrated Role of CT in Diagnosis
Raman SP, Fishman EK
AJR 2014; 203:347–354
Active Bleed in Bladder: Dx

Blood Clot in Bladder

Conclusion and Take Away

- Hematuria and flank pain are common clinical presentations
- Age of patient and clinical history may be helpful in defining optimal scan protocols
- Limited phase imaging in the ER setting is indeed a challenge
- The communication between Radiology and the ER doc is critical in study optimization
- The communication between the Radiologist and Urologist is critical
PET PROJECT:
ONCOLOGIC PET IN
PERSONALIZED CANCER THERAPY

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Division Chief Nuclear Medicine
University of California, San Diego
PET Project: Oncologic PET in Personalized Cancer Therapy
Carl K. Hoh, MD
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**TOPICS**
- Next generation sequencing
- Molecularly targeted drugs
  - Tryosine kinase inhibitor
  - Rampamycin and mTOR inhibitors
- Challenges in monitoring molecular imaging
- Molecular relationship to the Warburg effect

**Historical Perspective**
- First microscope: Robert Hook (1665)
- Phase contrast microscope: Frits Zernike (1930)
- DNA structure: Watson, Crick, Wilkins, Franklin (1953)
- Human Genome Project: £3 billion (2006)

**Next-generation Sequencing (NGS)**
- Genomically-informed cancer therapy
- Actionable Genomic Alteration (GA)
  - 182 to 315 genes
- Molecularly targeted trials
- Approach to precision (personalized) medicine
- Cost ~ $5,000


**Genomic Categories**
- TP53, EGFR, FGF/FGFR, ALK, MYC
- DNA repair genes
  - BRCA, BRIP, ATM, MMR, MSH, MLH
- PI3k/Alt/mTor (PAM) pathway genes
  - PTEN, PIK3CA, AKT, TSC, CCNB1, MTOR, FBXW2
- CYCLIN
  - CCND, CDK, CDKN, RB
- WNT pathway
  - APC, CTNNB, NOTCH

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Successes in the Pursuit of Precision Medicine

- > 70 FDA approved targeted agents for solid and hematologic malignancies
  - Bcr-Abl kinase for aberrant Bcr-Abl enzyme in CML
  - Kit inhibitors mutated KIT in GIST
  - http://www.mycancergenome.org/content/molecular-medicine
  - Immunotherapy
    - Reactivate immune system based on checkpoints, to enable detection of cancer cells
  - Combined fields of genomics and immunotherapy

Challenges in Precision Medicine

- Accurate measurement of biomarkers is not easy
- Heterogeneity and genomic complexity
- MOSCATO trial, 1035 pts, 948 bx, only 7% of patient had benefit from genomics in hard-to-treat advanced cancers
- Single biomarker is unlikely to be completely predictive for complex tumors
- Combination therapy rather than matched monotherapy
- Applying immunotherapy to patients with greatest number of genomic alterations


General Strategies for Molecular Imaging

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<td>G protein-coupled receptor</td>
<td><em>18</em>F-fluciclovine (Axumin)</td>
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Monitoring Therapy with FDG

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<td>Tyrosine Kinase Inhibition</td>
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Tyrosine Kinase Receptor Model

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Malignancies and treatments with Tyrosine Kinase Inhibitors

Gastrointestinal Stromal Tumor (KIT RTK)
- Imatinib
- Chronic Myelogeneous Leukemia
  - Nilotinib
  - Dasatinib
  - Bosutinib
  - Ponatinib
- Axitinib (BCR-ABL TKI)
  ** (VEGFR, PDGFR, Stem cell FR, Colony SFR)
- Sunitinib

Pancreatic and Lung Cancer (EGFR)
- Gefitinib
- Erlotinib


Tyrosine Kinase Inhibitor (Imatinib) Therapy in Gastrointestinal Stromal Tumor


Compared with bevacizumab (Avastin), axitinib did not improve outcomes when added to second-line chemotherapy for metastatic colorectal cancer. With current dosing regimens, axitinib plus FOLFOX or FOLFIRI seems to be less well tolerated than bevacizumab-based regimens.


Vascular Normalization

Goel et al, Physiol Rev 2011; 91: 1071– 1121

Ma and Waxman, Clin Cancer Res 2009; 15: 570-584
Intermittent dosing of axitinib combined with chemotherapy is supported by 18FLT-PET in gastrointestinal tumours

Hoh et al, Br J Cancer 2014; 110: 875-881

Intermittent dosing of axitinib combined with chemotherapy is supported by 18FLT-PET in gastrointestinal tumours

Percent change by kinetic modeling
Percent change by SUVmax

Hoh et al, Br J Cancer 2014; 110: 875-881

Intermittent dosing of axitinib combined with chemotherapy is supported by 18FLT-PET in gastrointestinal tumours

21 patients (pre-existing resistance for FOLFIRI or FOLFOX)

- 2 (10%) patients had partial response
- 12 (57%) patients had stable disease
- 7 (33%) patients had no response

Hoh et al, Br J Cancer 2014; 110: 875-881
The target of rapamycin (TOR) was originally discovered in the budding yeast, Saccharomyces cerevisiae.

Every eukaryote genome examined (including yeasts, algae, plants, worms, flies and mammals) contains a TOR gene.


mTOR inhibitors in Clinical Trials

<table>
<thead>
<tr>
<th>mTOR inhibitors</th>
<th>Development status</th>
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<tbody>
<tr>
<td>&gt;2063511</td>
<td>ATP competitive inhibitor of mTOR</td>
</tr>
<tr>
<td>Xi-0847721</td>
<td>Specific to mTORC1 and mTORC2</td>
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<tr>
<td>PD15</td>
<td>ATP competitive inhibitor of mTOR</td>
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<tr>
<td>RIP150</td>
<td>ATP competitive inhibitor of mTOR</td>
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<td>L605-374</td>
<td>ATP competitive inhibitor of mTOR</td>
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Table of Contents
Proposed mechanism of regulation of Na-K-ATPase by T3 in Alveolar Epithelial Cells

Thyroid Hormone (T3)

Src kinase

MAPK/ERK

PDK/Akt

Na,K-ATPase activity

Downregulation of 18F-FDG Uptake in PET as an Early Pharmacodynamic Effect in Treatment of Non–Small Cell Lung Cancer with the mTOR Inhibitor Everolimus

FDG uptake is a surrogate marker for defining the optimal biological dose of the mTOR inhibitor everolimus in vivo

FDG uptake is a surrogate marker for defining the optimal biological dose of the mTOR inhibitor everolimus in vivo
Biological significance of 18F-FDG uptake on PET in patients with non-small-cell lung cancer

CONCLUSIONS

1. “…the activity of mTORC1 affects the amount of 18F-FDG accumulation within lung cancer cells.

2. “The amount of early follow-up 18F-FDG uptake may be a potential surrogate marker for predicting the tumor response to mTORC1 inhibitor.”

Loss of expression of the oncosuppressor PTEN in thyroid incidentalomas associates with GLUT1 plasmamembrane expression

2-[F-18]Fluoro-2-Deoxy-D-Glucose (FDG)

Cellular uptake of FDG

Warburg O., Science 1956 123; 3191: 309-314
Possible Paths of Glucose

GLUT (1-14) Proteins

- Affected by hormonal and environmental controls
- Glucose hypermetabolism associated with deregulated overexpression of GLUT1 and GLUT3.
- Increase GLUT1 associated with matrix metalloproteinase (MMP-2)
- Increased GLUT1 in primary lung tumor
- Increased GLUT3 & GLUT5 in liver metastases from lung cancer
- Hypoxia increase GLUT1 upregulation and vascular endothelial growth factor (VEGF).

