Upper Urinary Tract Obstruction and Urinary Stones

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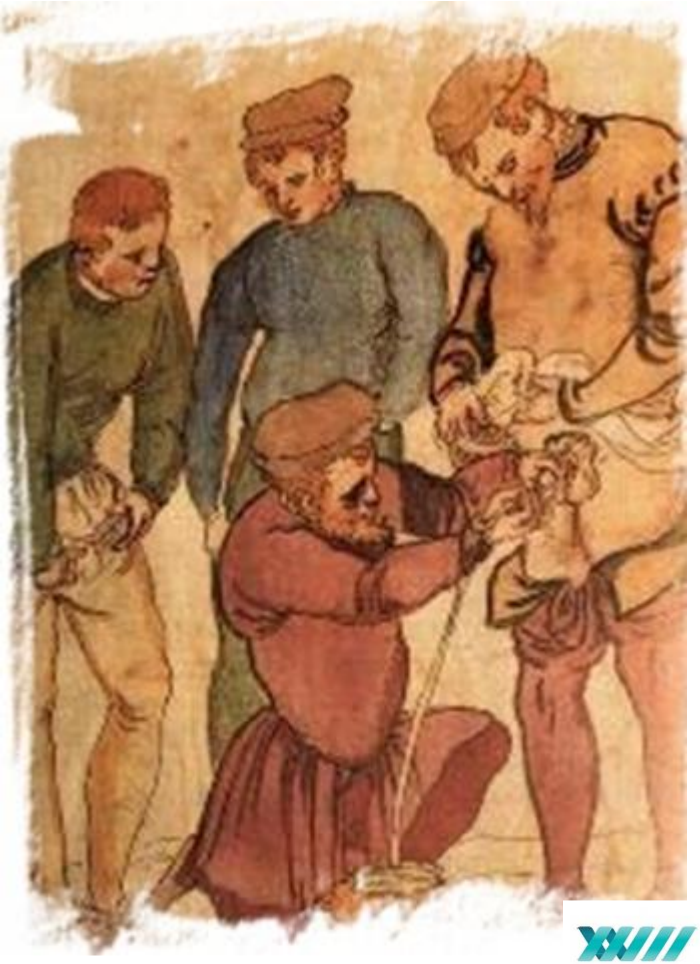
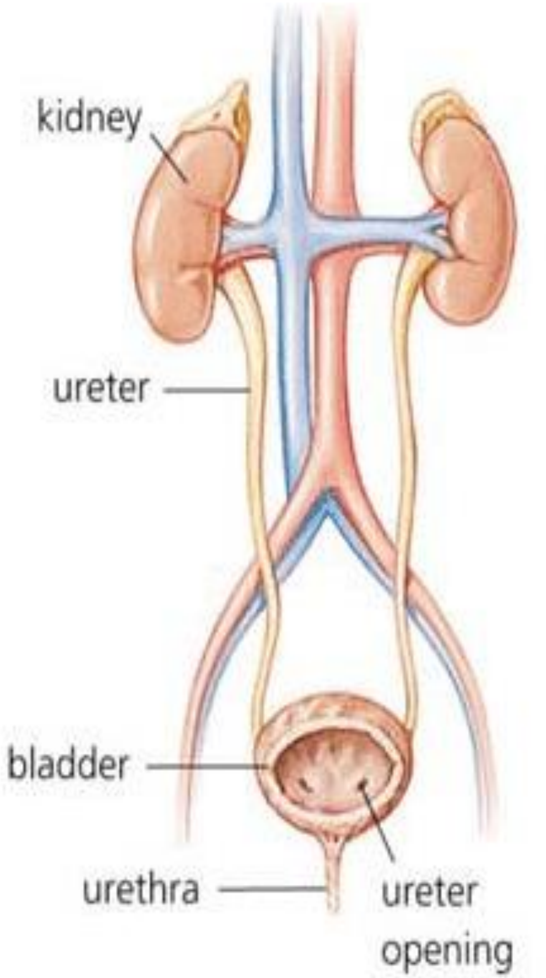
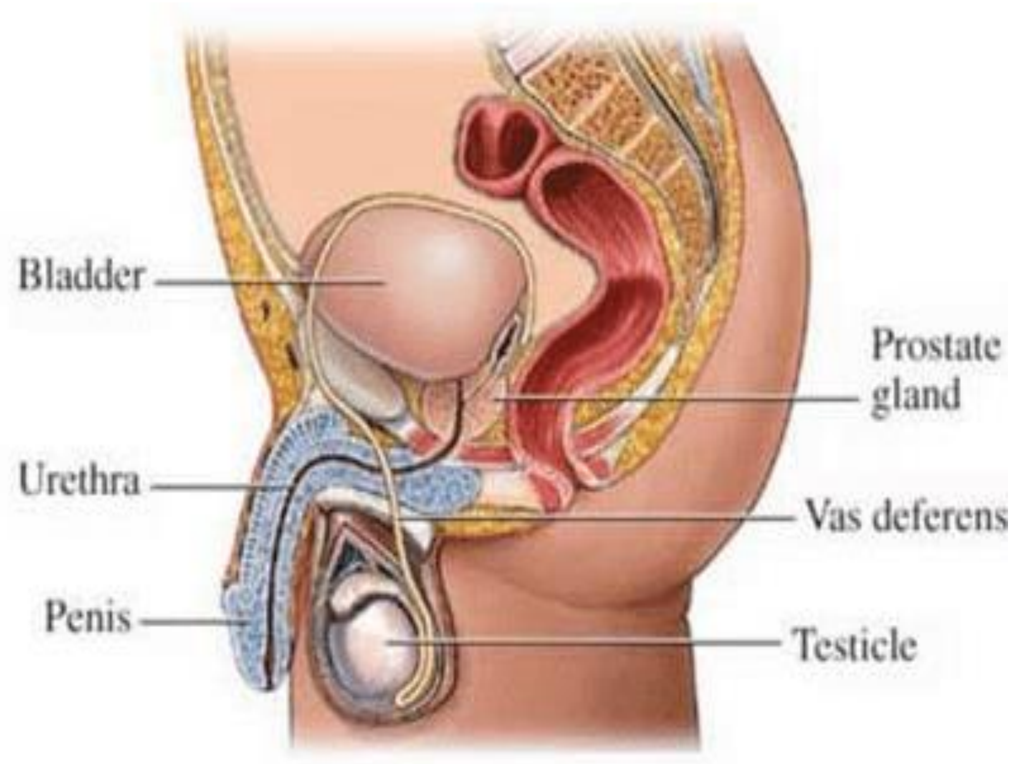
Urology

Oûron (urine) – λογία (study)



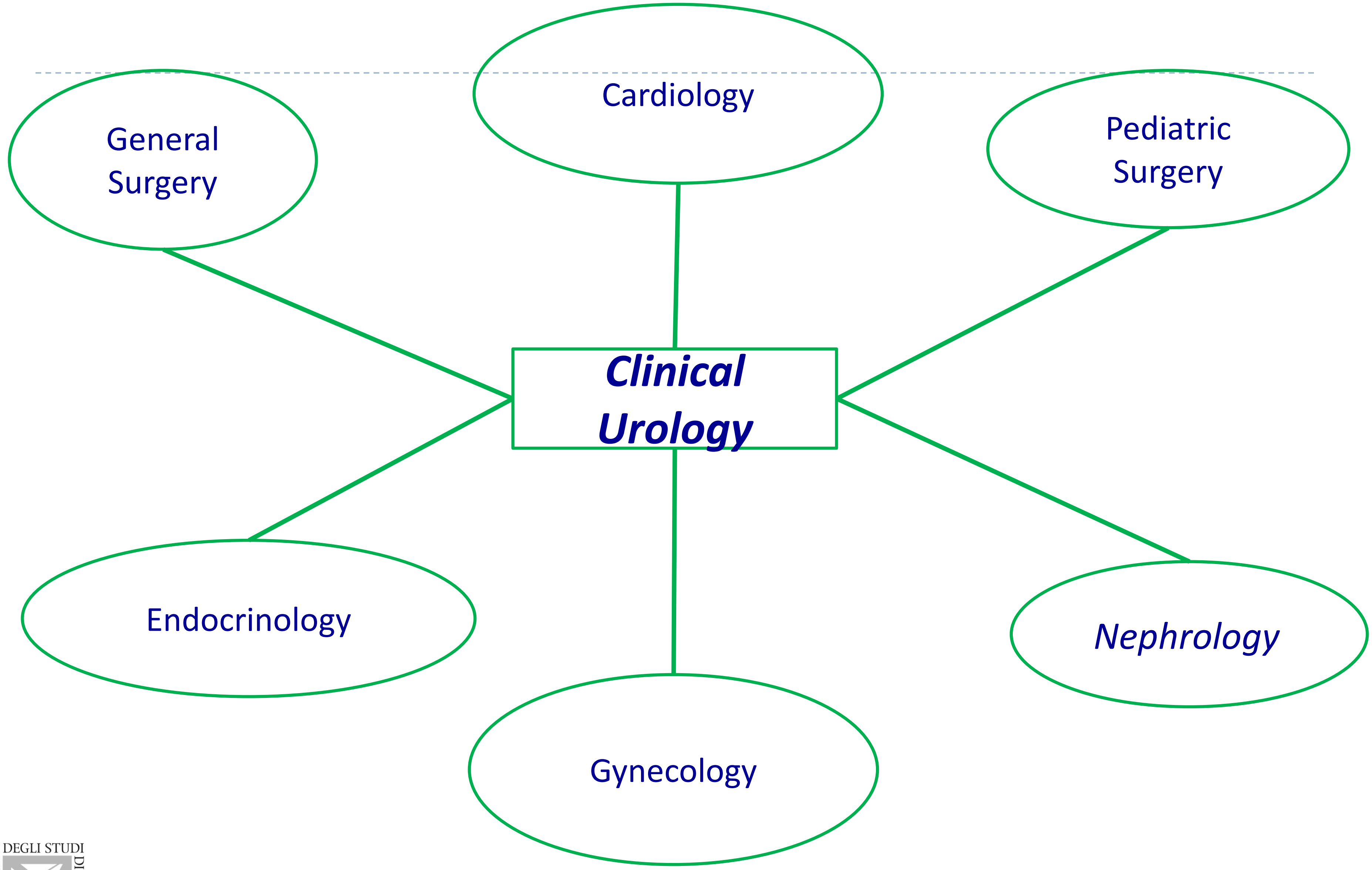
Urological Organs



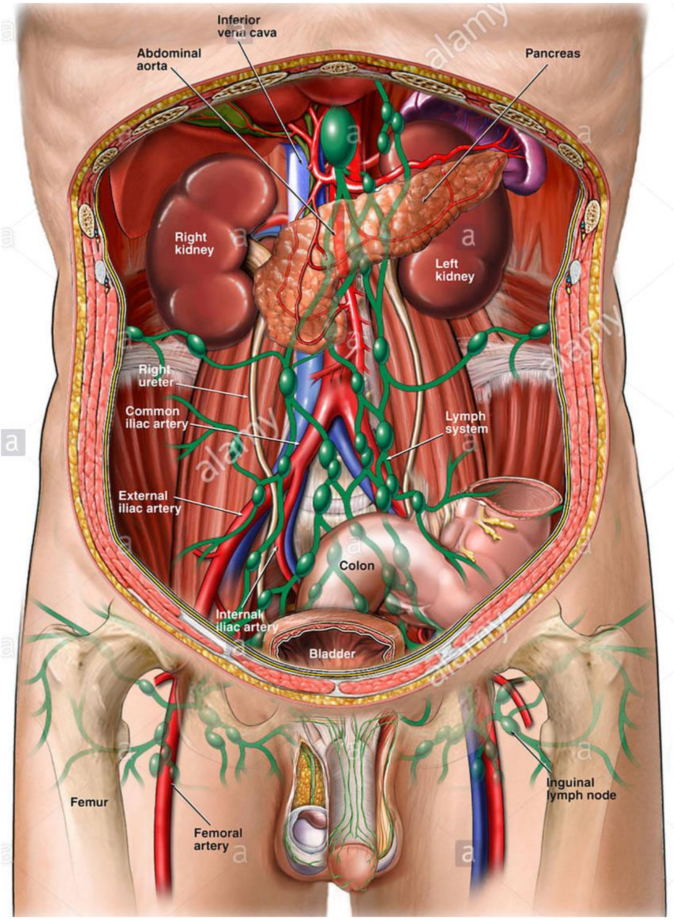


Urological Areas of interest

- BPH (benign Prostatic Hyperplasia)
- Stones
- Oncology
- Pediatrics
- Transplant surgery
- Emergency Surgery
- LUTS (Lower Urinary Tract Symptoms)
- Infections
- Trauma
- Neurology
- Gynecology/incontinence
- Sexual function


Cardiology
General Surgery
Pediatric Surgery
Clinical Urology
Endocrinology
Nephrology
Gynecology

Urologist = Surgeon



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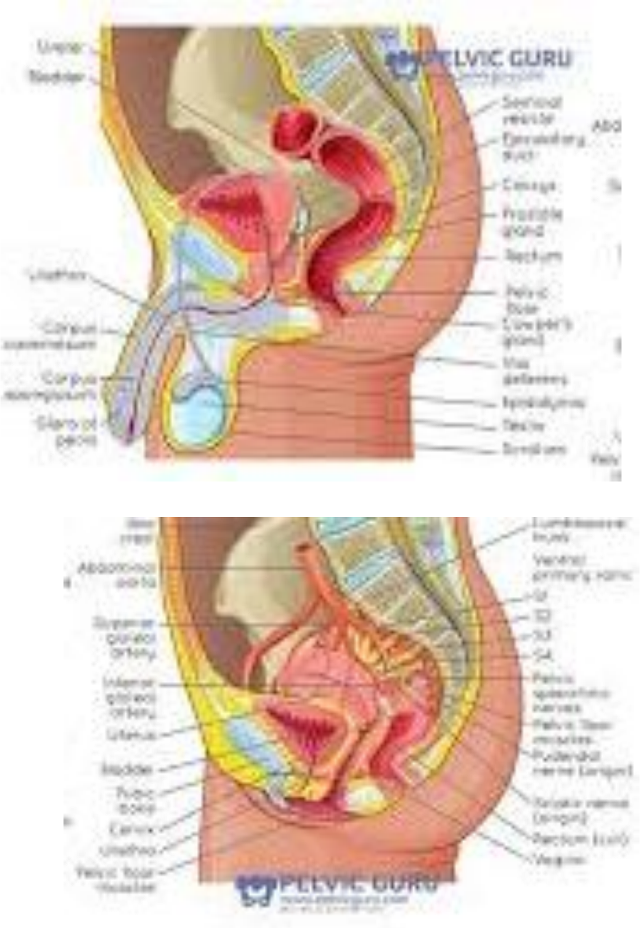
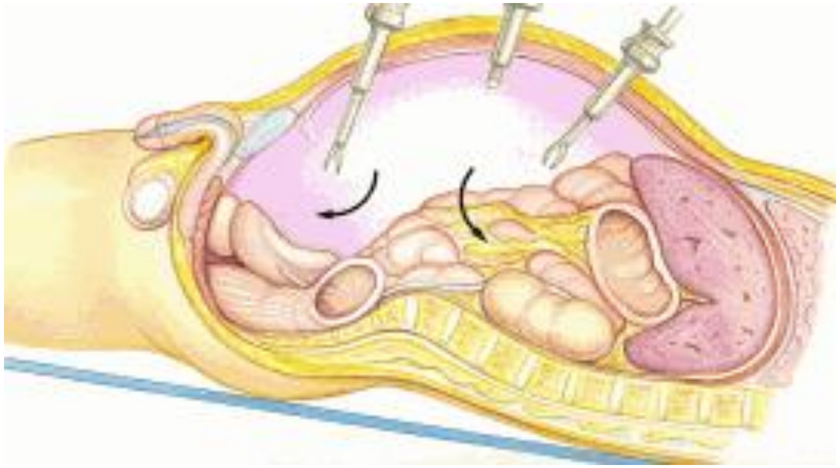


