Unequivocal Obstructive Uropathy
Radiologic Assessment

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Goals

Review Anatomy: Urinary Tract
Define Unequivocal Obstructive Uropathy
Pathophysiology
Pathology
Clinical Presentation
  Patient KA
  Patient JL
  Patient JM
Radiologic Work-up Modalities
Management
Anatomy: Urinary Tract

Medline Plus: Medical Encyclopedia: Female Urinary System

http://www.urostonecenter.com/images/p1.gif
Unequivocal Obstructive Uropathy

= Urinary tract obstruction

Unequivocal: clear etiology

- Obstruction may be at any site within GU tract
- Evidence of post-renal failure
- Variable presentation based on etiology

Sign: Hydronephrosis = dilatation of renal pelvis and ureters
Pathophysiology of Obstructive Uropathy

Hydronephrosis

Pathogenesis of unilateral hydronephrosis. Smith's Urology p.181

Mechanical or functional obstruction

Back up of urine flow = increased renal pressure

Tubular dilatation

Initial increase in renal blood flow

Decrease in renal blood flow

Increase in renal lymphatic flow

Initial increase in ureteral peristalsis & pelvic muscle hypertrophy

Muscle stretched & atonic → Aperistalsis

Dilatation of ureters and renal collecting duct system

Parenchymal Atrophy

Renal failure
How Acute Obstruction leads to Dilatation and Decreased Tubular Function

Fig. 23.2 Pathophysiology of acute obstruction.

Blandino et al., AJR 2002; 179: 1307 -1314
Pathology

Dilated renal pelvis (arrow), external view
http://www.smbs.buffalo.edu/pth600/IMC-Path/y1case/y1ans21.htm#Obstructivelesionsintheurinarytract

Dilated pelvis & calyces, renal atrophy, cut surface
http://www.smbs.buffalo.edu/pth600/IMC-Path/images/Year1/Hydronephrosis_Gross-_Robbins.jpg
# Clinical Presentation: Obstructive Uropathy

## Lower and Mid Tract (Urethra and Bladder)
- Hesitancy in starting urination
- Lessened force
- Weak stream
- Terminal dribbling
- Hematuria
- Burning on urination
- Cloudy urine (infection)
- Acute urinary retention

## Upper Tract (Ureter and Kidney)
- Flank pain radiating along ureter course (distension)
- Gross hematuria
- Nausea/Vomiting
- Fever/Chills
- Burning on urination
- Cloudy urine with infection
- Bilateral uremia
- N/V/weight loss

### Renal insufficiency
Consider UTO in all patients with unexplained renal insufficiency.

### Urine Output Changes
- **Anuria** = complete bilateral UTO
- Partial obstruction $\rightarrow$ normal to elevated UO

### Hyperkalemic renal tubular acidosis

### Hypertension

### Lab Abnormalities:
- normal, microscopic/gross hematuria, pyuria, azotemia, uremia, anemia (2/2 chronic infection, ACD), leukocytosis
**Presentation: Patient KA**

65 yo male c/o several days of hematuria and back pain.

Exam: MM dry, enlarged prostate, difficult foley placement, minimal urine output (30cc following 1 L IVF)

U/A: Large blood, + nitrite, protein > 300mg/dL, glucose 100, ketones 15 mg/dL, large bilirubin, Urobilin 4 mg/dL, pH 6.5, large leukocytes

WBC: 6.2
Hgb: 11.2
Cr: 8.4 (baseline 1.4)
Presentation: Patient JL

57 yo male with history of bladder CA, renal stones, presents with severe L flank pain. s/p TURBT for bladder CA.

Exam: no CVA tenderness, no abdominal tenderness, normal sized prostate

Labs:
- Cr = 1.3
- Hgb = 15.4  WBC = 11.7
- U/A: large blood

Hematuria  
Flank Pain  
Renal function unperturbed
Presentation: Patient JM

27 yo male with h/o left ureter stenosis presents with severe left sided flank pain.
Exam: unremarkable
U/A: clear yellow urine, neg dipstick
WBC: 12.8

Flank Pain
Renal function unperturbed
Differential Diagnosis: Obstructive Uropathy

In The Lumen
- Sloughed papillae/blood clots
- Urinary calculi
- Infection

Intrinsic/Congenital
- Urethral valves
- Urethral strictures
- Meatal stenosis
- Bladder neck obstruction
- Ureteropelvic junction stenosis/obstruction
- Ureterovesical junction stenosis/obstruction
- Ureteric strictures: infectious, iatrogenic, XRT, TB
- Severe vesicoureteral reflux

Extrinsic
- Benign prostatic hypertrophy (BPH)
- Tumors - carcinoma of the prostate, bladder tumors, contiguous malignant disease, transitional cell carcinoma of renal pelvis/ureters/bladder, squamous carcinoma of the cervix, retroperitoneal lymphomas
- Inflammation
  - prostatitis, ureteritis, urethritis, retroperitoneal fibrosis
  - Idiopathic, B-blocker/methysergide use, malignancy, connective tissue disorder
- Uterine prolapse or cystocele
- Endometriosis
- Fibrosis around renal transplant

Dilatation without obstruction
- Gram neg cocci in pyelonephritis → dilatation due endotoxin
- Pregnancy
- Chronic obstruction post-release
- Mega-ureter

Young Adults

Children

Older patients
Think Anatomically: Where is obstruction?