FDG competes with glucose for carrier mediated transport and serves as an alternative substrate for hexokinase

PET Image Arterial ROI

PET Image Tissue ROI

FDG tracer kinetic model

Tracer Kinetic Modeling of FDG

Standardized Uptake Value on a Static Whole Body PET Image

Table of Contents
Correction of PET measured Net Glucose Uptake by plasma glucose level

Net Glucose Uptake = \( \frac{k_1 \cdot k_3}{k_2 + k_3} \cdot \frac{[\text{glucose}]}{\text{LC}} = \frac{K_{\text{NLR}}}{\text{LC}} [\text{glucose}] \)

SLR = non-linear regression
LC = lumped constant

Analogous SUV plasma glucose correction for SUV

\[ \text{SUV}_{\text{gluc}} = \frac{\text{SUV}_{\text{max}} [\text{glucose}]}{(100 \text{ mg/dl})} \]


Improved accuracy with SUVgluc


Alteration of FDG uptake by Metformin

We excluded three lesions in patients who were on metformin and had a high blood glucose level (>170 mg/dl) because metformin produces a dose-dependent increase in tumor glucose uptake [31] and the high blood glucose level causes the SUVgluc to be overcorrected.


Metformin divergently modulates tumor metabolism and proliferation, interfering with early response prediction by 18F-FDG PET imaging.


Increased FDG uptake and decreased FLT uptake after Metformin therapy

Hypotheses for the Warburg effect in Cancer

• Glycolysis induces microenvironmental acidification.
• Acidic microenvironment give advantage to tumor cells by promoting cell death of normal cells.
• Acidity increases extra-cellular matrix degradation by proteolytic enzymes (cathepsin B), facilitates tumor invasiveness
• Acidity stimulates release of vascular endothelial growth factor (neo-angiogenesis) and interleukin 8 (inhibits immune function)

Evolutionary dynamics of the Warburg effect: Glycolysis as a collective action problem among cancer cells

• Glycolysis is costly (because of energetically inefficient, thus leading to slower proliferation) but produces a collective benefit (acidity) for all cancer cells (glycolytic or not).
• A critical fraction of glycolytic cells is necessary

Archetti, J Theoretical Biology 2014; 341: 1-8

PET in Monitoring Response to Molecular Therapy

• Can be a tool in the design of new molecular therapies, dosing strategies, and clinical monitoring.
• Onset and resolution of therapy effect may change rapidly (within days).
PEARLS & PITFALLS IN PET IMAGING, INCLUDING BRAIN & CARDIAC PET

Farshad Moradi, M.D., Ph.D.
Assistant Clinical Professor
Department of Radiology
University of California, San Diego
Pearls & Pitfalls in PET Imaging
Oncologic, Cardiac, and Brain
Farshad Moradi, MD PhD

What is new?

• FDG is not the only game in town!
  – New radiotracers
    • Amyloid PET (florbetapir, flutemetamol, florbetaben)
    • Somatostatin receptor imaging (68Ga-DOTATATE)
    • Fluciclovine
  – Oldies but goodies
    • NaF bone PET
    • Cardiac PET (82Rb, 18NH3)
• PET/MR

= NOT FDG

18F-Fluciclovine (Axumin)
68Ga-PSMA
11C-Acetate

18F-NaF 68Ga-DOTATE FDG
Same patient

FDG
• Non-specific. BUT works most of the time!
It might not work because

- Tumor does not preferentially utilize glucose
  - Liposarcoma
- Low glucose metabolism
  - Low grade NETs
- FDG dephosphorylation
  - Well differentiated HCCs
- Too much background uptake
  - Brain mets. RCC, Bone marrow mets after G-CSF
- Low cellularity
  - Pulmonary adenocarcinoma, ovarian cystadenocarcinomas
- Treated disease

Metastatic breast cancer

Metastatic lung cancer vs. RCC, with resolution of uptake after chemotherapy

Marginal zone B-cell lymphoma

- Lymphomatous involvement of the right orbital roof and adjacent frontal bone

Peritoneal sarcomatosis & metformin

- 65 y/o female with GIST before treatment
- After tx, mass had resolved on CT
Sometimes, “all it takes is a little push”

- Urothelial or gynecologic malignancies
  - Lasix (20-40 mg iv, ~30 minutes before imaging)
- Peritoneal or bowel disease
  - Oral or IV contrast
  - Hold metformin (48h)
- Bone marrow
  - Wait 2-4 weeks after GSFS
- Anterior mediastinal or cardiac involvement
  - Low carb /Atkins diet
- Head and neck malignancies
  - Arms down
  - Small FOV reconstruction
  - Increase time/bed position
- Thyroid
  - rTSH

27 y/o with invasive poorly differentiated squamous carcinoma, pT1b1N0

- 20 mg Lasix

Overweight patients

- For new scanners, increasing scan time might be more effective than increasing the dose

FDG PET in patients with diabetes

- Prolonged fasting may increase risk of hypoglycemia
- Insulin alters biodistribution of FDG
  - Long acting is ok
  - Oral hypoglycemic agents may have the same effect as insulin
- Metformin

FDG PET in patients with diabetes

<table>
<thead>
<tr>
<th>Type of Insulin (Brand Name)</th>
<th>Onset (Hours)</th>
<th>Peak (Hours)</th>
<th>Duration (Hours)</th>
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| Rapid-acting
  - Insulin lispro (Humalog)
  - Insulin aspart (NovoLog)
  - Insulin glulisine (Apidra)
| 0.25-0.5 | 1-2 | 3-4 |
| Short-acting
  - Regular (Humulin, Novolin R)
| 0.5-1 | 1-2 | 3-6 |
| Intermediate-acting
  - NPH (Humulin, Novolin N)
| 2-4 | 4-6 | 8-12 |
| Long-acting
  - Insulin detemir (Levemir)
  - Insulin glargine (Lantus)
| 0.8-2 | - | 0-24 |
| 1.5-4 | - | 22-24 |
Insulinemic state is more important than glycemic state

- 73 y/o male
- Cheerios and milk at 8 am
- Injected at 10:20 am
  - Blood glucose 130 mg/dl at the time of injection

31 y/o female pT1N0M0 left breast IDC post lumpectomy

- Lipomatous hypertrophy of interatrial septum

Altered biodistribution of FDG

- 80 year old female
  - Fasting
  - Normal glucose
  - Lipomatous hypertrophy of interatrial septum

Post partum / lactation

- 24 y/o female
  - Burkitt lymphoma
  - Can she breast feed?
  - FDG is only minimally excreted in breast milk
- 37 y/o F with T1N2b right tonsillar SCC post surgery and chemoradiation

Technical issues

- Dose infiltration
  - Lymphoscintigram
  - Scatter correction artifact
- FDG “microembolism”
  - Focal uptake in the lung without nodule on CT
  - No lesion on follow up
- Arterial injection
  - 60 y/o male with left retromolar trigone SCC
FDG uptake is nonspecific

- A malignant lesion *usually* has higher uptake than benign lesion
- High grade *usually* has higher uptake than low grade
- Poorly differentiated *usually* has higher uptake than well differentiated

Florid reactive follicular hyperplasia

- Factors to consider
  - Degree of uptake
  - Location and distribution
    - Symmetry
  - Pattern of malignancy spread
  - CT appearance
  - Beware of collision tumors!
  - Tumor markers
  - Other findings
    - e.g. Perisplenic abscess + ipsilateral LAD, PNA and hilar LAD
  - Recent surgery or radiation

53 years of age, Male, with history of MEN1

- Lymph node, left axillary, biopsy
  - FLORID REACTIVE FOLLICULAR HYPERPLASIA
- Lymph node, left neck, excision
  - FLORID REACTIVE FOLLICULAR HYPERPLASIA WITH PROGRESSIVE TRANSFORMATION OF GERMINAL CENTERS

Thyroid uptake

- Diffuse thyroid uptake
  - Thyroiditis (fairly common after chemotherapy)
  - Grave’s disease
- Focal thyroid uptake
  - Concerning for malignancy, requires workup
    - Papillary or follicular adenoma or carcinoma
    - Mets (lymphoma, melanoma, RCC, H&N, lung, breast, GI)
    - MEN2

Warthin’s tumor

- Intense uptake in parotid gland
- Associated with smoking
- Can be bilateral and multifocal
- DDx: met (intraparotid LN), malignant salivary gland tumor
- Diffuse parotid uptake
  - Parotitis, Sjögren’s

ILD

- Thyroiditis
- Thyroiditis
- Thyroiditis
- Thyroiditis
Sarcoidosis

Granulomatous reaction post chemotherapy

22 y/o female
Hodgkin’s Lymphoma

Initial staging
After chemotherapy

Hybernoma

Diffuse hepatic uptake

• 78 y/o female with metastatic breast cancer
• DDX for diffuse hepatic uptake
  – Hepatitis, inflammatory
  – Sarcoidosis
  – Malignancy
  – Lymphoma
  – Cholangiocarcinoma
  – Metastasis
  – Hemophagocytic lymphohistiocytosis
  – VOD

Incidental tubular adenoma in a 68 y/o smoker with hypopharyngeal scc

• 2 cm sessile polyp in the cecum just proximal to the ileocecal valve
  – Tubular adenoma with focal superficial high grade dysplasia.
65 y/o female with recurrent DLBCL post stem cell transplant, involving the bowel. CT and MRI at the time of first PET were reportedly negative. F/U PET after 2.5 months showed progression as well as new liver involvement.