PELVIS

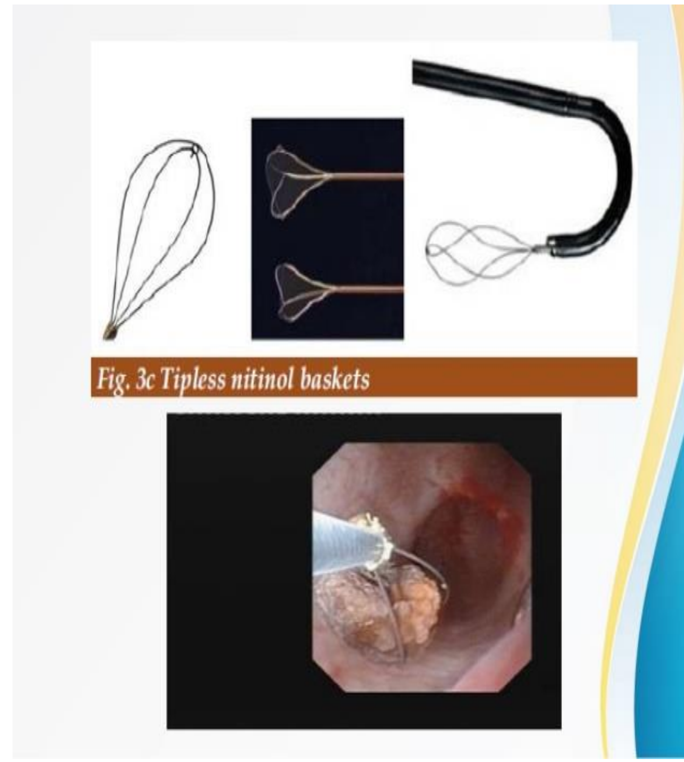
Open Surgery

Laparoscopy



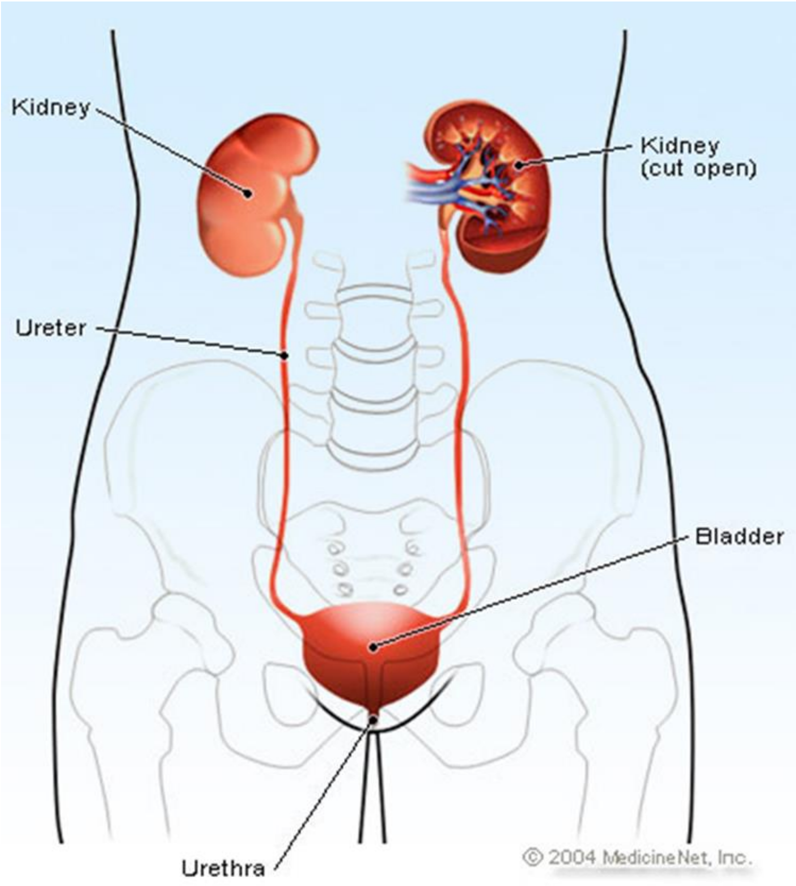
Robotic Surgery

Endoscopic Surgery



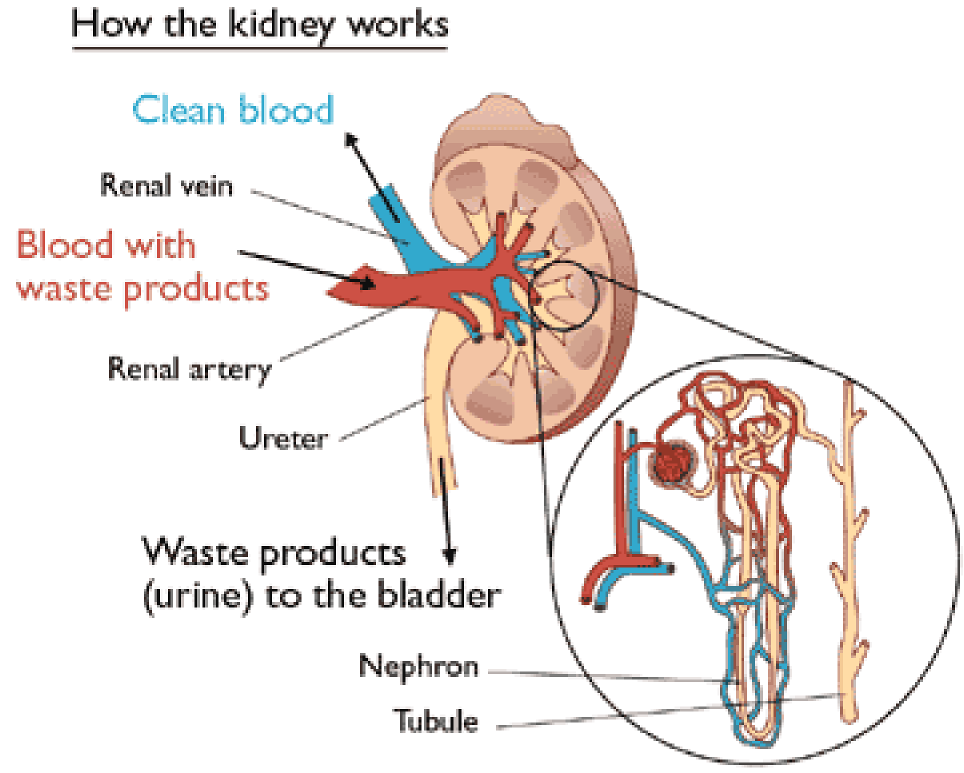
Urinary tract

- Basic function:
  - formation of ultrafiltrate that is free of protein with appropriate amount of water, electrolytes, and end products of metabolic pathways to maintain homeostasis.
- Remaining portion of UT
  - Eliminate and/or store urine



Urine production and transportion

- Pressure gradient from glomerulus to Bowman capsule.
- Peristalsis of renal pelvis and ureter.
- Effects of gravity.



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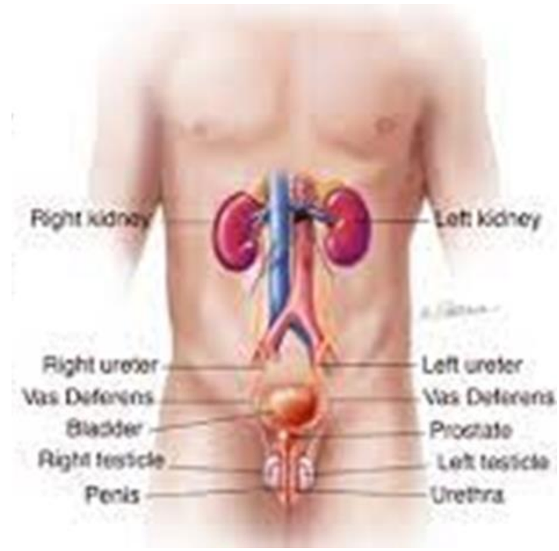
Urinary tract obstruction

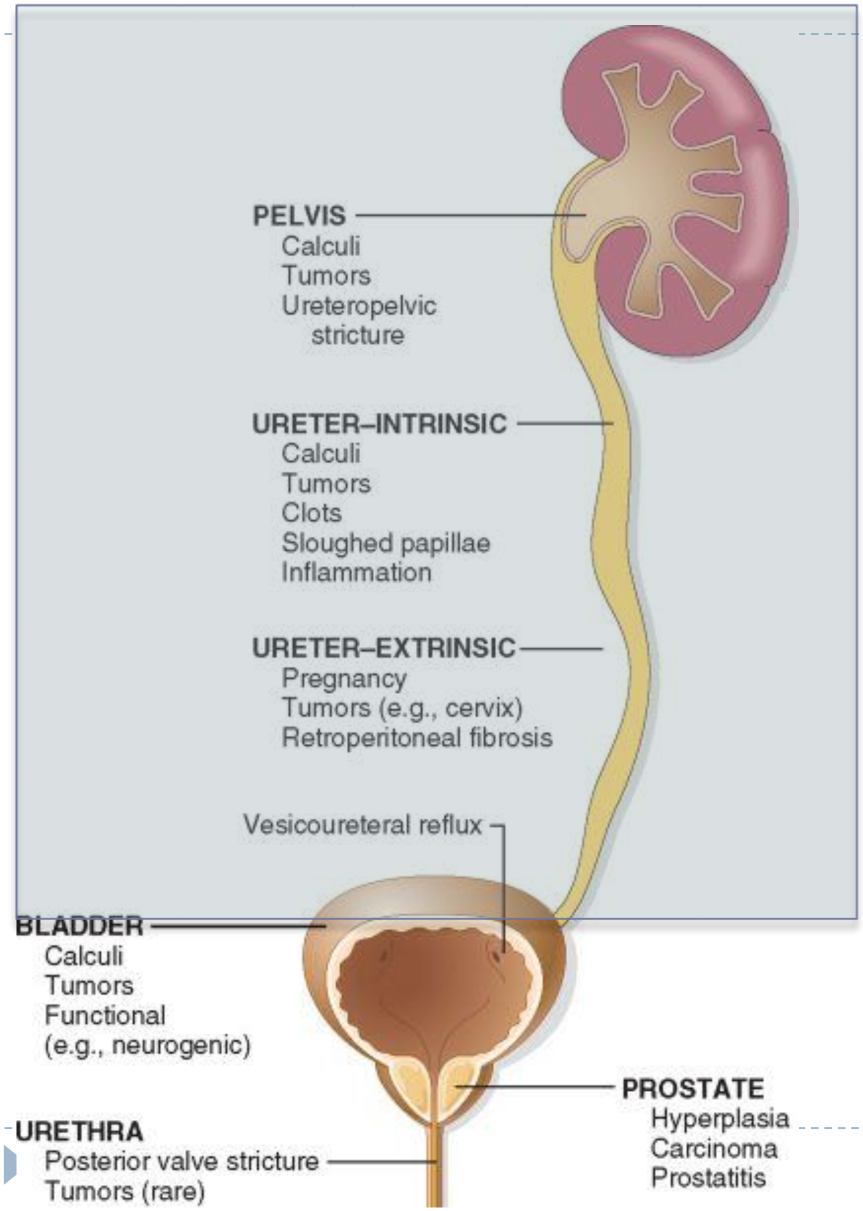
- ✓ Common cause of acute and chronic renal failure
- ✓ Potentially curable form of kidney disease

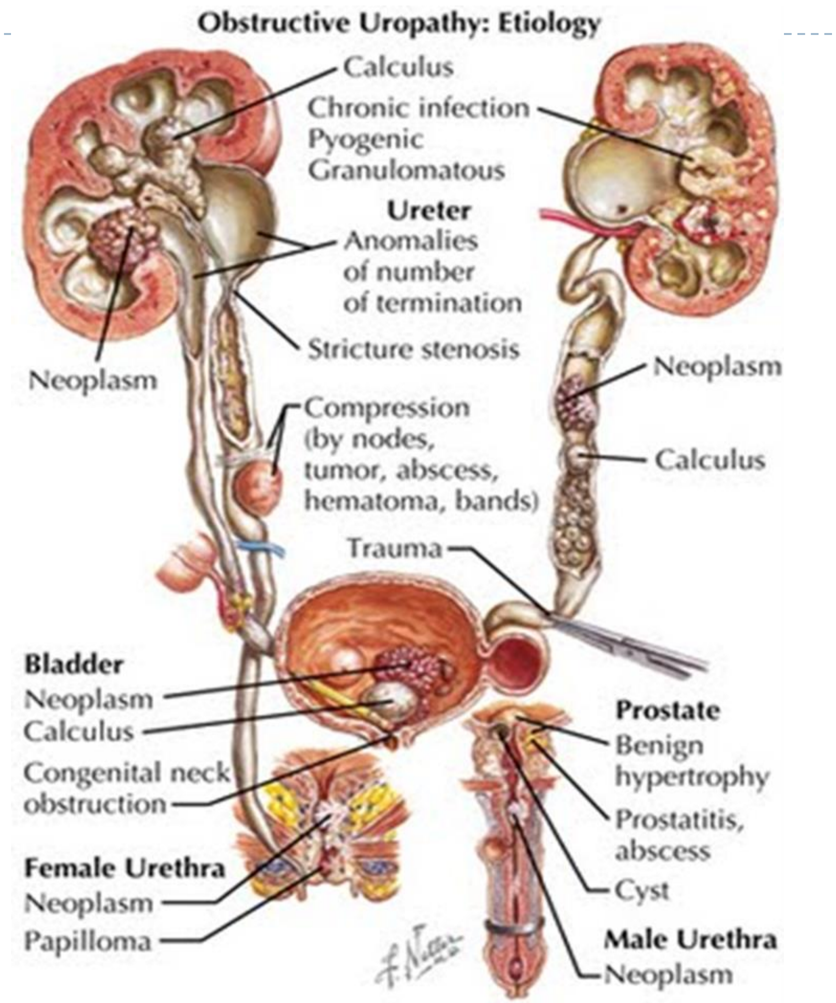


Definition of terms:

