CT Imaging of the Kidney

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Renal Anatomy: Axial View

- Peritoneum
- Right Kidney
- Renal Capsule
- Pararenal fat
- Perinephric fat
- Gerota’s Fascia
- Renal Vein
- Renal Artery

Renal Anatomy: Sagittal View

Renal Cortex

Renal Pyramids

Renal Column (of Bertin)

Minor Calices

Major Calices

Renal Pelvis

Ureter

Standard CT Technique for Renal Imaging

- 5mm-10mm collimation usually adequate to demonstrate kidneys
- IV contrast allows differentiation of pathologic processes from nl parenchyma
  - Corticomedullary differentiation max at 30 sec
  - Nephrographic phase best seen at 70-100 sec
- Non-contrast Helical CT for uro/nephrolithiasis
Congenital Abnormalities

• Duplicated collecting system/partial duplication → bifid renal pelvis
• Horseshoe Kidney
  – Connecting isthmus across midline, usu between lower poles
• Crossed Ectopia
  – The ureter of the ectopic kidney inserts into the bladder orthotopically (i.e. on opposite side)
• Pelvic or Intrathoracic Kidney
• Renal hypoplasia
• Renal agenesis
Crossed Ectopia

- Lower kidney is usually the ectopic one
- In 90% there is fusion of both kidneys (crossed-fused ectopia)
- Incidence 1:1000 births
- Slightly increased incidence of calculi, however, incidence of other assoc anomalies is low
Crossed Ectopia

Axial abdominal CT, contrast enhanced, nephrogram phase

Right orthotopic kidney

Left crossed ectopic kidney

Nephrocalcinosis

Causes:

• Renal Artery Atherosclerosis
• Nephrolithiasis = stones in the collecting system
• Medullary Nephrocalcinosis (95%) = calcium deposition in medulla
  – Renal Tubular Acidosis, Medullary Sponge Kidney, HyperCa2+
    states (hyperPTH, Paraneoplastic), Papillary necrosis (Diabetes
    Mellitus, sickle cell), TB
• Cortical Nephrocalcinosis (5%) = calcium deposition in cortex
  – Chronic poststrep glomerulonephritis, Oxalosis, Alport synd,
    Acute cortical necrosis
• Infection, Cyst, Tumor, Hematoma
Nephrolithiasis

• Epidemiology
  – Up to 10% by age 70, usu in 3rd to 4th decade
  – 4:1 M to F ratio
  – More prevalent in the South

• Risk Factors
  – Hypercalcemic states, Crohn’s, stents, RTA, infection, gout, hypercalciuria, hyperuricosuria, cystinuria

• Symptoms
  – Asymptomatic, flank pain, hematuria
Composition

OPAQUE contains calcium +/- phosphate
• Calcium calculi
  – Ca oxalate, Ca phosphate
• Struvite calculi
  – Magnesium ammonium phosphate = triple phosphate

SEMI OPAQUE contains sulphur
• Cystine calculi

LUCENT
• Uric acid stones; Xanthine
• Matrix (coagulated mucoid material)
CT Imaging of Stones

- Essentially all renal and ureteral calculi have high attenuation on non-contrast CT (all but matrix stones have atten of > 100HU)
- CT has sensitivity of 97% and specificity of 96%
- Can also see hydronephrosis, hydroureter, renal enlargement, or perirenal stranding
- Must differentiate from phlebolith which is a calcified blood clot in a pelvic vein. (appearance: round/ovoid, smooth, central lucency, in true pelvis)
Nephrolithiasis

Radio opaque stone in calyx

Hydronephrosis

Dilated urine filled pelvis

Stent

Hydroureter

Pyelonephritis

• Bacterial infection of portions of renal parenchyma
• Usually via ascending infection from the bladder
• Risk Factors include vesicoureteral reflux, DM, pregnancy, immunocompromised states, prolonged catheterization, neurogenic bladder
• Sx’s include flank pain, fever, pyuria, leukocytosis
• Usual suspects → E. coli, proteus, klebsiella
CT Imaging of Pyelonephritis

- Focal or diffuse renal enlargement
- Parenchyma may be low in attenuation on non-contrast (C-) images
- Usually wedge-shaped regions of decreased enhancement on C+ images
- Perinephric stranding or fluid collections, often with thickening of Gerota’s fascia
Pyelonephritis

Xanthogranulomatous Pyelonephritis (XGP)