Appendicitis
- 27 year old male with newly diagnosed Hodgkin’s lymphoma (post excisional biopsy)
- Appendectomy:
  - Benign appendix tissue with focal acute and chronic inflammation

Corpus luteum
- 31 year old female with squamous cell carcinoma of the ovary arising from a right dermoid cyst

Ovarian hyperstimulation
- Brown fat
- LAD
- IVC thrombosis
- Theca lutein cysts
- Primary cancer cervical adenoma
- Bladder

Bone marrow
- 55 y/o male with recurrent HPV+ SCC base of the tongue s/p chemoradiation
- Leukocytosis (37.3x1000/mm) at the time of PET
  - Oncologist attributed that to sinusitis
  - No recent bone marrow stimulation
- PET findings:
  - No evidence of sinusitis
  - Diffuse moderate bone marrow uptake
- Bone marrow biopsy
  - Chronic myelogenous leukemia, chronic phase.
  - Increased marrow fibrosis (WHO MF Grade 1)

Polycythemia Vera
Nerve sheath tumor

- 40 year old male with expanding plexiform neurofibromas of the right thigh
- Left leg sciatic nerve mass, biopsy
  - Nerve sheath tumor with atypical features

Leptomeningeal lymphomatosis

Brain PET

- FDG Brain Metabolism
  - Suspected Dementia
  - Seizure (inter-ictal metabolism)
  - Tumor versus post radiation change
- Amyloid PET
  - Alzheimer’s disease

Dementia: Parietotemporal

- AD
  - Frontal or global hypometabolism in advanced AD
  - Parietal>Frontal
- Dementia With Lewy Bodies
  - May have occipital hypometabolism
- PDD
  - Basal ganglia (putamina)

Dementia: Frontotemporal lobar degeneration spectrum

- FTD
- Primary Progressive Aphasia
  - Unilateral
- Corticobasal Degeneration
  - Thalamus, Basal ganglia
  - Sensorymotor cortex
  - Posterior frontal and parietal
  - May overlap with AD
Amyloid PET

- Negative study (no or sparse neuritic plaques)
  - Inconsistent with AD
- Positive scan (moderate to frequent plaques)
  - AD
  - 10% of cognitively normal elderly
  - Apo E ε4 carriers
  - Cerebral amyloid angiopathy
  - PDD, DLB
  - NPH (indicates poor response to shunting)
- Higher sensitivity and similar or better specificity for AD compared to FDG PET

Steps in interpretation of FDG brain PETs

- Image quality
  - Motion, tilt, rotation
  - Symmetry
- Volume
  - Interhemispheric and Sylvian fissures
  - Distance between caudate heads
  - Interthalamic distance
- Hierarchy
  - Cerebellum as reference
  - Basal ganglia ≥ Cerebral cortex ≥ Corticobasal GM
- Search pattern
  - Frontal, parietal, temporal (mesial, poles, lateral), cingulate gyrus, insula, primary sensory areas, basal ganglia, thalamus, pons, cerebellum
- Focal lesion / mass effect
Supranuclear palsy + DLB

Seizure (mesial temporal sclerosis)
- 32-year-old female
  - Right MTS
  - Focal hypometabolism in the right mesial temporal cortex and extensive left frontal hypometabolism
- Foramen ovale EEG:
  - Spread from right to left hippocampi and left cortical areas.

Neuromyelitis optica
- Diffuse cortical hypo-metabolism
- Abnormal signal and expansion of the upper cervical cord, medulla, and pons with foci of microhemorrhage

Primary CNS Lymphoma
- Initial presentation
- Treated disease and post-radiation changes

Cardiac PET
- $^{82}$Rb, $^{13}$NH3 Perfusion
  - Higher sensitivity and specificity compared to SPECT
  - Quantification and assessment of fractional flow reserve
  - Can be done within 1 hour
  - Lower radiation
- FDG
  - Viability
  - Sarcoidosis

Sarcoidosis protocol
- Requires strict diet to minimize physiologic myocardial uptake
  - ~80% success
- Rest perfusion study is complementary
- High count single bed acquisition (10 min. +gating)
- Skull-base to thigh PET for assessment of extracardiac disease
- 90% sensitivity, 75% specificity
  - Similar to MRI
- Can be used for monitoring disease activity

Cardiac viability

- Needs preparation
  - Insulin/glucose clamp
  - Fasting, oral or IV glucose load
    - Insulin if abnormal glucose tolerance
  - Postprandial
    - Not reliable
- Comparison with rest perfusion
  - Perfused myocardium is viable (even if it does not uptake FDG)

Quiz
MDCT of Adrenal Masses: A Pattern Approach

Elliot K. Fishman, M.D., FACR
Professor of Radiology, Surgery and Oncology
Director, Diagnostic Imaging and Body CT
The Russell H. Morgan Department of Radiology and Radiological Science
The Johns Hopkins University
Baltimore, MD
When do we evaluate the adrenal glands?
- Staging tumor (i.e. lung cancer)
- Evaluation of suspected hormonal abnormality (i.e. Cushing’s)
- As part of a routine CT exam of the chest and/or abdomen (incidentaloma)
Peds Patient with Severe Trauma and Shock Adrenals

Patient s/p Trauma with Adrenal Hyperenhancement

"We propose that adrenal enhancement may be a sign of hyperperfusion in early stage of shock due to the crucial role of the adrenal glands in this clinical situation. This may not persist with further circulatory compromise due to vasoconstriction. If confirmed, its recognition has potential value of identifying a therapeutic window before irreversible shock set in."

Persistent adrenal enhancement may be the earliest CT sign of significant hypovolaemic shock.
Cheung SC et al.
Clin Radiol 2003 April 58(4):315-318
“Finally, it is important to recognize intense adrenal enhancement in morphologically normal-shaped adrenals, especially in unwell patients, because this finding may be an early sign of impending shock, warranting early critical-care management, and may also be a marker of poor prognosis in ill patients.”

Intense Adrenal Enhancement: A Feature of Hypoperfusion Complex
Venkatanarasimha N, Roobottom C
American Journal of Roentgenology. 2010;195: W82-W82

Evaluation of an Adrenal Mass
• Clinical history and presentation
• CT findings
  – Adrenal size
  – Unilateral vs. bilateral masses
  – Attenuation of mass
  – Presence of fat or calcification
  – Enhancement pattern

Functioning Adrenal Masses
• Cushing’s syndrome
• Conn’s syndrome (primary aldosteronism)
• Pheochromocytoma

Incidentalomas of the Adrenal Gland: Definition
• Nonfunctioning adrenal tumor discovered on an imaging study performed for indications exclusive of adrenal related conditions.

“The prevalence of adrenal incidentalomas has increased, and our result of 5% prevalence corroborates the 4.4% reported from a recent series compared with the 1-2% reported in the older literature.”

