Infections of the urinary tract

Hematuria

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Urinary tract infection (UTI)

Asymptomatic bacteriuria

Fulminant pyelonephritis
Abscess formation
Life-threatening uro-sepsis

Urinary tract infection

► Lower/Upper UTI
  ▪ Lower UTI (urethritis/cystitis) rarely needs imaging
  ▪ Upper UTI (ureter, collecting system, parenchyma - pyelonephritis)
► Asymptomatic UTI / Symptomatic UTI
► Uncomplicated / Complicated UTI
  ▪ Complicated
    ▪ Unresponsive to treatment
  ▪ Atypical bacteria
  ▪ Underlying
    ▪ malformation
    ▪ tumor
    ▪ stone
    ▪ obstruction

Acute pyelonephritis - children -

► At age 7
  ▪ Girls: 8%
  ▪ Boys: 2%
► Peak incidence <1 year of age

Acute pyelonephritis - children -

► Newborns/neonates
  ▪ Elevated, normal or subnormal temperature
  ▪ Lethargy, anorexia, paleness, tenderness
► Infants and young children
  ▪ Unexplained fever (may be only symptom)
  ▪ Irritability
  ▪ Vomiting
  ▪ Failure to thrive
► Older children
  ▪ High fever >38.5°C or chills
  ▪ Flank pain and local tenderness
Acute pyelonephritis - children -

What are the risks?
- Acute: spread of infection leading to abscess, septicemia
- Long-term: renal damage (scarring)
  - risk for hypertension
  - risk for complications during pregnancy
  - risk for reduced renal function if extensive and bilateral damage

Goal of imaging
- Identify complications (obstruction, abscess) that may need acute intervention (drainage, pyelostomy)
- Identify underlying factors
  - malformations, parenchymal damage, reflux, stone, obstruction
- Identify individuals with, or at risk of, renal damage

Acute imaging
- Ultrasonography
  - renal parenchyma often appears normal
  - renal swelling
  - heterogeneous parenchymal echogenicity
    - Doppler/iv contrast may improve detection of inflammation
  - dilatation (endotoxins and/or obstruction)
    - ureteric jet may help in assessing obstruction
  - thickening of the urothelium
  - pyonephrosis (echogenic pus in collecting system)

Post-pyelonephritic scarring

Pyelonephritis - children -

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Acute imaging - children -

- Acute imaging
  - Ultrasonography
    - To detect dilatation
    - vesicoureteral reflux
    - If dilatation
      - VCUG to detect gross reflux and posterior urethral valve (boys)
      - MAG3 scintigraphy to evaluate obstruction and split renal function

Acute imaging - children -

- Ultrasonography
  - Patient friendly and available
  - Adequate for identification of dilatation
  - Insufficient for assessment of acute inflammation
  - Insufficient for assessment of renal scarring
Acute pyelonephritis - children -

► Urography
  • Does not show acute inflammation
  • Underestimates renal scarring, as compared to DMSA scintigraphy
  • Higher radiation dose
► Urography nowadays not recommended, if DMSA scintigraphy is available

Tc\textsuperscript{99}-DMSA scintigraphy

► i.v. injection
► Accumulates in proximal tubular cells
► Imaging 2-3 hours after i.v. injection
► Focally reduced or absent uptake in affected parts of the parenchyma
► Method of choice for assessment of acute inflammation and for follow-up (scarring)
► Differentiation between acute and permanent damage may be difficult
► Radiation dose ~1 mSv

Voiding cystourethrography (VCUG)

Key findings:
• Vesico-ureteral reflux
• Posterior urethral valve

Reflux grading:
I: reaching only ureter
II: reaching kidney, no dilatation
III: slight dilatation
IV: moderate dilatation
V: gross dilatation

Urography as adjunct imaging

Duplex

Acute pyelonephritis in children

Current trend:
• Acute imaging with ultrasonography
• Early imaging + f/u imaging with DMSA scintigraphy
• VCUG in all children or only if reflux is suspected (dilatation at US or abnormal DMSA)
• MAG3 if suspected obstruction (dilatation at US)
• Urography/CT/MRI if unclear
UTI in adults
► The majority:
  ▪ Sporadic, uncomplicated, lower UTI in women
  ▪ 1/3 of women aged 20-40 have had one or several UTIs
  ▪ Adolescence and after menopause
  ▪ Self-limiting or easily treated with antibiotics
► In men:
  ▪ Uncommon before age 50
  ▪ Increasing frequency with prostatic hyperplasia

Acute pyelonephritis in adults
- does it matter? -
► Uncontrolled infection
  ▪ Renal/perirenal abscess
  ▪ Septicemia
  ▪ Septic shock
  ▪ Death
Febrile UTI + obstruction = emergency

Acute pyelonephritis
► Fever >38°C
► Flank pain
► Tenderness over kidney area
► Nausea, vomiting, malaise
► Urinary frequency, dysuria
► Symptoms may be vague, especially in elderly
► Hypotension, tachypnea and clinical deterioration may indicate septicemia

Acute pyelonephritis in adults
► Who needs imaging?
  ▪ Women with single uncomplicated pyelonephritis, that responds to antibiotics, do not need imaging
  ▪ Women with >2-3 episodes/year need imaging
  ▪ Recommendations for men vary:
    ► Alternative 1: as for women
    ► Alternative 2: imaging in all cases
  ▪ Diabetics and immunosuppressed:
    ► Imaging usually indicated

Acute pyelonephritis?