- *Obstructive uropathy*
- *Obstructive nephropathy*
- *Hydronephrosis*

Upper Urinary Tract Obstruction





Aetiology

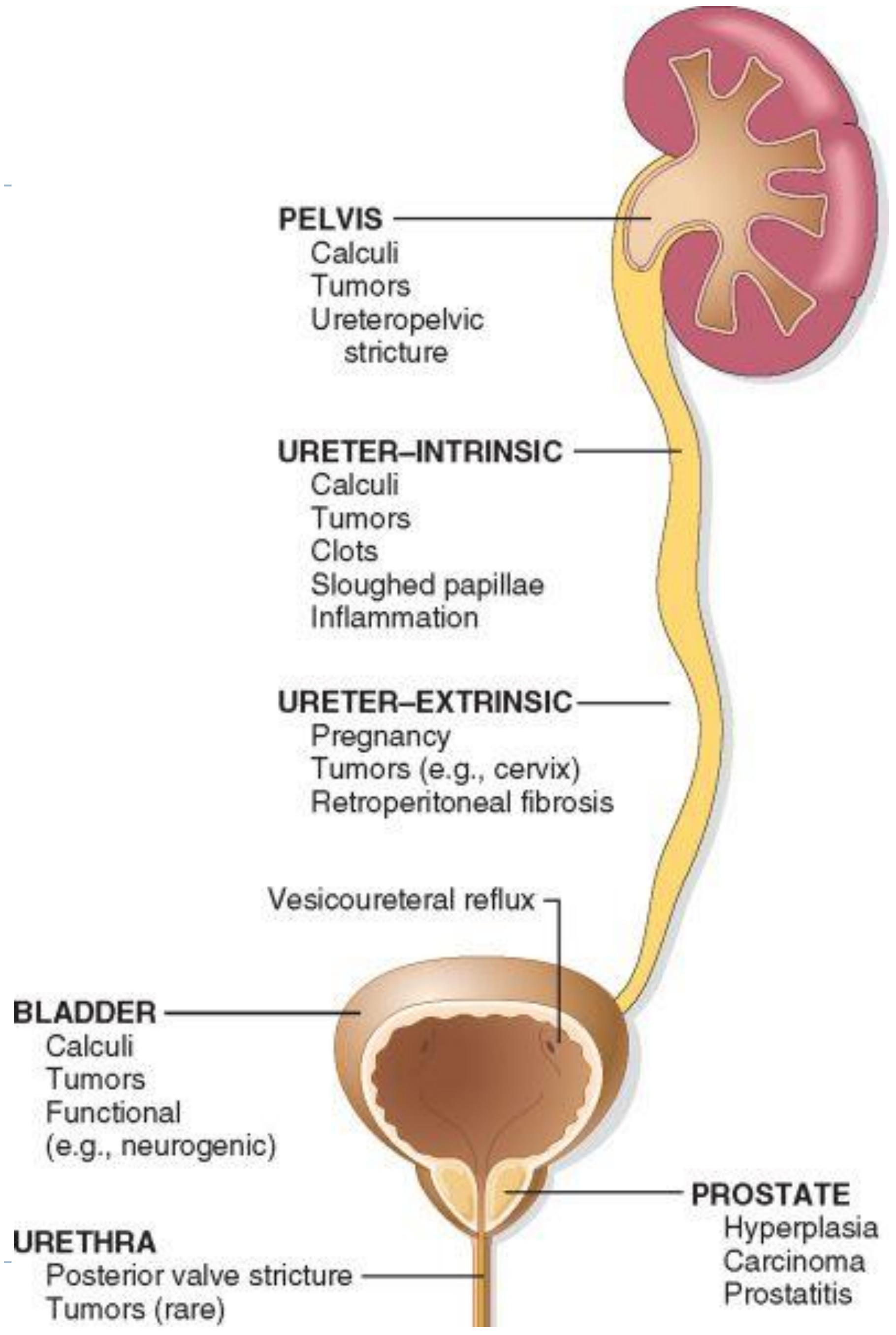
Causes of obstruction

Mechanical blockade

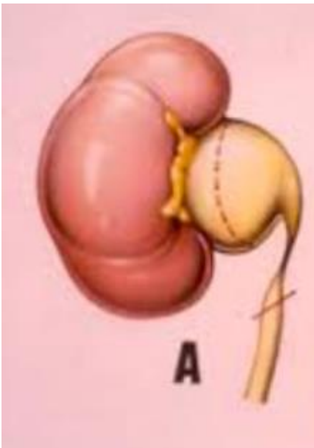
- ✓ Intrinsic
- ✓ Extrinsic

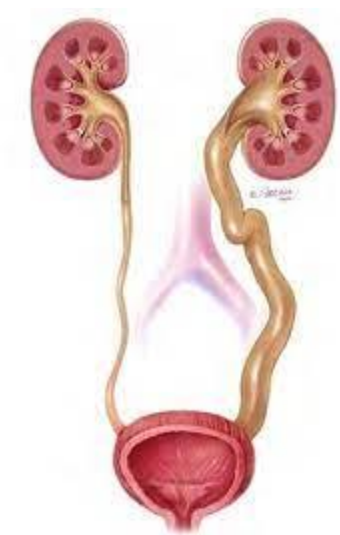
Functional defects

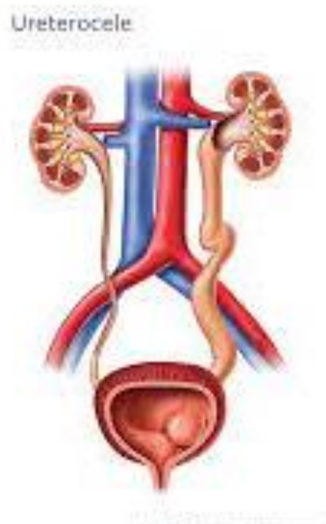
- ✓ Acquired
- ✓ Congenital



Congenital



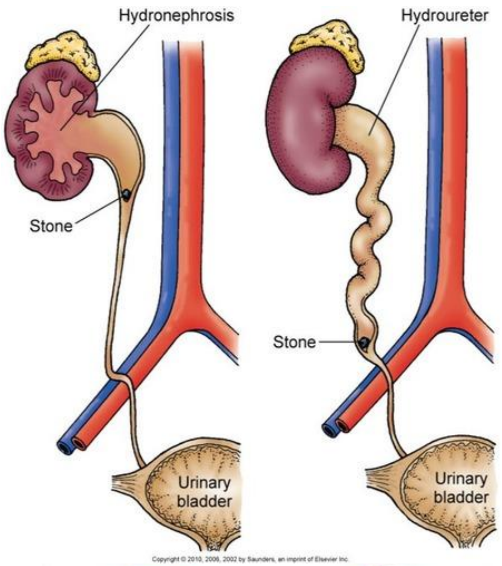


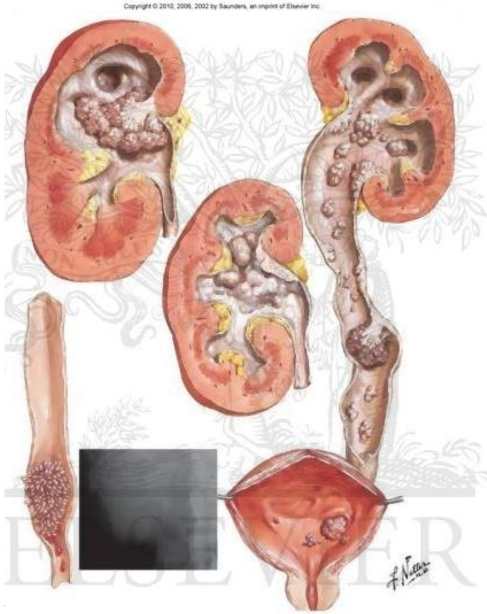


Common Congenital Causes of Urinary Tract Obstruction

Ureter	Bladder Outlet	Urethra
	CONGENITAL	
Ureteropelvic junction narrowing or obstruction	Bladder neck obstruction	Posterior urethral valves
Ureterovesical junction narrowing or obstruction and reflux	Ureterocele	Anterior urethral valves
Ureterocele	Damage to S2-4	Stricture
Retrocaval ureter		Meatal stenosis
VUR	VUR	Phimosis

Acquired - Intrinsic





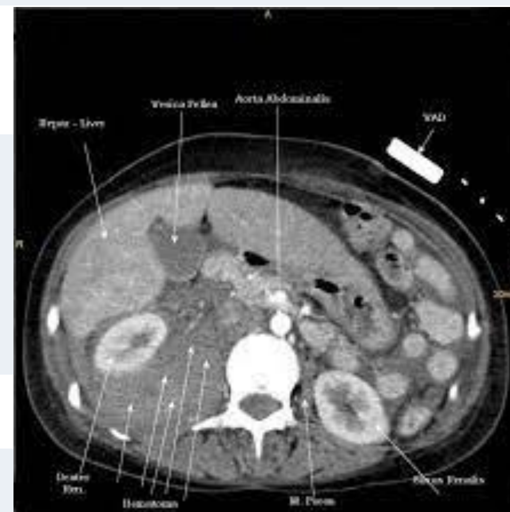
Ureter	Bladder Outlet	Urethra
Acquired Intrinsic Defects		
Stones	Benign prostatic hyperplasia	stricture
Inflammation	Cancer of the prostate	tumor
Infection	Cancer of the bladder	Stones
Trauma	Calculi	trauma
Sloughed Papillae	Diabetic neuropathy	phimosis
Tumors	Spinal cord disease	
Blood Clots Uric acid crystals	Anticholinergic drugs and alpha adrenergic antagonists	

Acquired Extrinsic Defects

Retroperitoneal fibrosis

Retroperitoneal cancer

Ureter	Bladder Outlet	Urethra
Acquired Extrinsic Defects		
Pregnant uterus	Carcinoma of cervix, uterus colon, rectum	trauma
Retroperitoneal fibrosis	Trauma	
Aortic aneurysm		
Uterine leiomyomata		
Carcinoma of, prostate, bladder, testis		
lymphoma		
Pelvic inflammatory disease, endometriosis		
Accidental surgical ligation		



Retroperitoneal post-traumatic haematoma

Pathophysiology

- Complete or incomplete?
- Unilateral (UUO)?
- Bilateral (BUO)?
- Obstruction relieved or not?
- Time to obstruction

Global Renal Function Changes

- Obstruction can affect hemodynamic variables and GFR
- GFR= $K_f(P_{GC}-P_T-\Pi_{GC})$

  K_f- glomerular ultrafiltration coeffecient related to the surface area and permeability of the capillary membrane

  P_{GC}- glomerular capillary pressure. Influenced by renal plasma flow and the resistance of the afferent and efferent arterioles

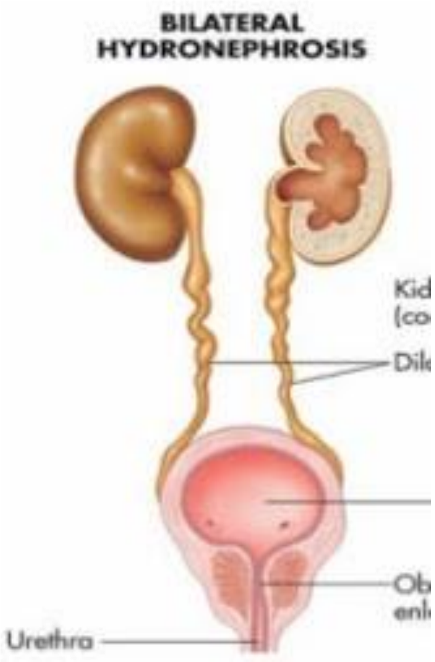
  P_T- Hydraulic pressure of fluid in the tubule

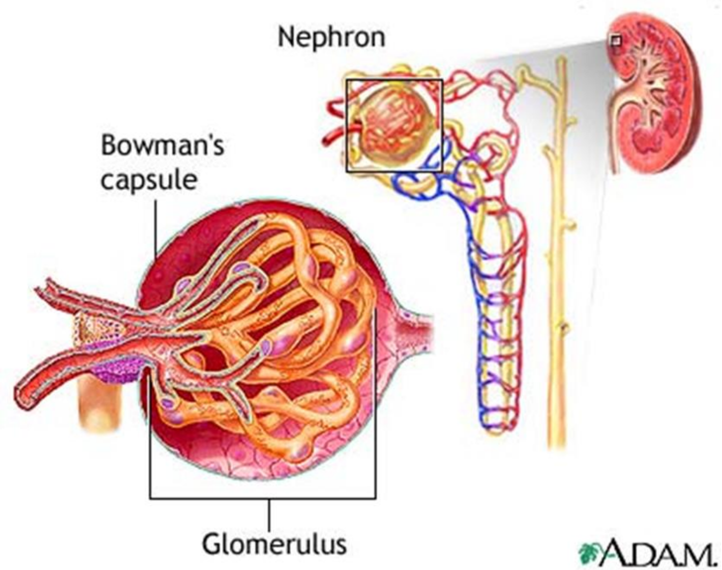
  Π- the oncotic pressure of the proteins in the glomerular capillary and efferent arteriolar blood

- Renal Blood Flow= $\frac{\text{(aortic pressure-renal venous pressure)}}{\text{renal vascular resistance}}$
  - Influences P_{GC}
  - Constriction of the afferent arteriole will result in a decrease of P_{GC} and GFR
  - An increase in efferent arteriolar resistance will increase P_{GC}

Urinary obstruction (Unilateral- Bilateral)

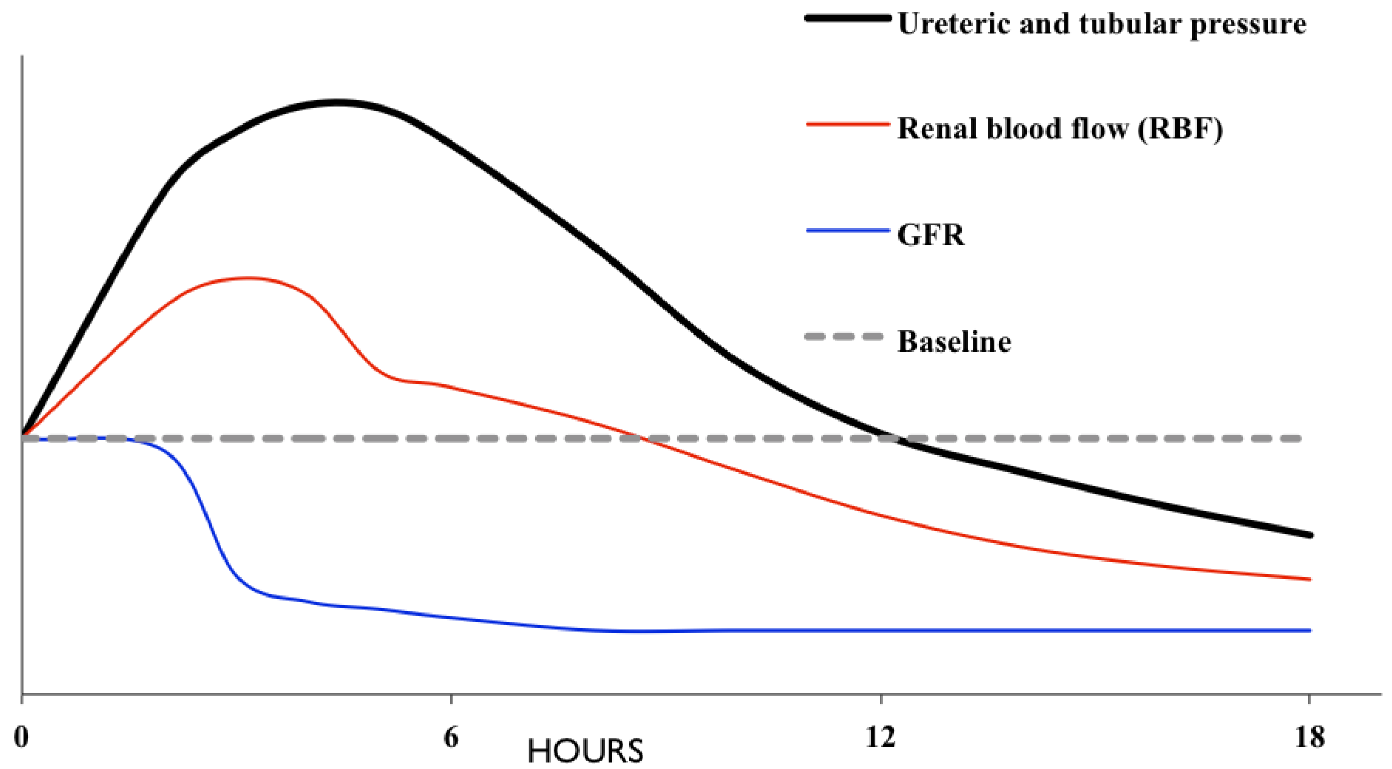
- Ureteral pressure higherin BUO than in UUO
- Effective Renal Blood Flow is markedly decreased after 48 hours
- GFR is significantly decreased after 48 hours