The Incidental Adrenal Mass on CT: Prevalence of Adrenal Disease in 1,049 Consecutive Adrenal masses in Patients with No Known Malignancy
Song JH et al.
AJR 2008; 190:1163-1168

“In 973 consecutive patients with an incidental adrenal mass and no history of cancer, no malignant lesions were identified. Adenomas (75%) and myelolipomas (6%) were the most common lesions.”

The Incidental Adrenal Mass on CT: Prevalence of Adrenal Disease in 1,049 Consecutive Adrenal masses in Patients with No Known Malignancy
Song JH et al.
AJR 2008; 190:1163-1168
“All of the incidentally detected adrenal masses with a CT attenuation of >10 HU were benign in patients with no known malignancy. Follow-up imaging to characterize an incidental mass appears to have a limited role in this patient cohort.”

The Incidental Indeterminate Adrenal Mass on CT (>10H) in Patients Without Cancer: Is Further Imaging Necessary? Follow-Up of 321 Consecutive Indeterminate Adrenal Masses
Song JH et al.
AJR 2007; 189:1119-1123

“Unenhanced CT attenuation values can characterize an adrenal mass as a benign adenoma with high specificity and acceptable sensitivity. Adrenal masses cannot be characterized using enhanced CT attenuation values or lesion size.”

Differentiation of Adrenal Adenomas from Nonadenomas Using CT Attenuation Values
Korobkin M et al.
AJR 1996;166:531-536

“In conclusion, the results of our study show that none of the incidentally detected adrenal masses was malignant in patients with no known cancer. If an incidental adrenal mass appears benign on imaging and the patient has no known malignancy, follow-up imaging appears to have a limited role.”

The Incidental Indeterminate Adrenal Mass on CT (>10H) in Patients Without Cancer: Is Further Imaging Necessary? Follow-Up of 321 Consecutive Indeterminate Adrenal Masses
Song JH et al.
AJR 2007; 189:1119-1123

“In clinical practice therefore, 10 HU is the most widely used threshold value for the diagnosis of lipid-rich adrenal adenoma.”

Adrenal Imaging
Blake MA et al.
AJR 2010; 194:1450-1460

Adrenal Adenoma

<table>
<thead>
<tr>
<th>Mean</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD</td>
<td>21</td>
</tr>
<tr>
<td>Minimum</td>
<td>-56</td>
</tr>
<tr>
<td>Maximum</td>
<td>59</td>
</tr>
</tbody>
</table>
"At 30 minutes, all adenomas had attenuation less than 37 HU, whereas all non adenomas had attenuation greater than 41HU."
Quantitative CT Evaluation of Adrenal Gland Masses: A Step Forward in the Differentiation between Adenomas and Nonadenomas
Szolar DH et al.
Radiology 1997; 202:517-522

"Thirty six (92%) of 39 nonadenomas and 124 (98%) of 127 adenomas were correctly characterized. The sensitivity and specificity of this protocol were 98% and 92%, respectively. This protocol correctly characterized 160 (96%) of 166 masses."
Adrenal Masses: Characterization with Combined Unenhanced and Delayed Enhance CT
Caoili EM et al.
Radiology 2002;222:629-633

"With a combination of unenhanced and delayed enhanced CT, nearly all adrenal masses can be correctly categorized as adenomas or nonadenomas."
Adrenal Masses: Characterization with Combined Unenhanced and Delayed Enhanced CT
Caoili EM et al.
Radiology 2002;222:629-633

Absolute Percentage Washout (APW)
- \( APW = 100 \times \frac{(EA - DA)}{(EA - PA)} \)
- \( EA = \) HU on contrast enhanced scan
- \( DA = \) HU on delayed enhanced scan
- \( PA = \) Precontrast attenuation
“Ten minute delayed multidetector CT adrenal washout tests have reduced accuracy compared with results from prior studies; overall test accuracy at 40% threshold was 77.7% according to our test results.”
Incidental Adrenal Lesions: Accuracy of Characterization with Contrast-enhanced Washout Multidetector CT — 10-minute Delayed Imaging Protocol Revisited in a Large Patient Cohort
Sangwaiya MJ et al.
Radiology 2010; 256:504-510

“In conclusion the 10 minute delayed adrenal enhancement washout tests have reduced sensitivity for the detection of adenomas compared with results from prior studies, and the test sensitivity appears to be clinically suboptimal. This finding might be explained by insufficient time for the intravenous contrast material to wash out from benign lesions.”
Incidental Adrenal Lesions: Accuracy of Characterization with Contrast-enhanced Washout Multidetector CT — 10-minute Delayed Imaging Protocol Revisited in a Large Patient Cohort
Sangwaiya MJ et al.
Radiology 2010; 256:504-510

“Precontrast attenuation of less than 0 HU supercedes the washout profile in the evaluation of an individual adrenal mass.”
Distinguishing Benign from Malignant Adrenal Masses: Multidetector Row CT Protocol with 10-Minute Delay
Blake MA et al.
Radiology 2006; 238:578-585

“Noncalcified, nonhemorrhagic adrenal lesions with precontrast attenuation of more than 43 HU should be considered suspicious for malignancy.”
Distinguishing Benign from Malignant Adrenal Masses: Multidetector Row CT Protocol with 10-Minute Delay
Blake MA et al.
Radiology 2006; 238:578-585

Adrenal Adenoma Noncontrast is 6HU

Arterial Phase is 67HU
Imaging Phase | Attenuation Values
--- | ---
Non contrast | 6 HU
Arterial | 67 HU
Venous | 56 HU
Delayed (15 min) | 18 HU
Fact to remember

• In this paper all pheochromocytomas were excluded from the analysis. This was done because they were felt to be diagnosed clinically. Please remember this is not always the case in real life.

• Distinguishing Benign from Malignant Adrenal Masses: Multidetector Row CT Protocol with 10-Minute Delay
  Blake MA et al. Radiology 2006; 238:578-585
"For indeterminate adrenal masses identified at dual-phase IV contrast-enhanced CT, higher enhancement during the arterial phase, arterial phase enhancement levels greater than 110 HU, and lesion heterogeneity should prompt consideration of pheochromocytoma."


"Greater enhancement of pheochromocytomas was variable: 25% greater in the arterial phase, 25% equal across phases, and 50% greater in the venous phase."


"First, adenomas usually are more enhancing in the venous than in the arterial phase or have equivalent enhancement across phases. Second, a mass that is greater than 110-HU enhancing in the arterial phase, particularly with higher enhancement in the arterial phase, is most likely a pheochromocytoma. Third a pheochromocytoma are more likely to be heterogeneous than are adenomas."


Adrenal Adenoma vs Pheo: Enhances >120HU
Adrenal Cysts: Types
- Endothelial
- Epithelial
- Parasitic
- Pseudocysts

Adrenal Cysts: CT Findings
- Water density
- Thin wall that does not enhance
- Wall may occasionally calcify
Adrenal Myelolipoma: CT Findings

- Benign tumors
- Usually older patients
- Composed of mature fat cells and hematopoietic tissue
- May have calcifications in addition to fat

Myelolipoma

- Benign
- Nonfunctioning
- Hematopoietic tissue & mature adipose
- 2-17 cm

Myelolipoma

- Change over time
  - remain stable
  - enlarge
  - get smaller
- Complications
  - mass effect
  - hemorrhage

“Adrenal Myelolipoma”


Pereira JM et al.

RadioGraphics January 2005 vol. 25 no. 1 69-85

"Myelolipoma is an uncommon benign tumor composed of mature adipose cells and hematopoietic tissue. The prevalence in autopsy series is between 0.08% and 0.2%. Typically, myelolipoma arises in the adrenal gland. Extra-adrenal myelolipoma is rare and is found most commonly in the presacral and other retroperitoneal areas. Usually asymptomatic and discovered incidentally at cross-sectional imaging, myelolipoma occasionally causes discomfort due to compression or hemorrhage."

The CT features are characteristic. Lesions usually have a negative Hounsfield unit value owing to macroscopic fat. Because of intermixed hematopoietic tissue, the attenuation is usually higher than that of retroperitoneal fat. High-attenuation regions may be seen due to hemorrhage or calcifications.”