Key findings:
- Renal swelling
- Perirenal stranding
- (Low attenuation areas)
- (Dilatation)

Acute pyelonephritis
- Perirenal stranding
Acute pyelonephritis

- Unenhanced CT
  - to reveal underlying stones
  - scanning diaphragm to symphysis
  - parenchymal swelling, focal or generalised
  - perirenal stranding
  - widening of collecting system/ureter
    - inhibiting action of bacterial endotoxins on smooth muscle
    - mechanical obstruction

- MDCT (CT-urography) is method of choice
  - Non-enhanced
  - Nephrographic phase for parenchymal assessment
  - Excretory phase (6-10 min) for assessment of obstruction
  - The latter two phases may be combined, using split bolus technique

Pregnancy

- May cause widening of collecting system and ureters
  - hormonal influence
  - mechanical obstruction from large uterus
- Increased risk of pyelonephritis
  - Increases risk for pregnancy complications
- Imaging: MRI or US+single plain film (urography)

Diabetics

- Increased frequency of UTI
- Higher frequency of complicated UTI
  - Pyelonephritis
  - Papillary necrosis
  - Renal abscess
  - Fungal infections
  - Emphysematous pyelonephritis
    - Necrotizing infection (mostly E Coli)
    - Gas within renal parenchyma, collecting system, perirenal space
    - Risk for progression to septic shock
    - Mortality up to 50%
Emphysematous pyelonephritis
► CT is method of choice
► US may show reflective gas, but is less sensitive than CT
► Urography less sensitive than CT

Renal/perirenal abscess
► Blood born or local spread
► Pain and fullness in the flank
► Fever, malaise
► Elevated CRP and leukocytosis

Low-echogenic lesion in right kidney

Follow up after antibiotic treatment
Post-pyelonephritic scars do occur also in adults, but are rarely extensive and rarely of clinical significance.

**Xanthogranulomatous pyelonephritis**
- Mostly females
- History of UTI
- Flank pain and/or palpable mass
- 10-30% diabetics
- Anorexia, malaise, fever, weight loss

**Pyelonephritis in adults**
- Indications for imaging
  - Treatment failure
  - Recurrent pyelonephritis
  - Growth of uncommon bacteria
  - Diabetics
  - Suspected complications
  - Febrile UTI + obstruction is a medical emergency!
- Method of choice = CT

**Tuberculosis of the urinary tract**
- Mostly history of TB, mainly of the lungs, but it may be years back, i.e. re-activation
- Often asymptomatic, easily overlooked
- Symptoms may be non-specific
  - Weight loss, fever, malaise
- Upper UTI, not responding to standard antibiotics
- Cystitis

**Xanthogranulomatous pyelonephritis**
- Elevated erythrocyte sedimentation rate
- Leukocytosis, pyuria, anemia, hematuria present
- Urine culture (E Coli or Proteus)
- Stone and obstruction, poor function
- Renal enlargement
- Replacement of renal tissue by lipid-rich xanthoma cells and inflammatory cells
- Necrosis, cavities due to granulomatous inflammation
- Spreading to the perirenal space

**Tuberculosis of the urine tract**
- Key findings
  - Parenchymal and urinary tract calcifications
  - Focal parenchymal scars
  - Strictures in calyces, pelvis, ureter
  - Abscesses, renal/perirenal
  - Obstructive uropathy
Tuberculosis
► “The Great Imitator”
► May affect any organ
► Always keep TBC in mind as differential diagnosis

Schistosomiasis (Bilharzia)
► S haematobium affects the urinary tract
► 70 million people in sub-Saharan Africa suffer from hematuria related to S haematobium
► 32 million have dysuria
► 18 million have bladder pathology at US
► 10 million have major hydronephrosis

TBC of the urinary tract starts in the kidney and proceeds to the lower urinary tract
► Schistosomiasis starts in the bladder and proceeds cranially

Hematuria (macroscopic)
► Malignancy
  ▪ Renal cell cancer
  ▪ Urothelial cancer in upper tract
  ▪ Urinary bladder cancer
  ▪ Prostate
► Stone
► Benign prostatic hyperplasia
► Infection
► Nephrological diseases
► Anti-coagulation therapy
► Exercise and more...

Acute onset of non-traumatic hematuria
► Cancer
  ▪ bladder, ureter, collecting system, kidney
► Angiomyolipoma
► Renal artery aneurysm rupture
► Stone (often typical symptoms)
► Trauma after all...??