Pathophysiology

Obstructive Uropathy → Obstructive Nephropathy



Consequences of urinary tract obstruction

1. Reduced glomerular filtration rate
2. Reduced renal blood flow (after initial rise)
3. Impaired renal concentrating ability
4. Impaired distal tubular function

- ✓ Nephrogenic diabetes insipidus
- ✓ Renal salt wasting
- ✓ Renal tubular acidosis
- ✓ Impaired potassium concentration

Consequences of urinary tract obstruction

- Progressive and permanent changes to the kidney occur
  - Tubulointerstitial fibrosis
  - Tubular atrophy and apoptosis
  - Interstitial inflammation

Clinical Presentation

- Acute Upper Urinary Obstruction: <u>PAIN</u>

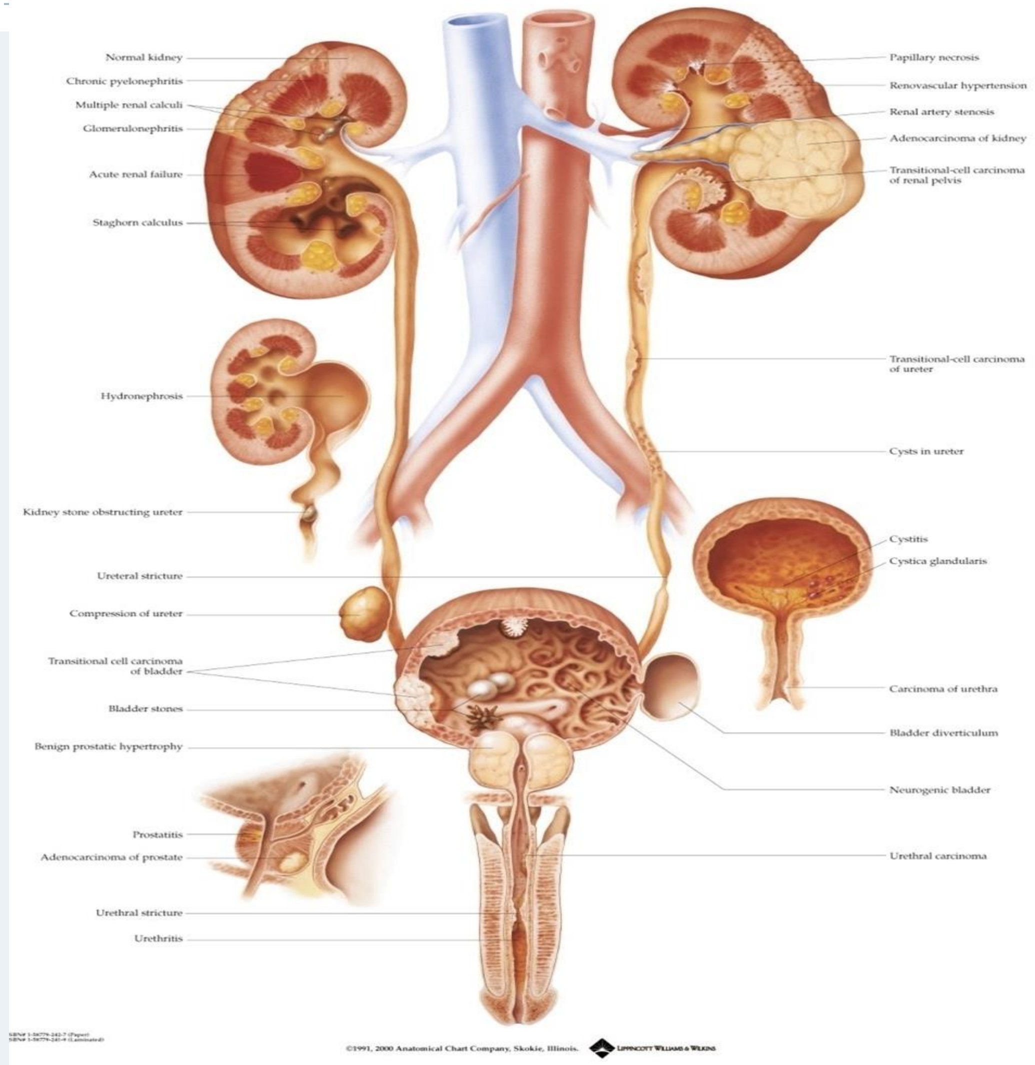
Renal Colic: a severe clinical presentation

- Cronic Upper Urinary

Obstruction: <u>NO PAIN</u>

Impaired renal function

if bilateral or uni-lateral with pre-existing cronic renal failure

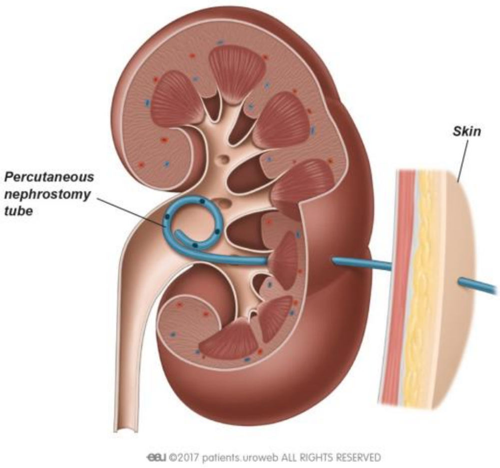


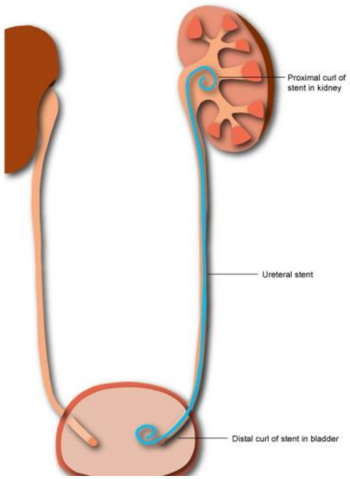
Treatment and management

- Stones – most common causes of unilateral ureteral obstruction
  - 90% pass spontaneously (calculi <5.0-7.0 mm)
  - Surgical drainage necessary if with unrelenting pain, UTI, persistent obstruction, progressive loss of renal function
  - Position of stone determines preferred method of removal

Treatment and management

- Bilateral ureteral obstruction – always asymmetric process
  - mid to proximal ureter – percutaneous nephrostomy
  - Distal obstruction – cystoscopic placement of ureteral stent
  - Intrarenal obstruction secondary to crystals or protein casts - hydration





Treatment and management

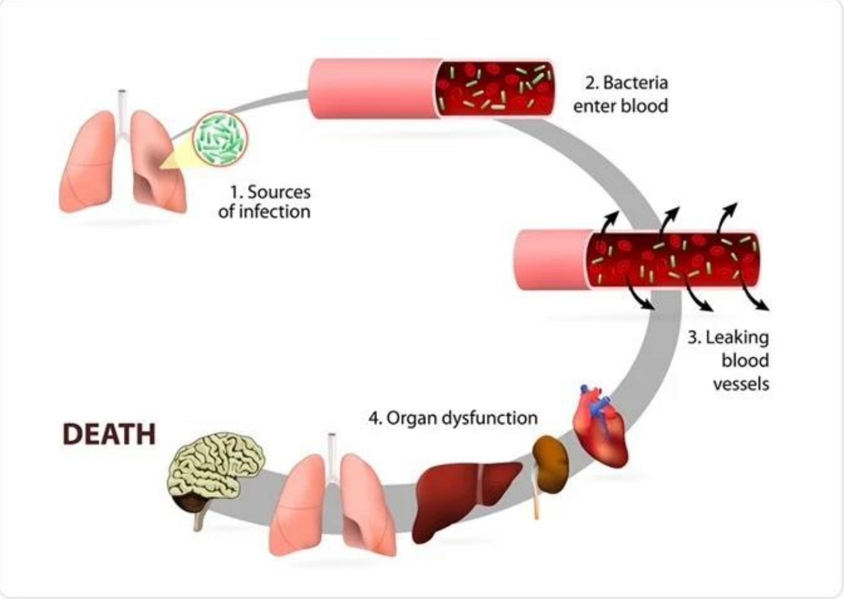
- Consultations
  - UROLOGIST – when transurethral catheter cannot provide adequate drainage and surgical drainage and removal of obstruction is necessary
  - NEPHROLOGIST – when emergent hemodialysis is necessary

Complications

- Post-obstructive diuresis
  - Occurs in BUO or obstruction in a solitary kidney
  - Physiologic – caused by retained urea, Na and H2O
  - Pathologic – impairment of concentrating ability or Na reabsorption
  - Iatrogenic – due to high-volume glucose containing fluid replacement
  - Most likely in patients with chronic obstruction, edema, CHF, HPN, weight gain, azotemia, uremic encephalopathy

Complications

- Urinary tract infection
  - Due to urinary stasis
  - Appropriate antibiotic based on in vitro bacterial sensitivity and ability of drug to concentrate in the urine
  - **UROSEPSIS: can be fatal in up to 30-40% of cases**



URINARY STONE DISEASE

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Epidemiology of Urinary Stones

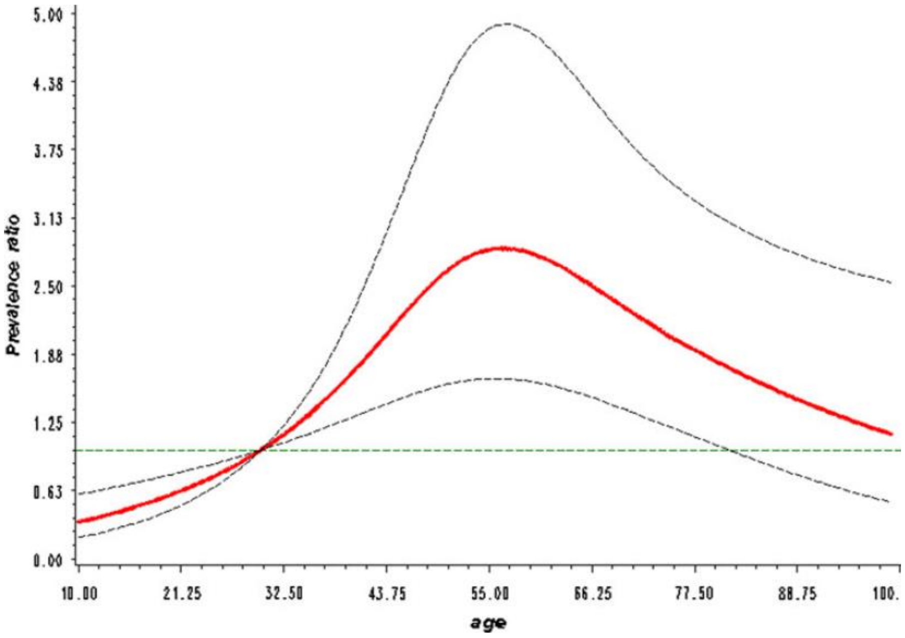
- Prevalence of stone disease is estimated between **1% and 20 %**
- Stone occurrence is **uncommon before age 20**
- **Stone incidence** peaks **between 4th and 6th decades of life**
- **Men:women** ratio = **2-3:1**
- **Phenotipic differences**: highest prevalence of stone diseases has been observed in **whites** (countries with high standard of life), followed by Hispanics, Asian and African-Americans

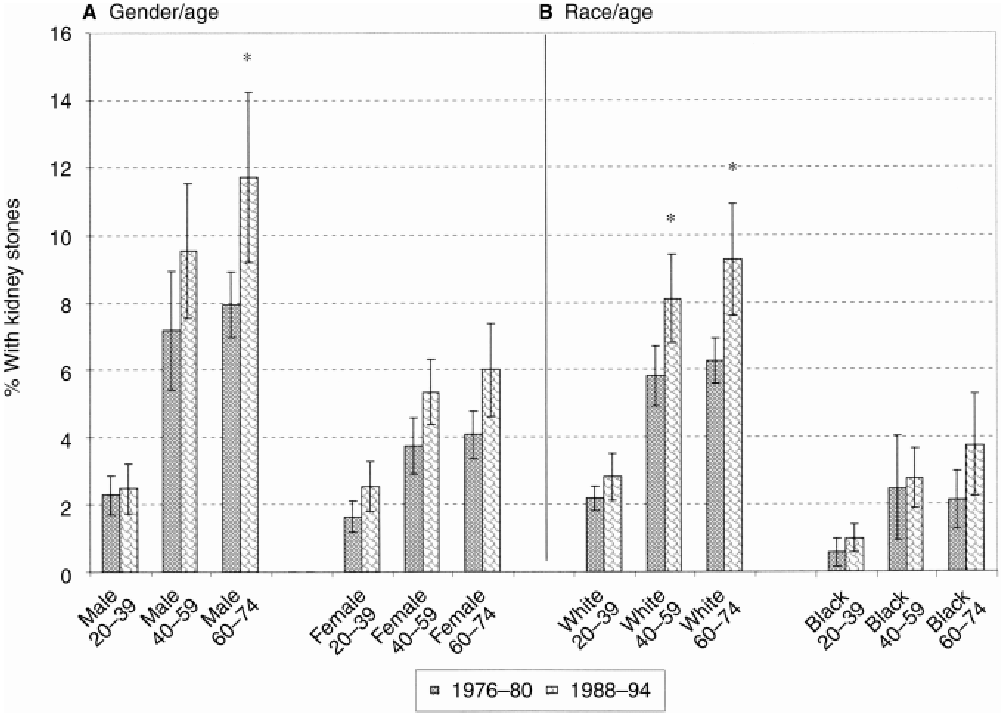
Guidelines on urolithiasis, Eur Urol 2019
Pearle et al J Urol 2005;173:848-57
Yasui et al Urol 2008; 71:209-13
Soucie et al Kidney Int 1994; 46:893-899
Hiatt et al Am J Epidemol 1982; 115:255-65