Pereira JM et al.

RadioGraphics January 2005 vol. 25 no. 1 69-85
Adrenal Myelolipoma
Adrenal Myelolipoma
“Myelolipomas contain macroscopic fat, which is characterized by attenuation of less than −20 HU on CT and signal dropout on fat-suppressed MRI sequences. Macroscopic fat rarely can be seen in adrenal adenomas, adrenocortical carcinomas (ACCs), and pheochromocytomas, and large myelolipomas may be difficult to distinguish from liposarcomas.”

Adrenal Incidentalomas: Clinical Controversies and Modified Recommendations
Garrett RW et al
AJR 2016; 206:1170–1178

Adrenal Hemorrhage: CT Findings
- High attenuation on non-contrast study
- May be unilateral or bilateral
- In time may calcify
- More common in females (3-1)

Adrenal Hemorrhage: Facts
- Can be unilateral or bilateral
- May result in adrenal insufficiency
- Can present clinically as an acute abdomen, myocardial infarction, or sepsis

Adrenal Hemorrhage: Etiology
- Underlying tumor
- Coumadin
- Trauma
- Infection
- Hypercoagulability states
- Stress

Adrenal Hemorrhage
“The most common imaging features include a 2-3 cm oval hematoma, irregular hemorrhage obliterating the adrenal gland, periadrenal hemorrhage or fat stranding, and uniform adrenal swelling with increased attenuation.”

Imaging of traumatic adrenal injury
To'o KJ, Duddalwar VA

“Traumatic adrenal injury occurs in 5% of cases of blunt abdominal trauma and most commonly affects the right adrenal gland only. While rare, adrenal injury is an indicator of severe trauma and should prompt a search for associated injuries. The most common imaging feature of adrenal injury is a 2-3 cm oval hematoma.”

Imaging of traumatic adrenal injury
To'o KJ, Duddalwar VA

Adrenal Trauma: CT Findings
- Adrenal hematoma (oval or round)
- Irregular hemorrhage obliterating the gland
- Uniform adrenal gland swelling with increased attenuation
- Periadrenal hemorrhage or stranding
- Retroperitoneal hemorrhage
- Adrenal pseudocyst (chronic)

Imaging of traumatic adrenal injury
To'o KJ, Duddalwar VA

Bilateral Adrenal Hemorrhage in NICU Patient

Bilateral Adrenal Hemorrhage
Adrenal Metastases with Hemorrhage

Perirenal Hematoma-Adrenal Carcinoma

Old Adrenal Hematoma

Prior Adrenal Hemorrhage

Adrenal hematoma (old)
“Imaging characteristics of adrenal tumors on CT scan predict benign pathology 100% of the time. Regardless of size, when interpreted as benign on CT scan, laparoscopic adrenalectomy, if technically feasible, should be the technique used when surgery is offered, or close surveillance may be a safe alternative.”


“Pathology was benign in 88.4%, indeterminate in 2.3%, and malignant in 9.3%, with a median tumor diameter of 2.7 cm (interquartile range, 1.7-4.1 cm) and 9.5 cm (interquartile range, 7.1-12 cm) in the benign and malignant groups, respectively (P < 0.001). Of the tumors with benign features on CT, 100% (143/143) had benign final pathology.”


“In resected adrenal tumors, the presence of nonbenign ImF is more sensitive for malignancy than mass size (100 vs. 55 %) with equivalent specificity. Regardless of mass size, adrenalectomy should be strongly considered when non-benign ImF are present.”


“Malignant Adrenal Tumors

- Metastases
- Primary adrenal carcinosarcoma
- Pheochromocytoma
- Lymphoma
- Neuroblastoma

“ If size ≥4 cm had been used as the sole criterion for surgery, 45 % of malignancies (9/20) would have been missed including 8 metastases and an ACC.”


“At routine contrast-enhanced MDCT, adrenal masses with irregular margins or a thick enhancing rim are likely to be malignant. Smooth margins and homogeneous density can be seen in both benign and malignant adrenal masses and are insufficient for characterization.”

Morphologic Features of 211 Adrenal Masses at Initial Contrast-Enhanced CT: Can We Differentiate Benign From Malignant Lesions Using Imaging Features Alone? Song JH et al. AJR 2013; 201:1248-1253
For individual morphologic features in diagnosing malignancy, irregular margins had 30-33% sensitivity and 95-96% specificity and an enhancing rim had 5-13% sensitivity and 98-99% specificity.

Notably, no malignant lesions occurred in patients without a known history of cancer.

Primary Adrenal Carcinoma - Epidemiology

- 0.02% of malignant tumors
- Peak incidence in fourth and fifth decades
- F > M (minimally)
- Functioning tumors are more common in women
- Less than 5% bilateral

Primary Adrenal Carcinoma - Presentation

- Local flank pain
- Weakness, fever
- Symptoms related to metastases
- Symptoms related to hormones produced by the tumor

Adrenal Carcinoma: Functioning Tumors

- >50% of adrenal cancers have excess steroid hormone production
- Cushing’s syndrome due to excess cortisol production is the most common presentation
- Other hormones produced include androgen secretion, estrogen secretion, and primary aldosteronism

Primary Adrenal Carcinoma: CT Findings

- Up to 1/3 have calcifications
- Average size is 9 cm. (range is 3-25 cm.)
- Tumor enhancement and necrosis may be seen
Adrenal Carcinoma - CT Staging

- local extension or invasion
- regional lymph nodes
- vascular invasion (including IVC)
- lung metastases
- skeletal metastases
- liver metastases

Primary Adrenal Carcinoma

Adrenal Carcinoma
Adrenal Carcinoma
“Secondary involvement of the adrenal glands with non-Hodgkin lymphoma has been reported to occur in up to 25% of patients during the course of their disease. However, primary adrenal lymphoma is extremely rare and accounts for just 1% of all non-Hodgkin’s lymphoma cases.”

Primary adrenal lymphoma: Radiological; pathological, clinical correlation

Zhou L et al.

“Primary adrenal lymphoma generally manifests as large, soft-tissue masses, replacing the adrenal glands with the maximal diameters often exceeding 6 cm. In this study, most (7/9) of adrenal lymphomas are round or oval and smooth with well-defined margins, even in the largest lesions as seen in our experience. Despite their large size, imaging often reflects preservation of the native triangular appearance of the normal adrenal gland.”

Primary adrenal lymphoma: Radiological; pathological, clinical correlation
Zhou L et al.

Primary Adrenal Lymphoma: Facts

• Primary adrenal lymphoma commonly affects elderly men; with a median age of 65 years old
• Bilateral involvement occurred in 73% of the cases in one study
• Approximately 50% of patients actually develop symptoms of adrenal insufficiency, such as pigmented skin and mucous membrane, fatigue, anorexia, and constipation

Primary Adrenal Lymphoma: CT Appearance

• It is characterized by large tumors, exceeding 10 cm in diameter, with a growth pattern of infiltration.
• Masses generally expand and infiltrate the glands, maintaining their triangular appearances.
• Some primary adrenal lymphomas may manifest as masses with necrotic or cystic components and heterogeneous, moderate enhancement, as occurred in one of our cases making it impossible to differentiate from primary adrenal cortical carcinoma, pheochromocytomas, or metastatic disease.

“Some primary adrenal lymphomas may manifest as masses with necrotic or cystic components and heterogeneous, moderate enhancement, as occurred in one of our cases, making it impossible to differentiate from primary adrenal cortical carcinoma, pheochromocytomas, or metastatic disease.”

Primary adrenal lymphoma: Radiological; pathological, clinical correlation
Zhou L et al.
“Although it is a rare entity, primary lymphoma of the adrenal gland should be considered in the differential diagnosis of bilateral nodular adrenal lesions, particularly when there is evidence of associated adrenal insufficiency.”

Diffuse large B-cell lymphoma of the adrenal gland: a rare cause of primary adrenal insufficiency.

de Sousa Lages A et al.