Angiomyolipoma
► Benign, but AML >4 cm tend to bleed
► May be previously unknown
► Bleeding may be life-threatening
► Treatable with embolisation
Trauma after all...?

27 y male
Mild trauma, hit by knee in abdomen during play.
6 hours later abd pain, vomiting, hematuria

Seemingly innocent trauma may cause bleeding if there is pre-existing hydronephrosis

Hematuria
Role for urography?

► Advantages
  ◦ Time honoured
  ◦ Visualization of collecting system and ureters
  ◦ Shows renal and urinary tract function

Urography - disadvantages

► Suboptimal for stone disease
► Insufficient for infection
► Insufficient identification of renal tumors
  ◦ 21% of tumors <2 cm identified
  ◦ 52% of tumors 2-3 cm
  ◦ 82% of tumors >3 cm (Warshauer 1988)
  ◦ Less sensitive than ultrasound, CT, MR
► Insufficient for bladder tumor
► Does not differentiate cyst from tumor

CT urography

Definition by CT Urography Working Group of ESUR (Eur Radiol 2008;18:4-17)

► CT examination optimized for
  ◦ Kidneys, ureters, bladder
  ◦ MDCT with thin slices
  ◦ Intravenous contrast medium enhancement
  ◦ Imaging in excretory phase mandatory

Possibilities with MDCT

► Identifies virtually all stones
► Identifies infection
► Identifies renal ischemia
► Identifies renal parenchymal tumors
► Adequate for upper uroepithelial lesions?
► Bladder tumors?
► Various scanning phases
  ◦ Non-enhanced
  ◦ Parenchymal
    ◦ Arterial (cortical, corticomedullary phase)
    ◦ Venous (medullary phase, nephrographic)
    ◦ Pyelographic (excretory phase)

Problems with CT-urolraphy

► Radiation dose
► Uroepithelial abnormalities
CT for Hematuria

- Requires scanning without iv contrast
  - for detection of stones
  - as baseline for lesion enhancement
- Requires early contrast enhanced scanning
  - for renal parenchymal tumor (and bladder ca)
- Requires late contrast enhanced scanning
  - for urothelial tumor in the collecting system, ureter, bladder
- Problem: 3 scans = high radiation dose

Effective dose mSv

- Conventional urography: 3-8 mSv
- Stone-CT: 3-5 mSv
- CT-urography: 10-30 mSv

CT-Urography

- How to optimise visualisation of the collecting system and ureter?
  - Abdominal compression?
  - Diuretics?
  - Intravenous fluid?
    - McTavish et al 2002: saline infusion effective
    - Maher et al 2001: saline infusion not effective
    - Sudakoff et al 2006: saline infusion not effective
  - Oral hydration?
  - Supine vs prone position?
  - Moving the patient around
  - No definite consensus as yet

Two alternatives

- Single bolus (3 or 4 scanning phases)
  - Unenhanced phase
  - Corticomedullar phase (25-35 sec after start of inj) - shows tumor enhancement, including bladder tumors
  - Nephrographic phase (90-110 sec)
  - Excretory phase (~8-12 min)
- Split bolus (2 scanning phases)
  - unenhanced phase
  - combined nephrographic-excretory phase

CT-Urography

- Patient preparation
  - No positive oral contrast
  - Oral hydration with 1 liter of water 30 min (20-60 mon) before CT urography
    - Promotes diuresis and ureteral visualisation
    - (Intravenous drip infusion of up to 500 ml 0.9% saline as alternative)
  - Do not empty bladder

CT-Urography, split bolus, example

1 liter of water to drink during 30 minutes preceding the CT

Scan 1: Non-enhanced low-dose (stone-CT) over urinary tract
Contrast inj 1: 40 ml 400 mg I/ml, 3 ml/s + 60 ml saline
  Wait 8 min
Contrast inj 2: 60 ml 400 mg I/ml, 2 ml/s + 40 ml saline
Scan 2 (90-110 s): Urinary tract standard mAs
Normal MIP-images for anatomical overview

Duplex
MIP reformatted images should not be used in isolation for diagnostic reading. Lesions may become hidden if surrounded by high intensity material (contrast), due to the projection of only maximum intensities.

Always scrutinize the source images.

Urothelial tumor:
- Slightly hyperdense mass, as compared to urine and renal parenchyma, on non-contrast scanning
- Compression of the renal sinus fat
- Filling defect
- Enhancing mass
- Wall thickening
- Proximal dilatation
Urothelial tumor grade II with infiltration into the parenchyma.

Urothelial tumor

73 HU
High density ureteral tumor

CT-urography for bladder cancer
Promising, but still inferior to cystoscopy
(79% sensitivity - Sadow et al, Radiology Oct 2008)
Conclusions CT-urography
► Covers most important conditions
► Limited scientific evidence available for small uroepithelial tumors
► CT-urography works in clinical practice
► Replacing urography
► Radiation dose has to be considered

Need for urography?

No,
…but availability, cost, radiation concerns with CT, and tradition, may still be life-saving for urography

Thank you