EPIDEMIOLOGY

- Prevalence in US: 8%

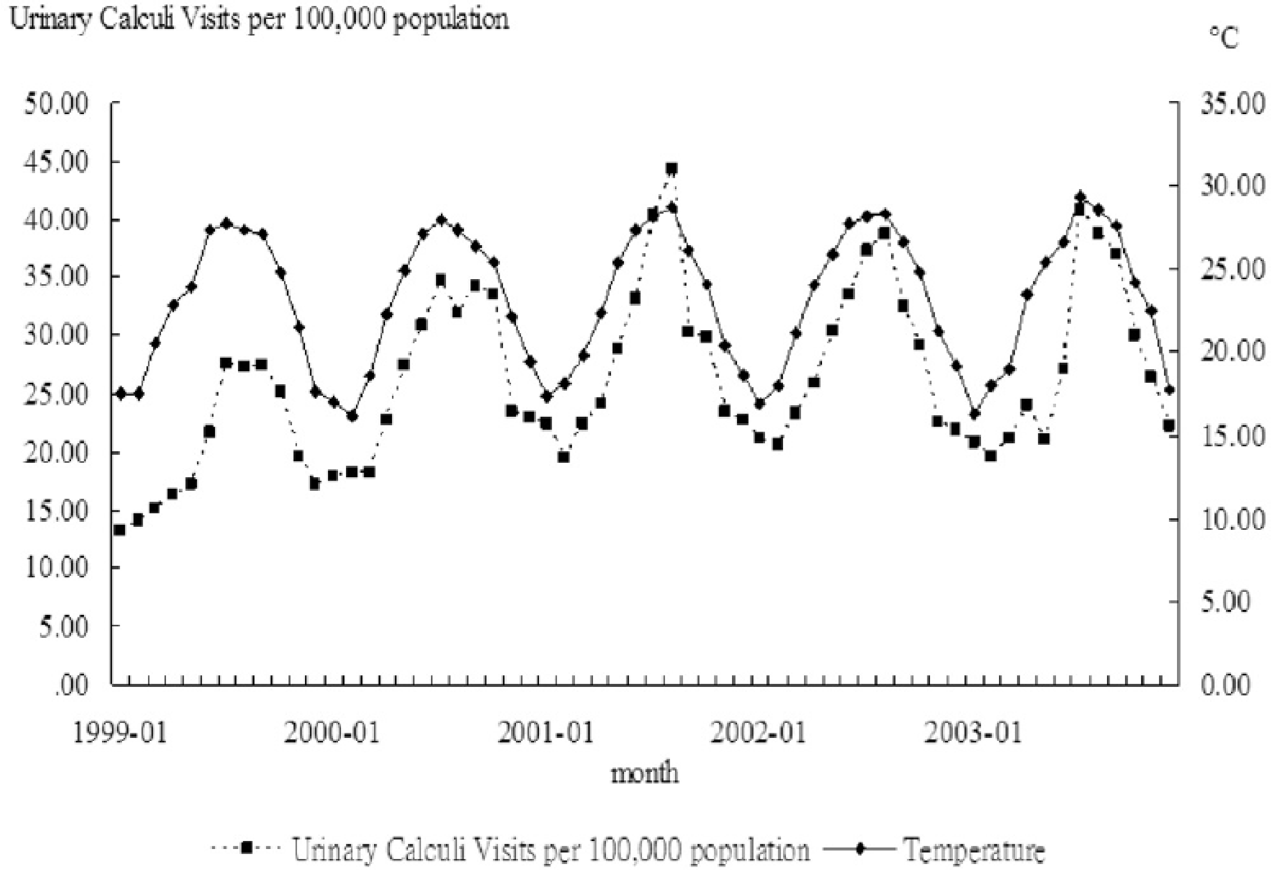
- Incidence peak between 30-60 yrs





Stamatelou et al. Kidney Int.2003
Croppi et al . Urol Res. 2012
Curhan et al. Urol Clin North Am. 2007

Epidemiology of Urinary Stones



Seasonal variations exist in the monthly urinary calculi attack rates with a peak between July and September.

Ambient temperature has been showed to be associated with monthly attack rates

Chen et al J Urol 2008;179:564-9

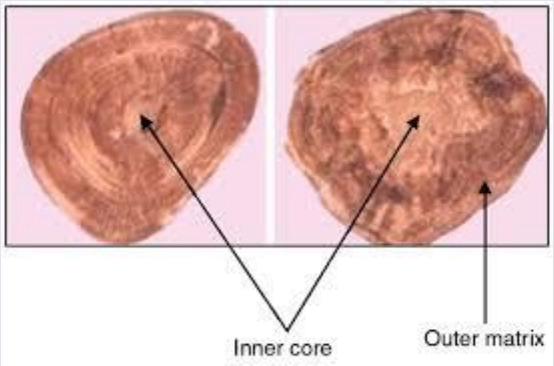
PATHOGENESIS & PATHOPHYSIOLOGY

Urinary stones are aggregates composed of **crystalloids and organic matrix**

Crystal component

- Stones are composed primarily of crystalline component.
- Steps involved in crystal formation:

nucleation
aggregation
growth



Matrix component

- The amount of matrix component ranges from 2 to 10% in different stones.
- Matrix is mainly composed of **proteins**, lipids, polysaccharides, which may serve as a nidus for crystal aggregation.

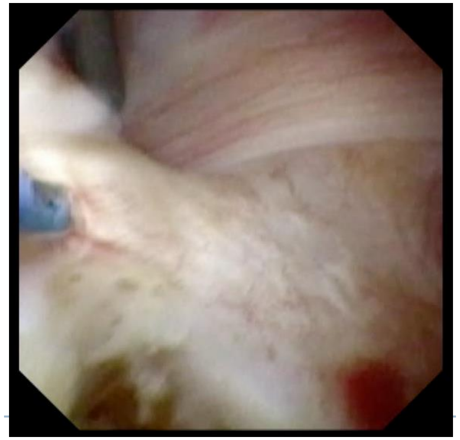
Smith's General Urology 2008

Stone Formation

- Stone formation starts with urine becoming **supersaturated,** such that dissolved ions or molecules precipitate out of solution and come to form **crystals**

- Crystals may flow out with urine or eventually **aggregate leading to stone formation** in certain conditions

- **Local areas of obstruction or stasis** in the upper urinary tract may prolong urinary transit time thus **allowing crystal formation**



Campbell-Walsh Urology 2012

Stone Formation

Inhibitors of crystal formation

Low concentration of inhibitors may facilitate stones formation

Molecules that raise the supersaturation needed to initiate crystal nucleation or reduce the rate of crystal aggregation

Citrate → a deficiency is associated with stone formation like in patients with chronic diarrhoea or renal tubular acidosis type I

Magnesium → lack of dietary magnesium is associated with increased calcium **oxalate stone formation**

Glycosaminoglycans → inhibit crystals nucleation and growth

Glycoproteins → nephrocalcin and **Tamm-Horsfall glycoprotein** are potent inhibitor of calcium oxalate crystal aggregation. Tamm-Horsfall is the most abundant protein found in urine and is expressed by **renal epithelial cells**

Campbell-Walsh Urology 2012

Stone types

Non-infection stones	
• Calcium oxalate	
• Calcium phosphate,	
• Uric acid	
Infection stones	
• Magnesium ammonium phosphate	STRUVITE
• Carbonate apatite	
• Ammonium urate	
Genetic causes	
• Cystine	
• Xanthine	
• 2,8-dihydroxyadenine	
Drug stones	

- The most common component of urinary calculi is **calcium (Calciun Oxalate – Calcium Phosphate)** , which is a major constituent of nearly 75% of stones
- **Uric acid** and **struvite** (ammonium phosphate)stones occur approximately in 10% of cases and are related to infection.
- **Cystine** stones are rare (1%) ans associated to hereditary iper-cystinuria

Stones **associated with medications** are uncommon and preventable

Eur Guidelines on Urollithiasis 2020
Campbell-Walsh Urology 2012
Wilson et al J Urol 1989;141:770-4

Risk Factors for Stone Formation

General Factors

Early onset of urolithiasis (children)

Familial stone formation

Diet

- High sodium intake
- Saturated and unsaturated fatty acids
- Animal protein
- Fluid intake: patients producing less than 1 L of urine per day are at highest risk

Obesity

Disease associated with stone formation

- **Hyperparathyroidism**
- **Hypercalciuria**
- **Gastrointestinal disease**
- **Sarcoidosis**

Genetically determined stone formation

- Cystinuria
- Primary hyperoxaluria
- Renal tubular acidosis type I
- Xanthinuria

Anatomical abnormalities

- Medullary sponge kidney (tubular ectasia)
- Ureteropelvic junction obstruction
- Calyceal diverticulum
- Ureteral stricture
- Horseshoe kidney

Campbell-Walsh Urology 2012
EAU Guidelines on Urolithiasis 2020

Stone Composition :
Do you recognize our friends ?

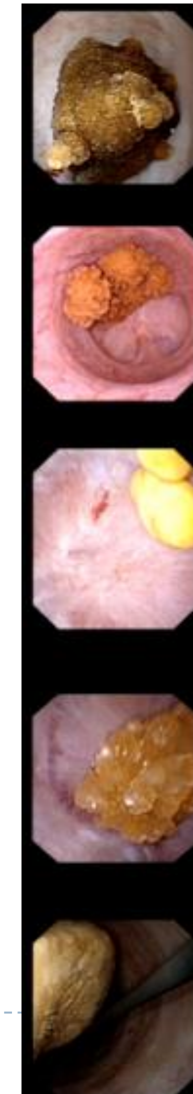
CaOx MonoHydrate

CaOx DiHydrate

Uric Acid

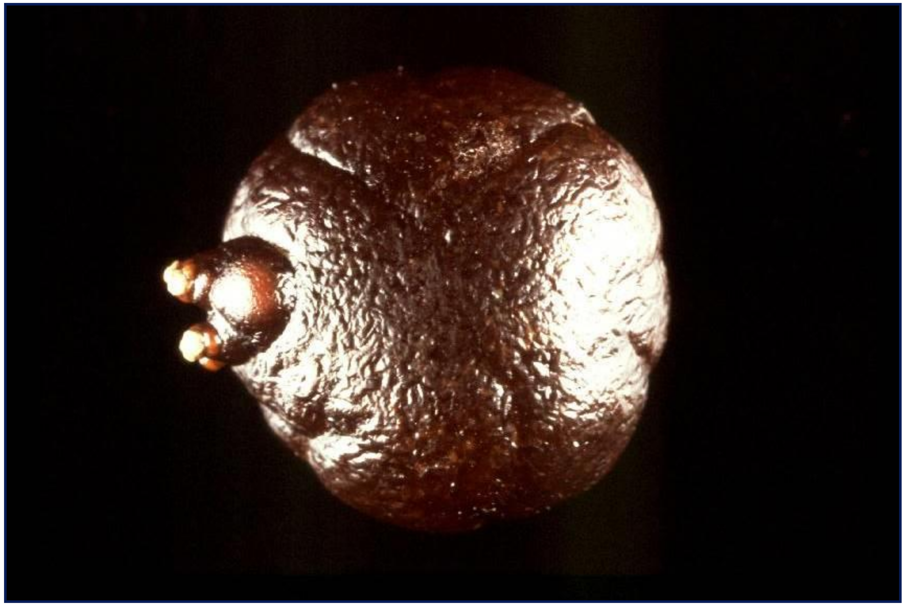
Cystine

Struvite



EVOLUTION of STONES…

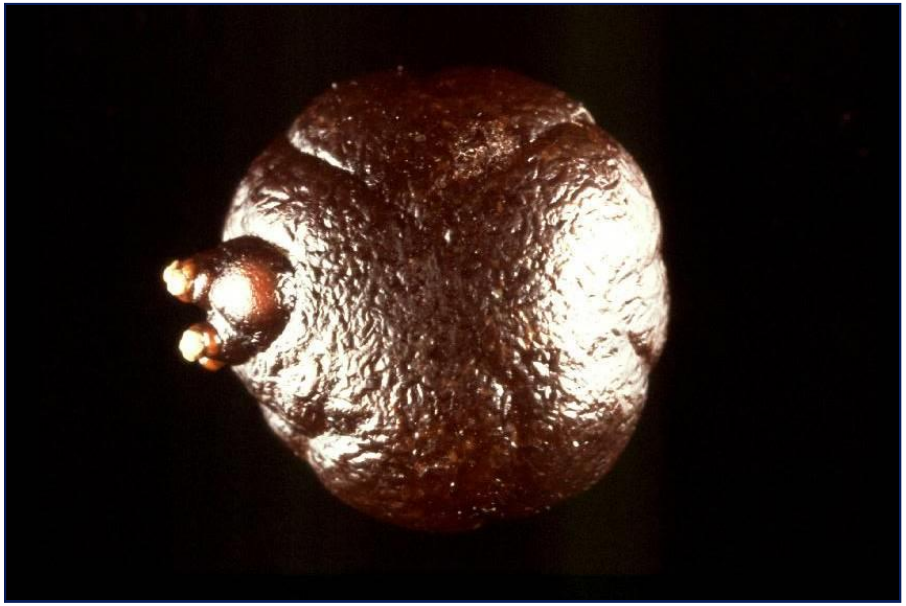
1918



2018

EVOLUTION of STONES…

Urates and Phosphate



Calcium Oxalate

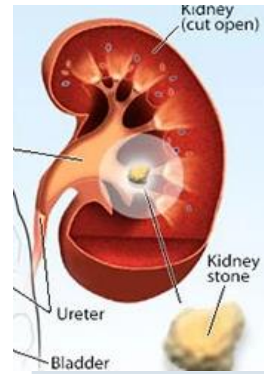
Change in Diet !

- Animal Protein x 5
- Fat / lipid x 10
- Sugar x 20
- Salt x 3
- Fibers ↓↓↓

CLINICAL PRESENTATION

Signs & Symptoms
Pain

- Upper tract urinary stones usually cause **PAIN only when they cause obstruction**
- **"Renal colic"** actually refers to a collection of symptoms attributed to the kidney and ureter
- The character of pain depends on the **location of stones**



NO PAIN

PAIN

Smith's Gener

Signs & Symptoms

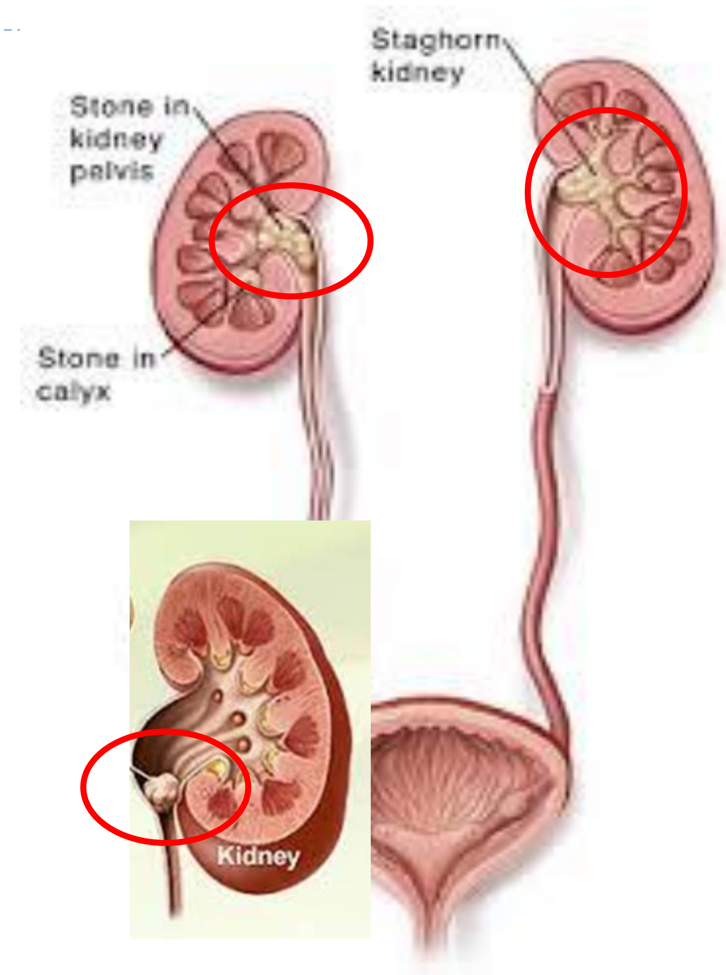
Renal pelvis

Stone > 1 cm **commonly obstruct uretero-pelvic junction** causing severe pain in the **costo-vertebral angle**

- Pain is usually **CONSTANT and radiates to flank and anteriorly to the upper ipsilateral abdominal quadrant**

Differential diagnosis *with* ***biliary colic*** *or* ***cholecystitis*** *if on the right side and with* ***gastritis****,* ***acute pancreatitis*** *or* ***peptic ulcer*** *if on the left side.*