Proximal etiology

Unilateral hydronephrosis

Most Common in Distal Ureter

Systemic or Distal etiology

Bilateral hydronephrosis

Series: 53 of 380 patients
52/53 in lower 1/3 of the ureter.

Causes:
- Ureteral stones 64%
- Ureteral edema or lucent stones 30%
- Neoplasms 4%
- Inflammatory disease 2%

Acute Obstruction and Anuria

Acute complete, bilateral obstruction = Medical Emergency

Patients may die from acute renal failure with oliguria/anuria
Requires prompt recognition and possible surgical intervention

CT examination: Postcontrast axial scan: The retroperitoneal giant tumor mass compresses the right ureter and causes hydronephrosis (arrows).

http://www.szote.u-szeged.hu/radio/panc/alep8c.htm
Diagnosis

Early diagnosis and decompression is critical to prevent renal failure

Continue to Radiologic work-up
Ultrasonography

Test of Choice for Suspected Urinary Tract Obstruction

Screening test
Indications: Renal failure of unknown origin/Hematuria/Signs of UTO/Urolithiasis

*Sensitivity for detection of chronic obstruction: 90%*

*Sensitivity for detection of acute obstruction: 60%*

Advantages:
- No allergic/toxic complications of radiocontrast media
- Fast, inexpensive
- Diagnose other causes of renal disease in patient with renal insufficiency of unknown origin
  - Polycystic Kidney Disease

Disadvantages
- Nonspecific
- Rarely identifies cause
- False positive rate: < 25% with minimal criteria (operator dependent)
  - Any visualization of collecting systems
- False negative with acute obstruction, dehydration, sepsis
- Bowel Gas decreases sensitivity
Ultrasound – Normal Kidney

Normal renal parenchyma, hypoechoic, normal function

Normal renal fat, no dilatation of collecting system, hyperechoic

Pt. AK, PACS, Courtesy of Dr. AC Kim
Ultrasound – Obstructive Uropathy

Renal parenchyma, hypoechoic

Dilated collecting duct, hypoechoic (fluid)

Compressed renal fat, hyperechoic

Pt. AK, PACS, Courtesy of Dr. AC Kim
Abdominal CT & Plain Film

1. CT
   ***Noncontrast***
   Urolithiasis → test of choice in ED
   Size
   Location
   Identify masses/Inflammation causing extrinsic obstruction
   Identify obstructive atrophy
   Quick
   Post Trauma

   Limitations of Plain Film and CT
   • Obstruction due to radiolucent stones (indinavir), sloughing of renal papillae, small blood clot
   • Radiation doses
   • Need Fat to see soft tissue

   Contraindications to Contrast
   • Pregnancy, children, nursing moms
   • Renal failure/insufficiency
   • Allergy
   • Multiple Myeloma
   • CHF
   • Gout

2. Plain Film
   Enlarged renal shadows
   Heavy metal densities → renal stones
   Tumor metastases to bones of spine/pelvis
   Osteoblastic? Likely prostate metastases

CT/Plain film + ultrasound will make the diagnosis of ureteral obstruction in ~90% cases
CT: normal renal parenchyma with proximal stone, no obstructive uropathy

Kawashima et al., RadioGraphics 2004;24:S35-S54
**CT: Hydronephrosis due to retroperitoneal fibrosis (soft tissue)**

CT (postcontrast): Giant retroperitoneal tumor mass compressing the right ureter, causing **hydronephrosis** with compression of **renal parenchyma** (arrows).

http://www.szote.u-szeged.hu/radio/panc/alep8c.htm
CT: Obstructive Uropathy

CT (postcontrast): Obstructive left-sided uropathy with proximal ureteric stone

PACS, Courtesy of Dr. D. Brennan
**IVU: Intravenous Urogram**

Intravenous Pyelogram = Excretory Urogram

1. Scout film → calculi?
2. IV bolus of radiocontrast dye (ionic contrast)
3. Series of plain films demonstrate kidneys, ureters, urinary bladder
4. Upright film post-void to evaluate for obstruction

**Advantages**

- Anatomy
- Pathology Location
- Rough indicator of function bilaterally
- Low false positive rate
- Detects associated conditions
  - Papillary necrosis → intraluminal filling defect
  - Caliceal blunting from previous infection