“Lymphomatous involvement of an adrenal gland during the course of a lymphoma is common, but a primary presentation of adrenal insufficiency in a patient with lymphoma involving both adrenal glands is rare. We describe a 36-year-old man with non-Hodgkin lymphoma (NHL) who presented with adrenal insufficiency. His evaluation consisted of several imaging modalities, including positron emission tomography-computed tomography (PET-CT) scans, which were helpful in defining the extent of disease prior to treatment and in monitoring the patient's response to treatment. Our case illustrates the importance of preoperative evaluation to exclude a lymphoma, particularly in patients with bilateral renal and/or adrenal masses.”

Adrenal insufficiency as presenting feature of non-Hodgkin lymphoma.

Jacobs BL et al.

Adrenal Metastases: Facts

• Most common malignant adrenal mass
• Variable size and appearance
• Attenuation values and enhancement patterns will vary

Adrenal Metastases: Sites of Origin

• Lung cancer
• Breast cancer
• Renal cancer
• Melanoma

Metastatic Melanoma and RVT
Metastatic RCC to Adrenals

Recurrent RCC to Nodes and Adrenal

RCC S/P Ablation with Adrenal Metastases
Metastatic Melanoma to the Adrenal Glands
Metastatic Adrenal Carcinoma from Renal Primary

Renal Cell Carcinoma Metastatic to the Adrenal Gland

“Pheochromocytomas are often considered the great mimicker of other adrenal tumors. Because of their varied clinical, imaging, and pathologic appearances, accurate diagnosis can be challenging.”

Pheochromocytoma: The Range of Appearances on Ultrasound, CT, MRI, and Functional Imaging

Leung K et al. AJR 2013; 200:370-378

Pheochromocytoma; Facts

- Peak incidence is age 40-50
- Multicentric in 10% of cases
- Of the 10% extra-adrenal pheochromocytomas about 90% are near the Organ of Zuckerkandl
- About 10% are malignant

Pheochromocytoma of the Adrenal Gland: Vital Statistics

- 10% are bilateral
- 90% of all pheochromocytomas are located in the adrenal gland
- these tumors secrete catecholamines which result in hypertension
- elevated plasma catecholamine levels and 24 hour urine VMA and metanephrine levels in 89-100% of cases

Pheochromocytoma: Facts

- 90% are sporadic and 10% are part of syndromes
  - von Hippel-Lindau syndrome (10-26%)
  - MEN Type II (50%)
  - Neurofibromatosis Type 1 (1%)
  - Pheochromocytoma-Paraganglioma Syndromes Associated with SDHB and SDHD Mutation
“In 40 (70.2%) of the 57 patients, an adrenal pheochromocytoma was detected in an imaging study performed without suspicion of an adrenal lesion. There were 13 chest computed tomography studies-8 to evaluate for possible pulmonary emboli. Other indications included abdominal pain or discomfort (n = 8), trauma (n = 3), abnormal liver function tests (n = 3), suspect renal artery stenosis (n = 3), hematuria (n = 2), colitis (n = 2), and 4 miscellaneous indications.”

Serendipity in the diagnosis of pheochromocytoma.
Oshmyansky AR et al

“Pheochromocytomas are typically round or oval masses that range in size from 1 to 10 cm or more. CT imaging usually shows avid enhancement and washout. These tumors may be complicated by varying degrees of degeneration, hemorrhage, necrosis, fibrosis, or cystic changes. Their various imaging features have earned these tumors the nickname of an “imaging chameleon”.
Pheochromocytomas may mimic adrenal adenoma, adrenal cortical carcinoma, or metastasis, and are not usually diagnosed by CT alone.”
Assessment of clinical and radiologic differences between small and large adrenal pheochromocytomas
Kim DW et al.
Clinical Imaging (in press)

“Approximately 5% of adrenal incidentalomas are pheochromocytomas. Although initial reports found that 11% of pheochromocytomas were found incidentally, due to the increased use of CT, more recent studies have reported an incidental adrenal pheochromocytomas rate of 44–58%. The incidental rate of discovery in those studies did not differ with the incidental rate of 58.9% (23 of 39 cases) in this study.”
Assessment of clinical and radiologic differences between small and large adrenal pheochromocytomas
Kim DW et al.
Clinical Imaging (in press)

“IV administration of nonionic contrast material for CT is a safe practice for patients with pheochromocytoma and related tumors even without alpha-blocking medication.”
CT of Pheochromocytoma and Paraganglioma: Risk of Adverse Events with IV Administration of Nonionic Contrast Material
Bessell-Browne R et al.
AJR 2007; 188:970-974
Pheochromocytoma: CT Findings

- Calcifications are found in 10% of Pheochromocytomas
- Pheochromocytomas typically are vascular on early phase CT scans
- Pheochromocytomas can have a 50% washout value and behave just like an adenoma
- In the absence of metastases it is hard to diagnosis whether or not a Pheochromocytoma is malignant
Pheochromocytoma

Incidental Pheochromocytoma

Cystic Adrenal Mass: Pheochromocytoma
Bladder Pheochromocytoma

Extraadrenal Paragangliomas: CT Findings
- Homogeneous or heterogeneous hyperenhancing mass
- Range in size from 1 cm to over 20 cm
- Common locations are carotid body, jugular foramen, aorticopulmonary region, posterior mediastinum, abdominal paraaortic region including Organ of Zuckerkandl, and pelvis

Is there anything in the horizon for adrenal CT imaging?

“Three dimensional volume rendered CT successfully displayed the relationship of adrenal masses to adjacent structures and organs before laparoscopic adrenalectomy.”

Three Dimensional Volume Rendered Helical CT before Laparoscopic Adrenalectomy
Hurley ME et al.
Radiology 2003; 229:581-586
“Imaging characteristics of adrenal tumors on CT scan predict benign pathology 100% of the time. Regardless of size, when interpreted as benign on CT scan, laparoscopic adrenalectomy, if technically feasible, should be the technique used when surgery is offered, or close surveillance may be a safe alternative.”

Computed Tomography in the Management of Adrenal Tumors: Does Size Still Matter?
Azoury SC, Nagarajan N, Young A, Mathur A, Prescott JD, Fishman EK, Zeiger MA
J Comput Assist Tomogr. 2017 Jan 20 [Epub ahead of print]

“A decrease in attenuation of an adrenal lesion between 140 kVp and 80 kVp is a highly specific sign of an adrenal adenoma. However, because an increase in attenuation at 80 kVp is seen with metastatic lesions and some adenomas, the sensitivity of this test is low.”

Dual-Energy CT for Characterization of Adrenal Nodules: Initial Experience
Gupta RT et al.
AJR 2010; 194:1479-1483

Conclusion
• CT is the study of choice for evaluating the adrenal glands
• Most adrenal lesions are benign
• The CT appearance may alone help determine the etiology of the pathology present especially when combined with the clinical history
Great Balls of Fire!
Scrotal Ultrasound Update

Katherine M. Richman, M.D., FACR
Medical Director of Thornton Radiology
Clinical Professor of Radiology
University of California, San Diego
Scrotal Ultrasound: A Pattern Approach

Meg Richman, MD
University of California, San Diego

27 yo with R palpable mass

Scrotal Ultrasound: Indications
- Palpable masses
- Pain
- Trauma
- Testicular location
- Infertility
- Gynecomastia
- Unexplained adenopathy

Scrotal Ultrasound Exam
- Gray scale: longitudinal/transverse
  - testes and epididymis
  - measure testis length, width, height
- Color doppler of each testis
- Duplex doppler of each testis
- Side-by-side color of both testes
- Color doppler of epididymis if needed

Testicular Cases: Part I

Table of Contents
Seminoma

- Most common tumor in cryptorchidism pts
- 30% pts with seminoma had prior cryptorchidism
- Most common tumor in microlithiasis pts
- Hypoechoic, well-defined, solid
Benign Testicular Masses

Epidermoid cyst
- 1% of testicular tumors
- Painless mass 20-40 yr old
- Benign!
- Testicular sparing excision
  - With adjacent biopsies to exclude TIN

Ultrasound:
- Echogenic fibrous or calcified rim
- ABSENT color flow in the mass

MRI
- T2: high signal lesion with low signal rim
- T1 post Gado: NO enhancement

31 yo with testicular pain

Testicular Infarction

40 yo with left testicular pain
40 yo with left testicular pain

Segmental Testicular Infarction

62 yo with right testicular mass

Spermatocytic Seminoma

70 yo with bilateral palpable masses

Ectasia of Rete Testes

70 yo with bilateral palpable masses

caused by bilateral Epididymal cysts

2 men with palpable mass

Cystic Teratoma

Fernández-Pérez, et al. AJR 2005; 184:1587-1593

Dogra, Radiographics October 2001
Testicular Cystic Lesions

- Cystic Teratoma
- Ectasia of Rete Testes

Testicular Cystic Lesions

- Tunica albuginea cysts

Testicular Cystic Lesions

- Intratesticular cyst

Testicular Cystic Lesions

- Two different patients with testicular pain

Which is Which?