- Partial or complete **staghorn calculi** may be not obstructive: patient can has few symptoms. If untreated may lead to **renal deterioration and infectious complications**



Smith's General Urology 2008

Signs & Symptoms

Upper and Mid-ureter

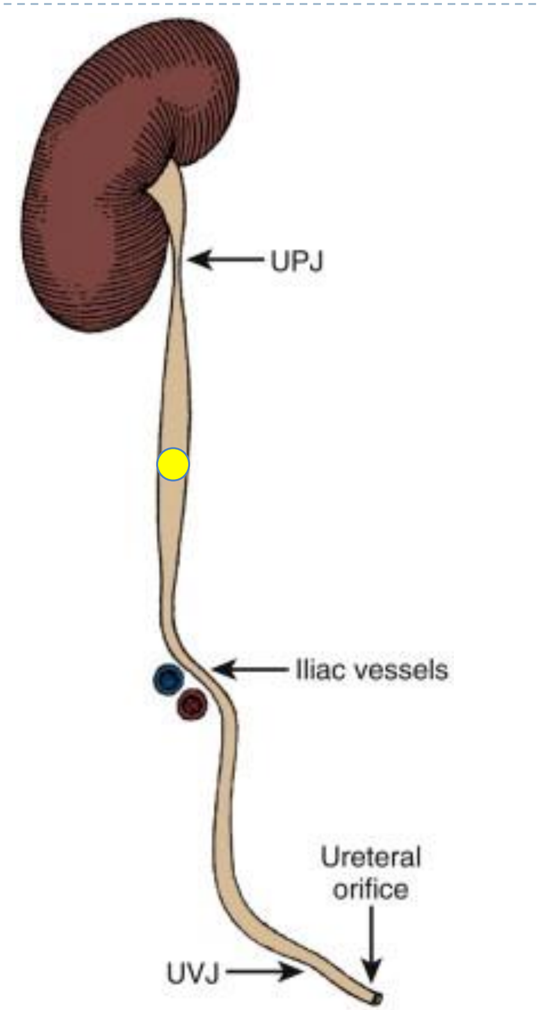
- Pain may be more **SEVERE AND INTERMITTENT** if the stone is progressing down the ureter

Upper tract→ radiates to **lumbar region and flank**

Mid-ureter→ radiates **caudally and anteriorly toward the mid and lower abdomen in a curved, band-like fashion**

***Differential diagnosis**: **appendicitis** (on the right); **diverticulitis** (on the left)*

- Stationary calculi with **constant obstruction** may allow **autoregulatory reflexes** and pyelovenous and pyelolymphatic backflow t**o decompress the upper tract with gradually easing pain**

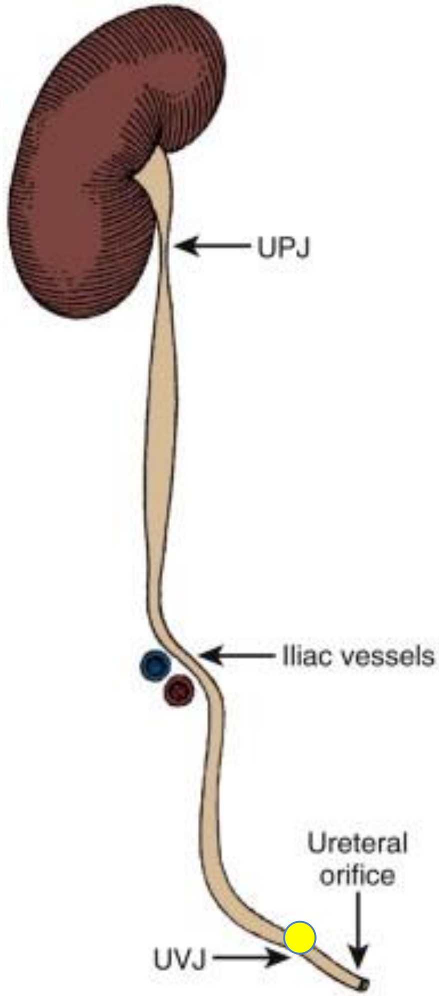


Smith's General Urology 2008

Signs & Symptoms

Distal Ureter

- Pain often radiates to the **groin or testicle**
- ***Differential diagnosis*** *with either* ***testicular torsion*** *or* ***epididymitis***
- May be associated with
  - **- suprapubic pain**
  - **- urinary frequency**
  - **- urgency**
  - **- stranguria**



Smith's General Urology 2008

Signs & Symptoms

Other signs or symptoms

- **Haematuria**

- intermittent gross haematuria may be present

- most patients have **micro-haematuria**

- **Nausea and Vomiting**

[frequently associated]

Smith's General Urology 2008

Signs & Symptoms

Other signs or symptoms

Infection

All stones may be associated with infections secondary to obstruction and stasis

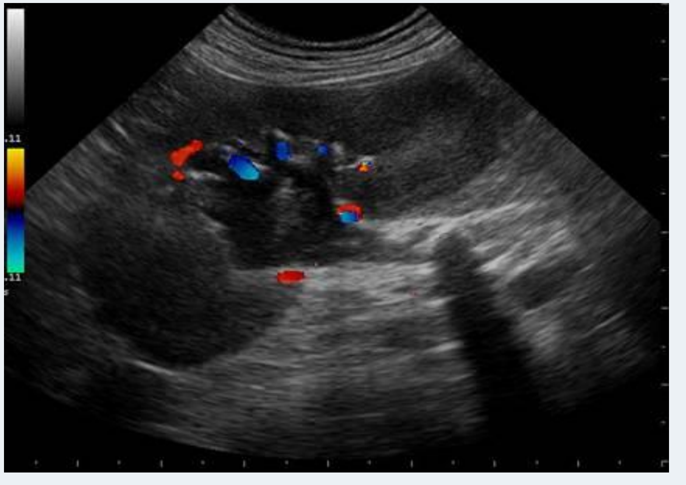
Infection may contribute to **pain,** through local inflammation

Pyonephrosis

- an extreme form of infected hydronephrosis

- can cause severe **urosepsis**

- **Signs of sepsis**
- Fever
- Tachycardia
- Hypotension
- Cutaneous vasodilation



Smith's General Urology 2008

Evaluation

Medical History

Pain should be evaluated in terms of:

–**Onset**

–**Character and location**

–**Activity associated with exacerbation/relieve**

–**Associated nausea and vomiting or haematuria**

–**History of similar pain**

Smith's General Urology 2008

Evaluation

Physical Examination

- **Percussion of the costo-vertebral angle** often localize the pain

  (Giordano's maneuver)

- In men **testes must be examined** because scrotal pathology may present with abdominal pain

- Systemic components have to be evaluated (tachycardia, hypotension, fever)

Smith's General Urology 2008

Imaging

Ultrasonography

usually (real-life setting) used as the **primary diagnostic tool**

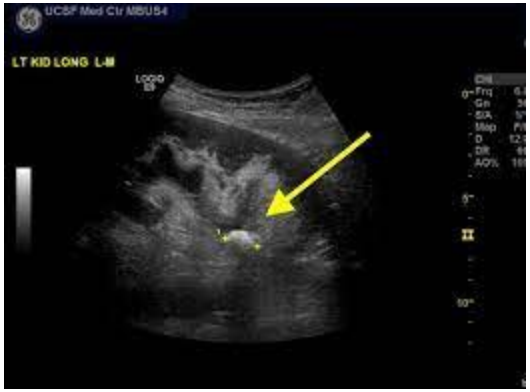
- safe, reproducible and relatively inexpensive
- US can identify **stones located in**:

–**Calices**

–**Pelvis**

–**Pyeloureteric junction**

–**Vescicoureteric junction-**



For these specific locations **sensibility** and **specificity** **are of 96% and 100%, respectively for stones > 5 mm**

Smith's General Urology 2008
EAU Guidelines on Urolithiasis 2020

Imaging

Ultrasonography

Stones elsewhere in the ureter (between the pelvic-ureteric junction (PUJ) and VUJ) are **unlikely to be seen**

Secondary signs, such as **dilation,** which may suggest an obstructing stone, **improve test sensitivity**

Smith's General Urology 2008
EAU Guidelines on Urolithiasis 2020

Imaging

Abdomen radiography

could be helpful in **differentiating between radiolucent and radiopaque stones**

[Sensitivity and specificity 44-77%]

should not be performed if NCCT is considered

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Imaging

Non-contrast enhanced CT (NCCT)

- Has became the **standard for diagnosis** of urinary stones

[Sensitivity 93%; Specificity 96%]

- NCCT has replaced iv urography

- NCCT can determine **stone diameter** and **density**, thus differentiating radiolucent vs radio-opaque stones
- **NCCT can detect radiolucent stones** like uric acid or xanthine stones

- To reduce radiation risk **low-dose CT** can be used→ diagnosis of urolithiasis with a sensitivity of 96.6% and specificity of 94.9%

- **Constrast-enhanced CT** is recommended in specific cases when stone removal is planned, in order to analyze the anatomy of the collecting system also with 3D reconstruction

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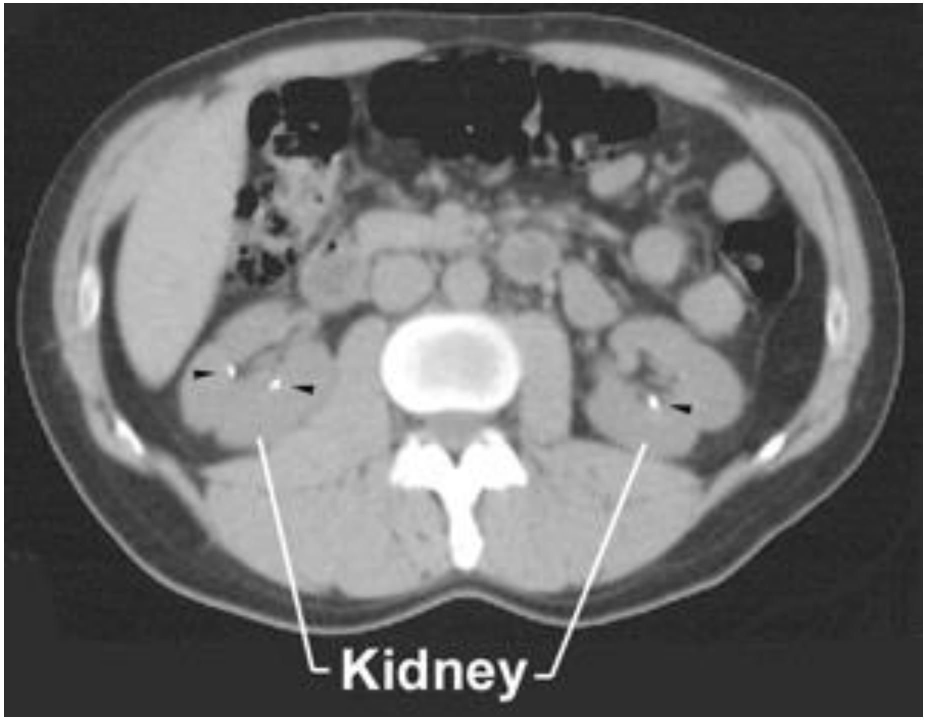
Imaging



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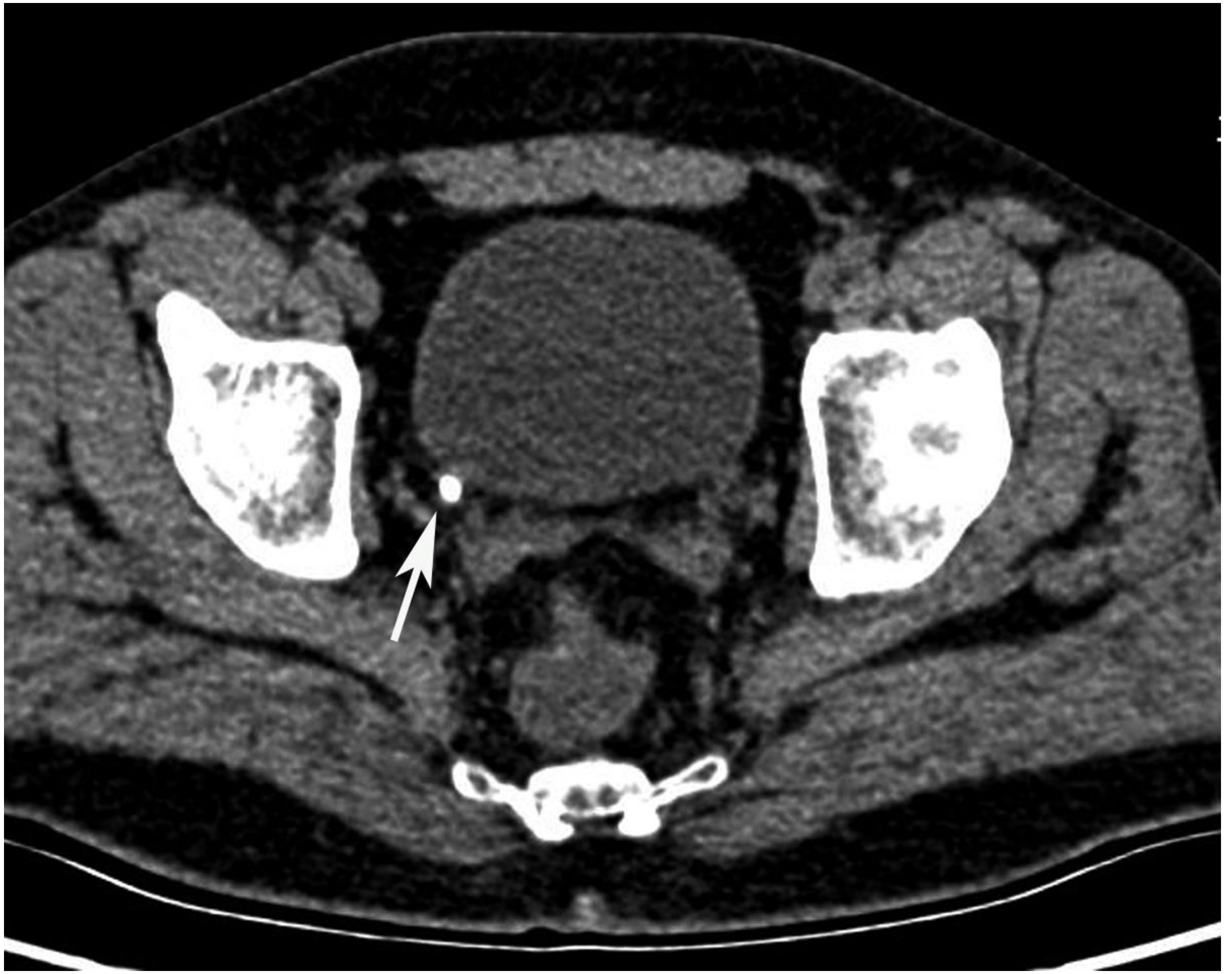

Imaging

ORIGINAL ARTICLE

Ultrasonography versus Computed Tomography for Suspected Nephrolithiasis

R. Smith-Bindman, C. Aubin, J. Bailitz, R.N. Bengiamin, C.A. Camargo, Jr., J. Corbo, A.J. Dean, R.B. Goldstein, R.T. Griffey, G.D. Jay, T.L. Kang, D.R. Kriesel, O. J. Ma, M. Mallin, W. Manson, J. Melnikow, D.L. Miglioretti, S.K. Miller, L.D. Mills, J.R. Miner, M. Moghadassi, V.E. Noble, G.M. Press, M.L. Stoller, V.E. Valencia, J. Wang, R.C. Wang, and S.R. Cummings

The NEW ENGLAND JOURNAL of MEDICINE

N Engl J Med 2014;371:1100-10.