- Bacterial renal infection with an unusual/characteristic immune response
- Parenchyma infiltrated with lipid-laden macrophages
- Proteus mirabilis is usual causative organism
- Associated with staghorn calculus
- Often chronic, non-spec sx’s → fever, malaise, pain, leukocytosis
CT Characteristics of XGP

- May demonstrate classic finding of staghorn calculus
- Low-attenuation renal mass; decreased excretion of contrast
- Enlarged kidney
- Perinephric inflammatory changes
- 85% of cases have diffuse renal involvement
Xanthogranulomatous Pyelonephritis

XGP with Staghorn Calculus

Perinephric Stranding from XGP

Renal Cystic Disease

- Very common ➔ 50% of pts over age of 50
- Assoc w/ many syndromes, etiology unknown, probably arise from obstructed tubules or ducts
- Most commonly asymptomatic
- Rarely, may have hematuria, HTN, cyst infection, or mass effect
CT Characteristics of Simple Cysts

- Smooth, imperceptible cyst wall
- Sharp demarcation from surrounding renal parenchyma
- Water attenuation (<15 HU), homogenous throughout lesion
- Non-enhancing
- Simple cysts are w/o septations or calcification
- May have slight elevation of adjacent renal parenchyma → Beak sign
Complex Cysts: Categorized using the Bosniak Classification

- Categories based on imaging features that are intended to serve as guideline for estimating likelihood of malignancy
  
  Type I - simple cyst
  Type II - mildly complicated cyst ➔ mild Ca2+, thin septations, no enhancement
  IIF - slightly more complex type II lesions
  Type III - complex cysts ➔ thick wall; multiple, irreg, thick septations/calcifications, no enhancement
  Type IV - cystic neoplasm ➔ enhancing wall or solid component
Treatment

- Type I – no f/u required
- Type II – no f/u required
- Type IIIF – f/u CT after 3-6 months
- Type III – Excision
- Type IV - Excision
Type I Simple Cyst

Bird Beak Sign

Simple Cyst

Aortic aneurysm

Inferior vena cava with filters

Type IV Cystic Neoplasm

Complex renal mass infiltrating lvc

Conditions Associated with Multiple Cysts

- Autosomal Dominant PCKD
- Autosomal Recessive PCKD
- Acquired Cystic Disease (hemodialysis pts)
- Von-Hippel-Lindau disease
- Tuberous Sclerosis
- Medullary Sponge Kidney
Benign Masses

- Cysts
- Angiomyolipoma
- Oncocytoma (via epithelial cells of prox tubule)
- Renal Adenoma
- Mesoblastic Nephroma (hamartomatous tumor, usu present at birth)
- Hemangioma
- Various Renal Pelvic Tumors(papilloma, angioma, fibroma)
- Hematoma
Angiomyolipoma

- Hamartomas containing fat, smooth muscle, and blood vessels
- Usually asymptomatic, but may spontaneously bleed
- Large AMLs resected or embolized
- Multiple AMLS usually Associated w/ tuberous sclerosis
- On CT→ *fat attenuation in mass*, strong contrast enhancement (RCCs rarely contain fat), no Ca2+
Angiomyolipoma

Note fat content

Malignant Masses

- Renal Cell Cancer
- Transitional Cell Cancer
- Wilm’s Tumor
- Nephroblastomatosis (multiple rests of embryologic metanephric blastoma)
- Lymphoma
- Metastases (lung, breast, colon, melanoma)
Renal Cell Ca

- Most common primary renal malignancy (85% of primary renal tumors)
- Assoc w/ smoking, family hx, age, Von Hippel-Lindau, Acquired Cystic Disease/chronic dialysis, phenacetin abuse
- Presentation: Hematuria, flank pain, wt loss, palp mass, fever, anemia, paraneoplastic syndromes
- ↑ liver enzymes w/o mets → Stauffer syndrome
CT characteristics

- Variable from complex cyst to large, heterogeneous renal mass
- Generally enhancing
- May have calcifications
- May have hemorrhage and central necrosis
- Usually no fat
Robson Staging

- Stage I – contained w/in renal capsule
- Stage II – contained w/in Gerota’s fascia
- Stage III
  - A – venous invasion (renal v, IVC)
  - B – lymphatic invasion
  - C – both
- Stage IV – distant metastasis (lungs, liver, lytic bone, adrenal, contra renal)
Renal Cell Ca

RCC

References

- Beth Israel Deaconess Medical Center, Dept of Radiology, Teaching Files, 2001
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