- Abscess
- Seminoma

Solitary Testicular Mass: DDx

- Testicular tumor
  - Benign
  - Malignant
- Focal orchitis/abscess
- Hematoma
- Infarct
- Ectasia of rete testis
34 yo with gynecomastia

Leydig Cell Tumor

Malignant Testicular Tumors

- Germ cell: 90%
  - Seminoma
  - Embryonal cell
  - Teratoma
  - Choriocarcinoma
  - Yolk sac
- Gonadal: 5-10%
  - Leydig, Sertoli
- Metastases: lymphoma, leukemia

Testicular Mass: DDx

Most Common Testicular Tumors by Age

- Child
  - Yolk sac tumor
  - Teratoma
- Adult
  - Seminoma
  - Embryonal

Post-intervention Testicular Mass

- Sperm retrieval
- Post biopsy
- Post Orchiectomy
**Post-intervention Testicular Mass**

Post biopsy
- Round, hypoechoic lesion
- Contour defect
- Striations

**Post-intervention Testicular Mass**

Sperm retrieval
- Frequent hematoma
- Calcifications

**40 yo s/p left orchiectomy**

Metachronous Germ Cell Cancer

**45 yo male with prior left orchiectomy**

Metachronous Germ Cell Cancer

**Post-Orchiectomy**
- 1-3% incidence contralateral dz
- Focal mass: 67% = malignancy
- Heterogeneity: 27% = malignancy

**Testicular Cases: Part II**
One day old male

Congenital Torsion, Bilateral

45 yo with right scrotal swelling

Right Testicle

Left Testicle

Non-Hodgkins Lymphoma

Ectopic Adrenal Rests

Multifocal Testicular Masses

Ectopic adrenal rests

• Pts with congenital adrenal hyperplasia
  • Chronically raised ACTH
• Ectopic rests fail to involute
• Bilat, multiple, round, hypoechoic, solid

40 yo with right scrotal swelling

Multifocal Seminoma
30 yo with left testicular pain

Granulomatous Orchitis

34 yo wrong place, wrong time

Testicular Trauma/Hematoma

Testicular Trauma

- Grades
  - 1 = hematoma
  - 2 = minor lac of tunica
  - 3 = major lac
  - 4 = avulsion/destruction

Rumack Diag US 2nd edition

40 yo MCA

Salvage Rate:
- 90% @ 72 hrs
- 45% after that
Testicular Trauma

• Features:
  • TUNICA DISRUPTION
  • Focal abn1 "mass"
  • Hematocele 33%
  • Irregular contour
  • Fracture line 17%

Darwin Award winner

Multiple Testicular Masses: DDx

• Testicular tumor
  – Malignant: mets vs primary
• Ectopic adrenal rests
• Hematomas/Trauma
• Abscess/orchitis
• Congenital Torsion

21 yo with right palpable mass

Bilateral Microlithiasis

Right Testicle  Left Testicle

Epididymal cyst on Right, not shown

Testicular Microlithiasis

• First reported in 1970, 4 yr old
• Uncommon condition (2%)
• Multiple, 2-3mm calcifications
• Associations:
  • Cryptorchidism
  • Infertility
  • CIS and Testicular Cancer
Pathology study of 11 children with microlithiasis

“Our findings favor the interpretation that the microliths are located outside the tubules and have been present there since very early stages of testicular development.”


Testicular Microlithiasis

Malignancy Rates in Patients with Microlithiasis

- Ikinger 74% 92 p orchiectomy
- Backus 40% 42 patients
- Hobarth 45% 1,1710 U/S
- Miller 30% 86 patients
- Ganem 36% 22 patients

Testicular Microlithiasis

- Furness et al
  - 26 children followed prospectively
  - No interval development of cancer (2 yrs)
  - Still recommend yearly U/S and PE
- Whitman et al
  - 21 patients (age 4 to 41) with microlithiasis
  - Average follow-up 6 years
  - No interval development of malignancy

Testicular Microlithiasis

Madigan Army Prevalence Study

- Examined cohort of asymptomatic men
- 5% incidence (84 of 1504 men, 18-35)
- All with normal tumor markers
- Racial/geographic distribution
  • opposite of testicular cancer
- No association with testicular cancer

Peterson J of Urology 2001; 166: 2061-2064

Testicular Microlithiasis

MIR Prospective Study

- Prospective study of 1,079 men
- Signs/sxns = pain, mass, infertility
- Two forms
  • Classic = > 5 calcif per field
  • Limited = < 5 calcif seen

W. Middleton Radiology August 2002

Testicular Microlithiasis

MIR Prospective Study

- Incidence of microlithiasis = 18%
- Testicular cancer:
  • Total men with cancer = 1.4%
  • Of men with Classic form = 8%
  • Of men with Limited form = 5.8%

W. Middleton Radiology August 2002
40 yo with left testicular pain

Testicular Microlithiasis

MIR Prospective Study: F/U Study

- 72 with TM of original 1,079 men
- 45 month f/u
- All received U/S
- No interval tumors

Bennett Radiol 2001; 218: 359-363

Testicular Microlithiasis

- 3,477 patients
- Microlithiasis seen in 2%
- Odds ratio 9.5 for testicular cancer
- Association with primary intra-testicular malignancy


Testicular Microlithiasis

Madigan Army Prevalence Study F/U

- F/U of 84 asymptomatic men with TM
- Clinical f/u for 63 men over 64 months
- 1 (1.6% of 63) dx’d with testicular CA
  - Mass on self exam
  - Confirmed on US
  - Stage 1 mixed type

DeCastro J of Urology 2008 179: 1420-1423

50 yo with right testicular pain

Pre-op bHCG 91
Post op bHCG 8

Testicular Microlithiasis

- Microlithiasis & Seminoma

?? yo Professional Football Player

Elevated bHCG

No tumor; Steroid use!
Testicular Microlithiasis

Current Recommendations
- Regular Self Exam
- Yearly physical exam
- Consider laboratory tests
- U/S if abnormality develops
- ...but what would You do?

36 yo abnl R testicle on OSF

2008: Lesion was 5.2 mm

2011: Lesion was 15 mm

Microlithiasis & Interval Development of Seminoma

Testicular Cases: Part III

38 yo with recurrent right testicular pain

Orchitis, partially treated
**Epididymal Orchitis**

Recommendations:
- Antibiotics for 4-6 weeks
- Briefs, not boxers
- Scrotal Immobilization
- Repeat ultrasound for focal lesion

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**11 yo with left scrotal swelling**

Leukemic infiltration of left testis

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**38 yo with palpable mass**

Fibrosis from Mumps 14 years ago

---

**Unilateral Striated Testis DDx:**

- Neoplasm
  - Leukemia, Lymphoma
  - Rarely, primary testicular CA
- Orchitis
- Fibrosis (especially if > 50 yo)

---

**Striated Testis DDx:**

Differential Diagnosis:
- Neoplasm
- Orchitis
- Fibrosis

---

**Striated Testis DDx:**

Differential Diagnosis:
- Neoplasm
- Orchitis Painful
- Fibrosis
15 yo with left scrotal swelling

Orchitis

Bilateral Striated Testes

Bilateral Fibrosis

2 yo with enlarged testicles

2 cm each

Leukemic Infiltration, Bilateral

25 yo with Groin Pain

Testicular Cancer

Right Testis 5.7 x 3.5 x 4.8 cm

Testicular Cases: Part IV

Table of Contents
Cryptorchidism

- 22-fold increase risk of malignancy
  - 25% in contralateral “normal” testis
- Orchiopexy:
  - Improves fertility
  - Reduces risk of malignancy
  - Orchiopexy best at 1 year of age

21 yo with History Withheld

Undescended Right Testis

38 yo with left scrotal swelling

Germ Cell Cancer

38 yo with left scrotal swelling
19 yo with right testicular pain

Rt Testicular Torsion, proven at surgery

Diffuse Testicular Abnormality: DDx
- Tumor: mets vs. primary
- Diffuse Orchitis
- Torsion
- Post-infarction
- Trauma/avulsion

"What's your HCG level?" Wolff asked me.