METHODS

In this multicenter, pragmatic, comparative effectiveness trial, we randomly assigned patients 18 to 76 years of age who presented to the emergency department with suspected nephrolithiasis to undergo initial diagnostic ultrasonography performed by an emergency physician (point-of-care ultrasonography), ultrasonography performed by a radiologist (radiology ultrasonography), or abdominal CT. Subsequent management, including additional imaging, was at the discretion of the physician. We compared the three groups with respect to the 30-day incidence of high-risk diagnoses with complications that could be related to missed or delayed diagnosis and the 6-month cumulative radiation exposure. Secondary outcomes were serious adverse events, related serious adverse events (deemed attributable to study participation), pain (assessed on an 11-point visual-analogue scale, with higher scores indicating more severe pain), return emergency department visits, hospitalizations, and diagnostic accuracy.

Evaluation

Laboratory test analysis

Each emergency patient with urolithiasis needs a **biochemical work-up of urine and blood**

Recommendations: basic laboratory analysis - emergency urolithiasis patients	Strength rating
Urine	
Dipstick test of spot urine sample: • red cells; • white cells; • nitrites; • approximate urine pH; • urine microscopy and/or culture.	Weak
Blood	
Serum blood sample: • creatinine; • uric acid; • (ionised) calcium; • sodium; • potassium; • blood cell count; • C-reactive protein.	Weak
Perform a coagulation test (partial thromboplastin time and international normalised ratio) if intervention is likely or planned.	Strong
Perform stone analysis in first-time formers using a valid procedure (X-ray diffraction or infrared spectroscopy).	Strong
Repeat stone analysis in patients presenting with: • recurrent stones despite drug therapy; • early recurrence after complete stone clearance; • late recurrence after a long stone-free period because stone composition may change.	Strong

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Evaluation

When can a patient be managed in a

primary care or outpatient setting?

- Patients with clear diagnosis, with **adequate pain relief** and **no complicating factors** **(sepsis or impaired renal function)**

- Patients should be advised that **further episodes of pain are possible** and may be caused by stone passing

- Patients should be supplied with **non-steroidal anti-inflammatory drugs**, on demand for pain relief, and with **medical expulsive treatment** (α-blockers and calcium antagonist)

Bultitude M et al. BMJ 2012;345:e5499

Evaluation

When does a patient require hospital admission?

- **Inability to control pain**
- Patient with **complicating factors**

Box 1: Indications for acute hospital admission[6]

Diagnostic uncertainty (consider admission for patients older than 60 years, because a leaking aortic aneurysm could present with similar symptoms)

Inability to obtain or maintain adequate pain control

Presence of significant fever (>37.5°C) in association with suspected renal colic

Renal colic in patient with solitary or transplanted kidney

Suspected bilateral obstructing stones

Impending acute renal failure

Inability to arrange early investigation or urological assessment

Box 2: Signs of sepsis

Fever (>37.5°C)

Facial flushing

Tachycardia (especially once pain relieved)

Hypotension

Loin tenderness

Bultitude M et al. BMJ 2012;345:e5499

Renal Colic Treatment

Analgesia

- **NSAIDs** and **opiates** are the mainstay of treatment
- **NSAIDs should be used as first line analgesia**

Diclofenac is suggested as first line treatment, although meta-analysis failed to determine which NSAID is best

Bultitude M et al. BMJ 2012;345:e5499

Renal Colic Treatment

- Patient should be advised to **increase oral fluid intake**

- In some cases intravenous fluid replacement is needed

If analgesia cannot be achieved medically, **drainage** using stenting or percutaneous nephrostomy or stone removal **should be performed**

Bultitude M et al. BMJ 2012;345:e5499

Renal Colic Treatment

Sepsis secondary to stone-induced renal obstruction

- **Urgent decompression** of the obstructed collecting system is needed

- **Definitive stone removal should be delayed** until the infection is cleared following a complete course of antimicrobial therapy

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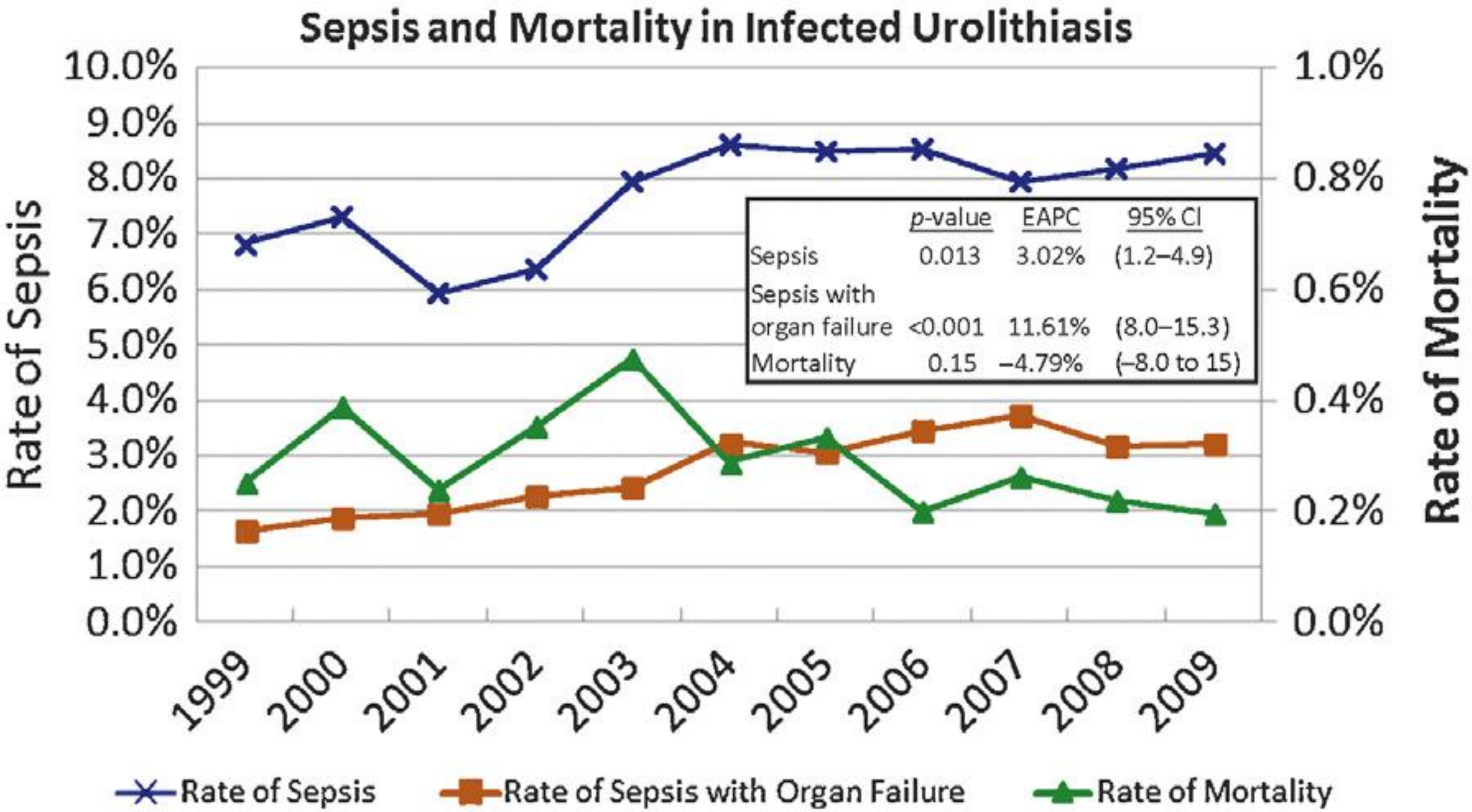
Renal Colic Treatment



Sammon et al. Temporal Trends, Practice Patterns, and Treatment Outcomes for Infected Upper Urinary Tract Stones in the United States. Eur Urol 2013

Renal Colic Treatment

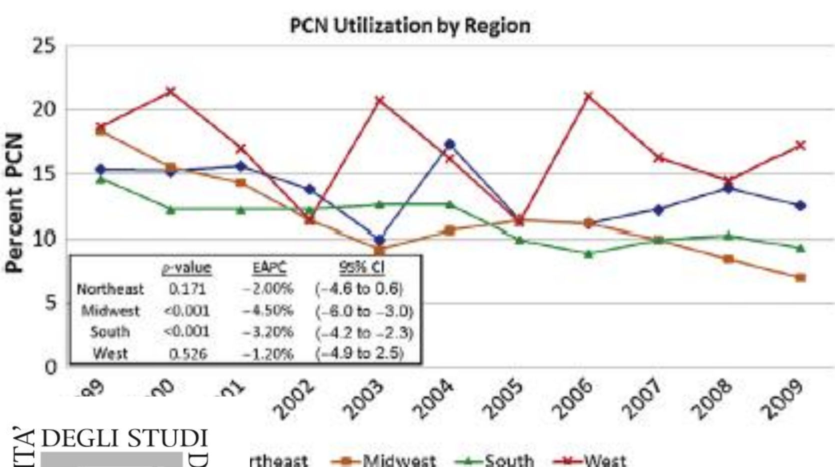
1999-2009: 396.385 patients hospitalized with infected urolithiasis

→

113.459 (28.6%) underwent immediate decompression (first day of admission)

12.3% percutaneous nephrostomy

87.7% retrograde ureteral catheterization



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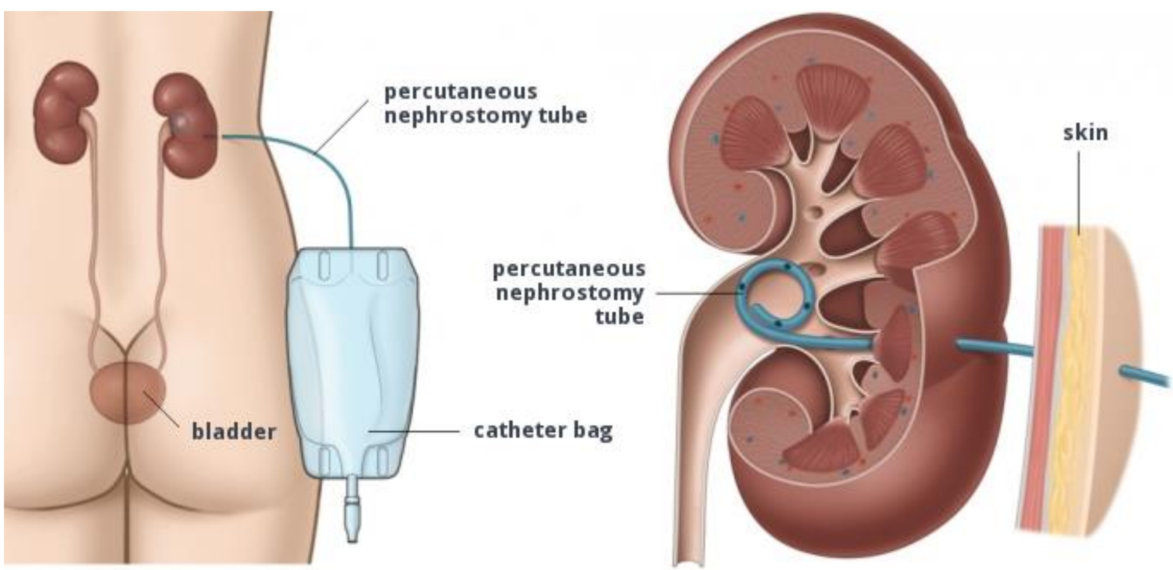
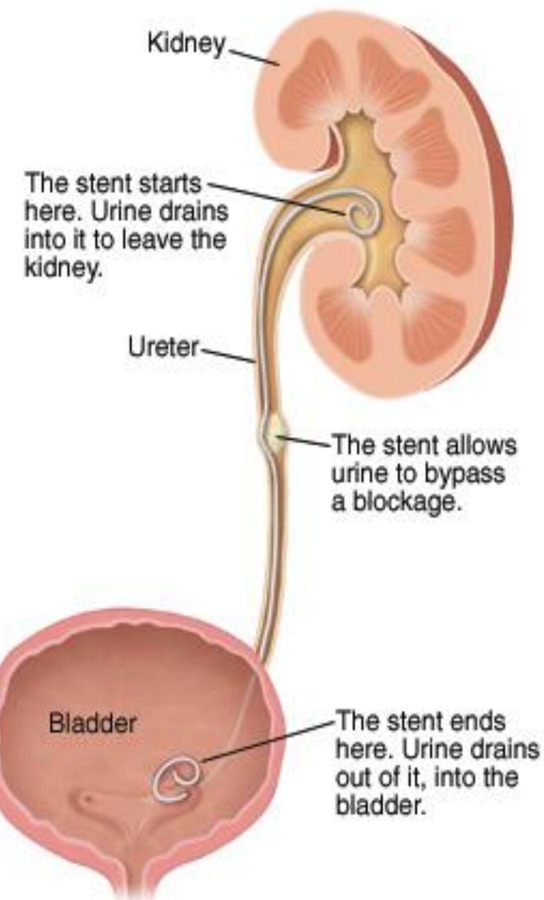
Sammon et al. Temporal Trends, Practice Patterns, and Treatment Outcomes for Infected Upper Urinary Tract Stones in the United States. Eur Urol 2013

Renal Colic Treatment

Statement	LE
For decompression of the renal collecting system, ureteral stents and percutaneous nephrostomy catheters are equally effective.	1b





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Observation of Ureteral Stones

What is the chance of stones passing spontaneously and how long does it take?

- Stone-passage rates depend on **stone size and location**

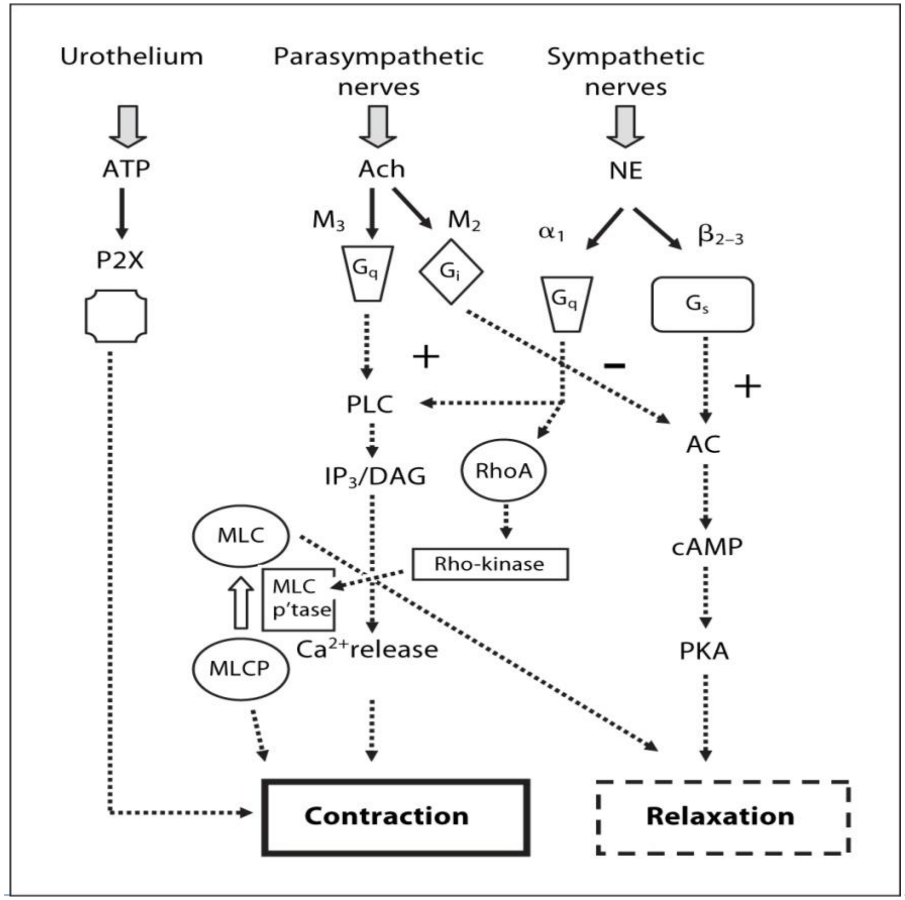
Stone size	Average time to pass	Percentage of passages (95% CI)
< 5 mm (n = 224)		68% (46-85%)
> 5 mm (n = 104)		47% (36-58%)
< 2 mm	31 days	
2-4 mm	40 days	
4-6 mm	39 days	

- International guidelines stated that in newly diagnosed **ureteral stones < 10 mm** observation with periodic evaluation is an optional treatment

Preminger GM, Eur Urol 2007
EAU Guidelines on Urolithiasis 2020

Medical Expulsive Therapy (MET)

Drugs that expel stones might act by **relaxing ureteral smooth muscle** through inhibition of **calcium channel pumps or α-1 receptor blockade**



Kobayashi et al J Smooth Muscle Res 2009

Medical Expulsive Therapy (MET)

- MET seems efficacious in the treatment of patients with ureteral stones who are amenable for conservative treatment.