**Disadvantages**

- Cumbersome
- Requires radiocontrast
- Need bowel prep with conventional IVU
- Radiation dose
- Need cross-sectional imaging follow up

**CT Urography**

Evaluate urinary tract for flow defects
- Noncontrast Scout first: Urolithiasis
- Coronal reconstructions: visualize entire urinary tract

**Advantages over Conventional IVU**
- Speed
- Sensitive to renal parenchyma abnormalities
- Simultaneous evaluation of both renal parenchyma and urinary tract
- Cross-sectional imaging

**Disadvantages**
- Radiation dose
- Ionic Contrast reactions/cannot be used in patients in renal failure

Kawashima et al., RadioGraphics 2004;24:S35-S54
Normal CT Urogram

Pt. JL, PACS, Courtesy of Dr. AC Kim
Normal CT Urogram

CT Urography

Total Body Opacification

Nephrogram

Pyelogram

Pt. JL, PACS, Courtesy of Dr. AC Kim
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CT Urography

Total Body Opacification

Nephrogram

Pyelogram

Pt. JL, PACS, Courtesy of Dr. AC Kim
Contraindications for IVU/CTU

History of allergy to IV contrast
- Bronchospasm, laryngeal edema, anaphylactic shock
- May use with history of minor allergic reactions with preprocedural steroids, antihistamines (diphenhydramine) 12 hours prior to study

Renal insufficiency

Pregnancy = relative contraindication (radiation exposure)
- MR Urogram can be used
- Likewise: children → minimize radiation doses

Pts taking oral hypoglycemics (metformin) should stop taking meds prior to study
- May resume after renal function is confirmed normal
- Risk of lactic acidosis

Must be Physician-Supervised
- Contrast reactions
- Minimize no. of images
- Minimize radiation
- May use Fluoroscopy
**MR Urography**

A. **Unenhanced MR urography**  
   Heavily T2 weighted

B. **Gadolinium-enhanced excretory MR urography**

C. **Excretory MR urography + diuretic**  
   10 mg furosemide IV  
   Gadopentetate dimeglumine

**Advantages:**
- Distinguishes adjacent soft tissue abnormalities  
- With Gadolinium: functional information  
- No ionic contrast → OK in renal failure  
- No radiation → children, pregnancy women

**Drawbacks**
- High cost  
- Low sensitivity in detecting calcifications  
- Time intensive  
- Metallic implants/Foreign Body = Contraindications

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Sagittal contrast-enhanced excretory MR urography obstructing right sided papillary TCC

Blandino et al., AJR 2002; 179: 1307 -1314
Excretory Urogram/CTU/MRU

Acute Obstruction

<table>
<thead>
<tr>
<th>Mild → Moderate → Marked</th>
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<tbody>
<tr>
<td>Kidney minimally enlarged</td>
</tr>
<tr>
<td>Dense Nephrogram</td>
</tr>
<tr>
<td>• Preferential absorption of Na and water from diseased tubules = concentration of contrast</td>
</tr>
<tr>
<td>Delayed appearance of contrast in collecting system</td>
</tr>
<tr>
<td>= delayed function</td>
</tr>
<tr>
<td>Poor concentration of contrast in the collecting tubules</td>
</tr>
<tr>
<td>No ureteral dilatation acutely</td>
</tr>
<tr>
<td>Ureters not tortuous</td>
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### Excretory Urogram/CTU/MRU

**Chronic Obstruction**

<table>
<thead>
<tr>
<th>Partial</th>
<th>Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Progressive dilation of collecting system and ureters/tortuous</td>
<td></td>
</tr>
<tr>
<td>Urectasis = dilated ureter</td>
<td></td>
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<tr>
<td>Decrease number of nephrons</td>
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<tr>
<td>6-12 weeks: irreversible loss of renal function</td>
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<tr>
<td>“Shell nephrogram” → parenchymal atrophy</td>
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<tr>
<td>Collecting system: blunt calyces/forniceal angles</td>
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**Calyceal Clubbing**

Blandino et al., AJR 2002; 179: 1307 -1314
Evaluation of Renal Function: Renal Scan

Renal scan = Renogram = Nephrogram

- Nuclear medicine examination using radioisotopes (Tc-99m DPA) to measure kidney filtration of blood

Findings indicative of decreased renal function
- Delayed appearance of radionuclide
- Diminished uptake compared with normal side
- Dilated collecting system and ureter to point of obstruction on delayed scans

Advantages
- No contrast

Lasix Renogram

http://www.med.harvard.edu/JPNM/TF96_97/Nov26/WriteUp.html

Prompt excretion of activity from the right kidney, but an obstructed pattern on the left side
Evaluation of Renal Function: Renal Scan