HCG is the endocrine protein that stimulates women's ovaries, I had learned, and it was a telling blood marker because it should not be present in healthy males. I shuffled through the papers, looking at the various figures. "It says a hundred and nine," I said.

"Well, that's high," Wolff said. "But not extraordinary"

As I stared at the page, I saw another notation after the number.

"Uh, what's this "K" mean?" I asked.

He was silent for a moment, and so was I.

"It means it's a hundred and nine thousand," Wolff said.
Testicular Torsion

- Incidence: 1 in 4000 men < 25 yr
- 30% with acute scrotal pain
- Types:
  - Extravaginal: neonates, in external ring
  - Intravaginal: boys 12-18
    - Puberty enlarges testes
    - Abnormal suspension, "bell-clapper" deformity

Testicular Torsion

- Improve Sensitivity to Flow
  - Color flow
    - Low scale
    - Low Pulse repetition frequency
  - Doppler: open sampling box
  - Use Power Doppler
  - Contrast agents?
19 yo with left testicular pain

Left Testicular Torsion

23 yo with R-sided pain

Right Testicular Torsion → Detorsion

Which side is abnormal?

9 year old

Pediatric Patients
- Asymptomatic testis = internal control
  - Blood flow symmetric normally
- Lack of diastolic flow seen in 20% of nl
- 3-20% boys = no internal flow in nl testes

Barth Radiology 1997; Bader Radiology 1997

Right testicular pain

9 year old

Right Epididymal Orchitis
11yo with right testicular pain

Right Epididymal Orchitis

42 yo s/p hernia repair

Testicular Infarction
With atrophy/fibrosis

42 yo s/p hernia repair

Ischemia, NOT Torsion

60 yo s/p hernia repair; pain x 1 mo

Too much flow

Testicular Waveforms

Too little flow

Just Right

60 yo s/p hernia repair; pain x 1 mo

Table of Contents
Testicular Resistive Indices

- Symptomatic men vs controls
- RI ≤ 0.5 RI’s = much lower
- Results in setting of inflammation
  - Sensitivity 91%
  - Specificity 94%
  - Accuracy 94%
  - PPV/NPV 83%/77%

Jee Acta Radiol 1997

Extra-testicular Cases: Part I

33 yo with palpable scrotal mass
- Adenomatoid Tumor

55 yo with palpable scrotal mass

55 yo with palpable scrotal mass
- Leiomyoma

40 yo with palpable scrotal mass
- Lipoma

Woodward Radiographics Jan 2003
40 yo with palpable scrotal mass

39 yo with palpable scrotal mass

5 yo with painless scrotal swelling

5 yo with painless scrotal swelling

Scrotal Rhabdomyosarcoma

- Most common solid extratesticular tumor in boys/adolescents
- Fast growing
- Imaging for Staging
  - Chest CT
  - Bone scan/MR spine

Epididymal Lesions: DDx

- Spermatocele
- Infection
- Inflammation: sarcoid
- Sperm cell granuloma (s/p vasectomy)
- Tumors
  - Benign
  - Malignant

Sperm Cell Granuloma

Rhabdomyosarcoma
Epididymal Solid Masses

- Adenomatoid tumor
  - 30% of epididymal tumors
  - Benign
- Leiomyoma
- Lipoma
- Embryonal rhabdomyosarcoma
- Metastases
- Cystadenoma (von Hippel Lindau)
- Sarcomas

Most Common Masses by Age

Boy/Adolescent  Rhabdomyosarcoma

Older man  Adenomatoid
           Lipoma (cord)

Extra-testicular Cases: Part II

20 yo with left palpable mass

Papillary renal cell carcinoma in 20 yo male

20 yo with left palpable mass
Varicoceles

- Vessel > 3 mm
  - Increases in size with valsalva
- Left-sided > right
  - Bilateral in 40%
- Associated testicular atrophy
  - Absolute indication for varicocelectomy
Male Infertility

Why Ultrasound Is Important
• May discover cause of infertility
  • Varicoceles
  • Up to 64% infertile men have atrophy
    – Normal Testicular volume: 15 to 20 ml
  • Blocked ducts to prostate (endorectal U/S)
• Association with testicular malignancy
  • 0.5%, 1/200 compared to 1/20,000 gen. pop.

Extra-testicular Cases: Part III

68 yo diabetic with scrotal swelling

Fournier’s Gangrene

• Wide age range; peak 50-70
• Risk Factors:
  • Diabetes
  • Alcoholism/IVDU
  • Immune incompetence
• 20% fatality
• Treatment: Abx, debridement

Fournier’s Gangrene

Fournier’s Gangrene

60 yo with scrotal swelling

Scrotal Thickening

Scrotal Thickening: DDx
- Cellulitis/Necrotizing fasciitis
- Edema: vasculitis, third-spacing
- Trauma
  - Hematoma
  - Laceration

50 yo with swollen left scrotum

Extra-Extra-testicular Cases

16 yo with abnormal scrotum

Table of Contents
30-some yo radiologist, s/p 1 wk mountain biking and rope rock climbing

Edematous Spermatic Cord

Extreme Mountain Bikers

Scrotal Abnormalities (94%) versus Controls (16%)

- Scrotal calculi 81%
- Epididymal cysts 46%
- Epididymal calcific 40%
- Testicular calcific 32%
- Hydroceles 28%
- Varicoceles 11%
- Microlithiasis 1%

Frauscher Pad May 2001

65 yo with left inguinal pain

Diverticulitis

65 yo with left inguinal pain

40 yo with swollen right scrotum

Inguinal Hernia

35 yo with left scrotal swelling

Liposarcoma

Table of Contents
Liposarcoma

60 yo with swollen left scrotum

Lymphoma

60 yo with swollen left scrotum

25 yo Trauma pt s/p assault
25 yo Trauma pt s/p assault

Germ Cell Cancer

Extra-tesicular lesion in 34 yo male

Adenomatoid Tumor

74 yo with scrotal swelling

Hematoma

INR of 3.8

32 yo with scrotal swelling

Right Testicle

Left Testicle

Microlithiasis & Germ Cell Cancer

48 yo with scrotal swelling

Hernia

Woodward Radiographics Jan 2003

Woodward Radiographics Jan 2003
60 yo with scrotal swelling

25 yo with palpable mass

34 yo with SOB

Pressure Effects From Hydrocele

Epidermoid Cyst

Metachronous tumor

Left Testicle

Left Testicle

S/P Rt orchiectomy

Table of Contents

792
34 yo with SOB

Non-seminomatous Cancer

62 yo with scrotal pain

Fournier’s Gangrene

22 yo Trauma: Kneed in Groin

Rt testicle

L testicle

22 yo Trauma: Kneed in Groin

L testicle
22 yo Trauma: Kneed in Groin

Bodyguard for Mexican President, s/p assassination attempt

Bodyguard for Mexican President, s/p assassination attempt

Fetal Ultrasound, Gender Male

The End
43rd Annual
Post Graduate Radiology Course
October 22 – 26, 2018

20th Annual
Breast Imaging and Interventions Update
October 26 - 28, 2018