Renal scan = Renogram = Nephrogram
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Lasix Renogram

Prompt excretion of activity from the right kidney, but an obstructed pattern on the left side
Patient KA: Work-up

Ultrasound

Bilateral Mild Hydronephrosis

Right Kidney 11.9 cm (baseline 10.6 cm)
Left Kidney 12.7 cm (baseline 11.0 cm)
Normal flow bilaterally (seen on Doppler)
Patient KA

Bilateral Hydronephrosis with dilatation of renal pelvis

Pt. KA, PACS, Courtesy of Dr. AC Kim
**Patient KA: NSAID overdose leading to papillary necrosis and UTO, with secondary infection**

**Diagnosis:**
65 yo M with mild bilateral hydronephrosis, hydroureter, and fat stranding in the setting of acute post-renal failure and oliguria. Believed to be secondary to excessive NSAID use, causing renal papillae necrosis and sloughing and acute prostatitis.

**Management**
- Admitted
- Cystoscopy: R UO Sludge
- Ureteral stents placed
- Pain Management
- Antibiotics for UTI and Prostatitis
Patient JL: Workup

Enlarged kidney

Mild hypoechogenic renal pelvis

Pt. JL, PACS, Courtesy of Dr. AC Kim
Patient JL – Left Hydronephrosis

Pt. JL, PACS, Courtesy of Dr. AC Kim
**Diagnosis:**

57 yo M with known Bladder CA with left hydronephrosis secondary to left bladder cancer.

**Management**

Foley placement for immediate decompression. Pt urinated following catheter removal and was cleared for d/c

Urology consult for possible stent placement
Patient JM: Workup

Massive Hydronephrosis

Pt. JM, PACS, Courtesy of Dr. AC Kim
Patient JM

Fat stranding

Proximal renal pelvis dilatation without dilatation of distal ureter

Pt. JM, PACS, Courtesy of Dr. AC Kim
Pt. JM, PACS, Courtesy of Dr. AC Kim
Patient JM

Parenchymal thickness preserved

No visible stone

Pt. JM, PACS, Courtesy of Dr. AC Kim
**Patient JM: Severe Hydronephrosis Secondary to Ureter Stenosis**

**Diagnosis:**
27 yo M with severe right hydronephrosis likely due to congenital left ureter stenosis
Found to have simultaneous UTI

**Management**
Pain Control
Antibiotics
Referred to Urology for outpatient ureteral stent placement

Pt. JM, PACS, Courtesy of Dr. AC Kim
Urinary Tract Obstruction Without Hydronephrosis

CAVEAT:
UTO can occur without hydronephrosis or dilatation of the urinary tract

1. Acute: Days 1 - 3
   - Duplex Doppler U/S → detect increased resistive index vs. contralateral kidney

2. Mild obstruction without impairment of renal function

Normal Kidney Appearance in the setting of acute obstruction

Pt. AK, PACS, Courtesy of Dr. AC Kim
Hydronephrosis without Obstruction/
with Asymptomatic Obstruction

Presentation: Back/flank pain, hematuria, hydronephrosis and ureteral dilatation

Etiologies
- Pregnancy (normal finding)
- Megaureter due to previous Vesicoureteral reflux
- Dilated but unobstructed extrarenal pelvis
- Gram Negative Cocci infection (Endotoxin)

Goal: Rule out obstruction

1. Diuretic Renogram
2. Diuretic IVU
3. Whitaker Test/Perfusion pressure flow studies

Blandino et al., AJR 2002; 179: 1307 -1314

21 yo M with L Megaureter,
No obstruction
Radiologic Work-up for Urinary Tract Obstruction: Rationale

Obstructive Symptoms
- Flank pain
- Hematuria
- Renal failure
- Dysuria/Frequency
- Urgency

Is there hydronephrosis?
- Ultrasound
  - No: Alternate Work-up
  - Yes/Equivocal with High Clinical Suspicion

Is there mechanical obstruction?
- CT Plain Film
  - Answer Where is it?

What is renal function?
- IVU/CTU/MRU Renal scan/Nephrogram
  - Final Diagnosis

Management:
- Decompression
- Urology Consult
- Cystoscopy
Management of Urinary Tract Obstruction

Surgery
Nephrectomy
Partial Nephrectomy
Resect extrinsic masses

Intraureteral Stone removal
Extracorporeal Shock Wave Lithotripsy
Laser Lithotripsy
Percutaneous Ultrasonic Lithotripsy

Percutaneous Nephrostomy Tube
Emergency Drainage

Ureteral Stents

Cystoscopy
TURB

Foley Catheter

Prostate resection/TURP/PVP

Obstructive lesions of the urinary tract that cause hydronephrosis from Robbins & Cotran, 7th Ed, Chap 20, p 1013
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