- Tamsulosin → is the most commonly used **α-blockers**

However several trials demonstrated an α-blocker-class effect

- **Nifedipine** → is actually the only **Ca-antagonist** investigated

- **Tamsulosin is significantly better than Nifedipine** in relieving renal colic and facilitating and accelerating ureteral stone expulsion

- **Silodosin** → is a new selective **α-blockers** which facilitates spontaneous passage of distal ureteral stone

EAU Guidelines on Urolithiasis 2020
Sur RL Eur Urol 2015

Chemolytic Dissolution of Stones

Oral Chemolysis

- Efficient only for **uric acid** stones
- Based on alkalinisation with **sodium bicarbonate** or **potassium citrate**
- Urine pH should be adjusted to 7-7.2

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Active Stone Removal

Treatments

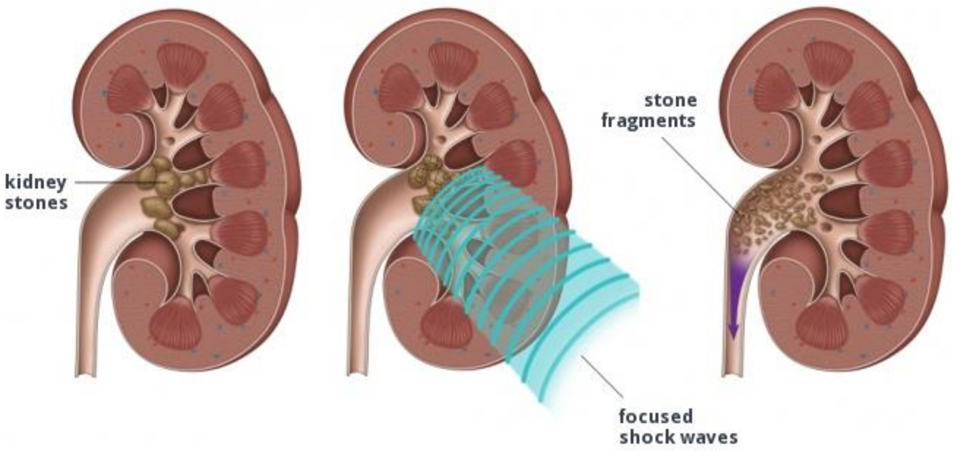
- **Extracorporeal shockwave lithotripsy [ESWL]**
- **Endourology**
  - **Percutaneous nephrolithotomy (PNL)**
  - **Ureterorenoscopy (URS)**
- **Laparoscopic/open surgery**

Extracorporeal shock wave lithotripsy (ESWL)

- Shockwaves could **pass through living tissue** without discernible damage to the tissue but they are **able to fragment brittle materials like kidney stones**

- Fragmentation of stones with shockwaves is achieved by complex phenomena of **pression, torsion, squeezing and cavitation** due to high pressure acoustic waves

LITHOTRIPTER



Smith's General Urology 2008

Extracorporeal shock wave lithotripsy (ESWL)

Imaging system of stone localization:

Fluoroscopy

- Ability to **visualize radiopaque calculi** throughout the urinary tract
- Ability to use iodinated contrast agents to aid in stone localization

Ultrasonography

- **Eliminates radiation exposure** to the patient
- Can identify **radiolucent stones**

- Difficult visualization with obese
- Confusing in identifying stone fragments

Smith's General Urology 2008

Extracorporeal shock wave lithotripsy (ESWL)

Complications			%
Related to stone fragments	Steinstrasse		4 – 7
	Regrowth of residual fragments		21 – 59
	Renal colic		2 – 4
Infectious	Bacteriuria in non-infection stones		7.7 – 23
	Sepsis		1 – 2.7
Tissue effect	Renal	Haematoma, symptomatic	< 1
		Haematoma, asymptomatic	4 – 19
	Cardiovascular	Dysrhythmia	11 – 59
		Morbid cardiac events	Case reports
	Gastrointestinal	Bowel perforation	Case reports
		Liver, spleen haematoma	Case reports

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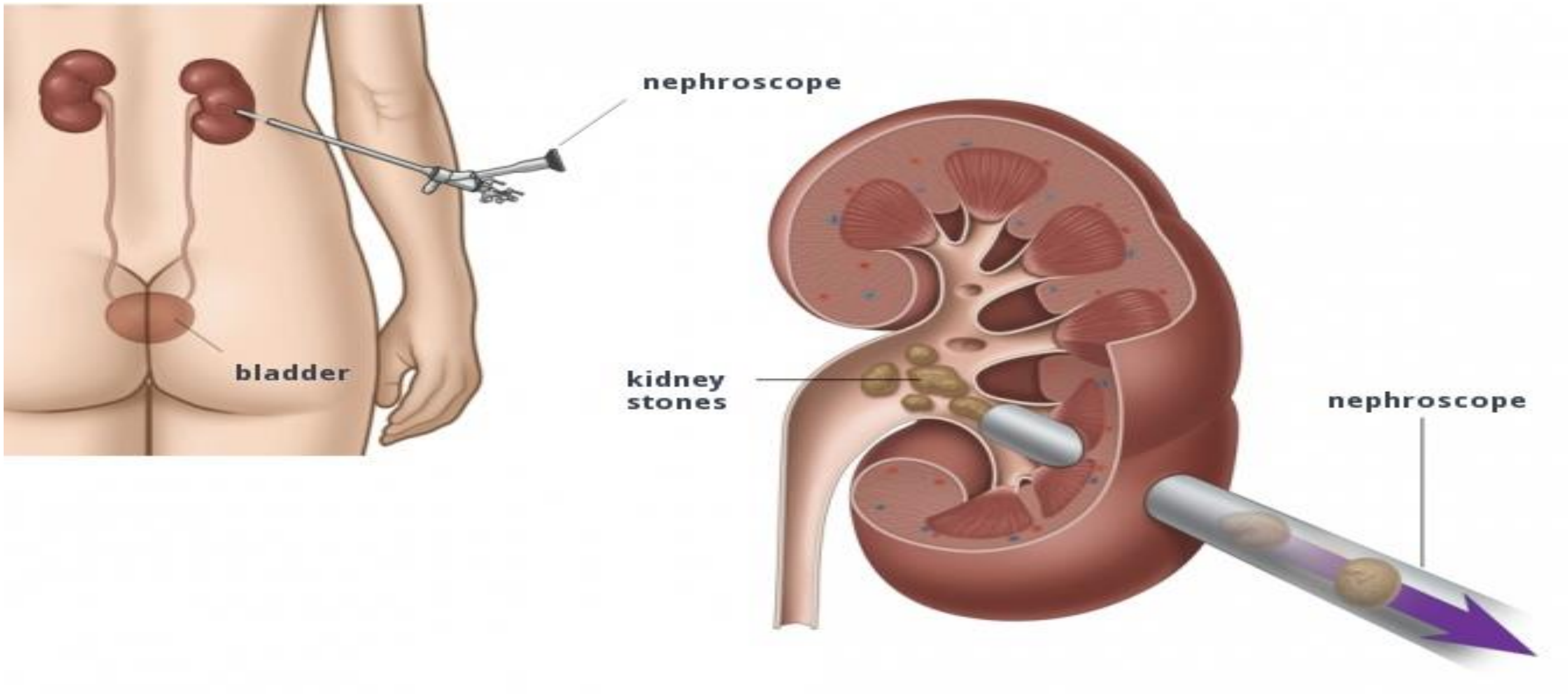
Percutaneous Nephrolithotomy

Large Kidney Stones

- **A percutaneous approach** to stone removal



- A **Rigid** or **Flexible** nephroscope is introduced through a nephrostomy access
- Small stones can be removed with **stone basket**

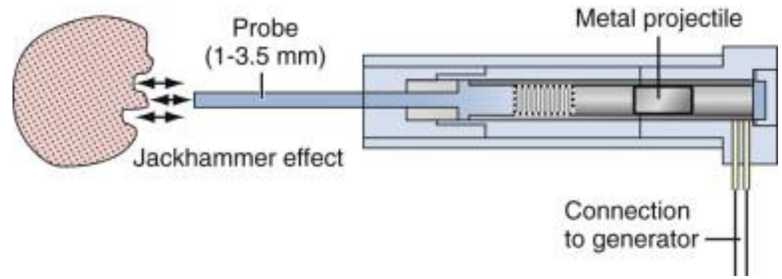
Campbell-Walsh Urology 2012

Percutaneous Nephrolithotomy

Larger stones can be fragmented

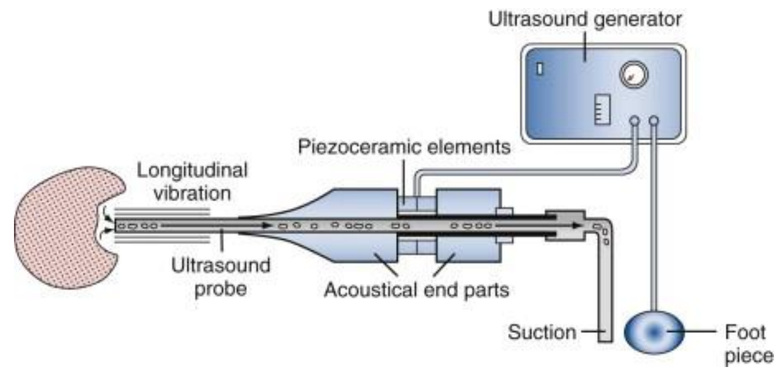
Ballistic lithotripsy

- The ballistic lithotripsy provide an effective means for stone fragmentation in the entire urinary tract, **with a wide margin of safety**; however is associated with an **high rate of stone retropulsion**.



Ultrasonic lithotripsy

- The ultrasound probe works by applying electrical energy to excite a piezoceramic plate in the ultrasound transducer
- The major advantage of ultrasonic lithotripsy is the **efficient combination of stone fragmentation and simultaneous fragment removal**. Fragments smaller than 2 mm **are aspirated through the hollow lithotrite** along with the



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Campbell-Walsh Urology 2012

Percutaneous Nephrolithotomy

- During PNL, ultrasonic and pneumatic systems are most commonly used for rigid nephroscopy.

- Flexible endoscopes require laser lithotripsy to maintain tip deflection and the Holmium laser has become the standard, as for ureteroscopy

Summary of evidence	LE
Imaging of the kidney with US or CT can provide information regarding inter-positioned organs within the planned percutaneous path (e.g., spleen, liver, large bowel, pleura, and lung).	1a
Both prone and supine positions are equally safe, but neither has a proven advantage in operating time or SFR.	1a
Percutaneous nephrolithotomy performed with small instruments tends to be associated with significantly lower blood loss, but the duration of procedure tended to be significantly longer. There are no significant differences in SFR or any other complications.	1a
In uncomplicated cases, a totally tubeless PNL results in a shorter hospital stay, with no increase in complication rate.	1a

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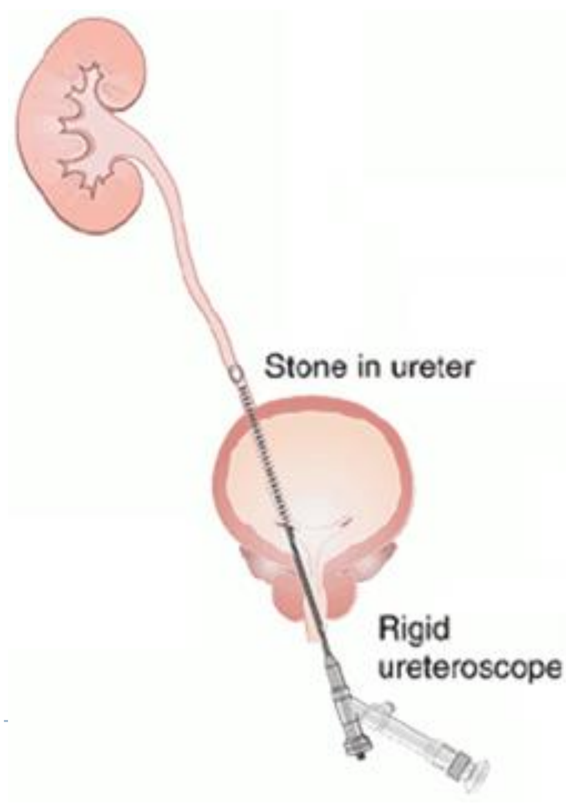
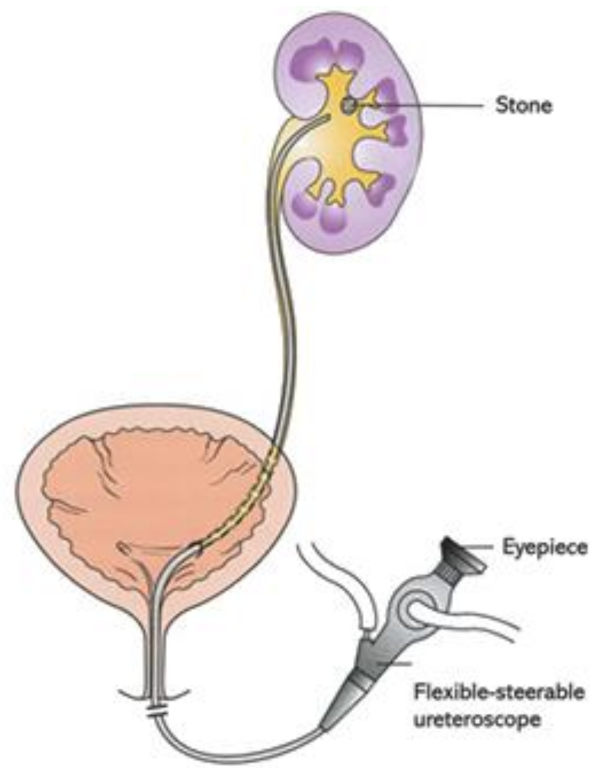
Uretero-renoscopy (URS)
Uretero-lithotripsy

- **Ureteroscopy** is performed with an endoscope that is passed through the urethra, bladder and then directly into the ureter

- Ureteroscopes are available as **flexible** or **rigid** instruments.





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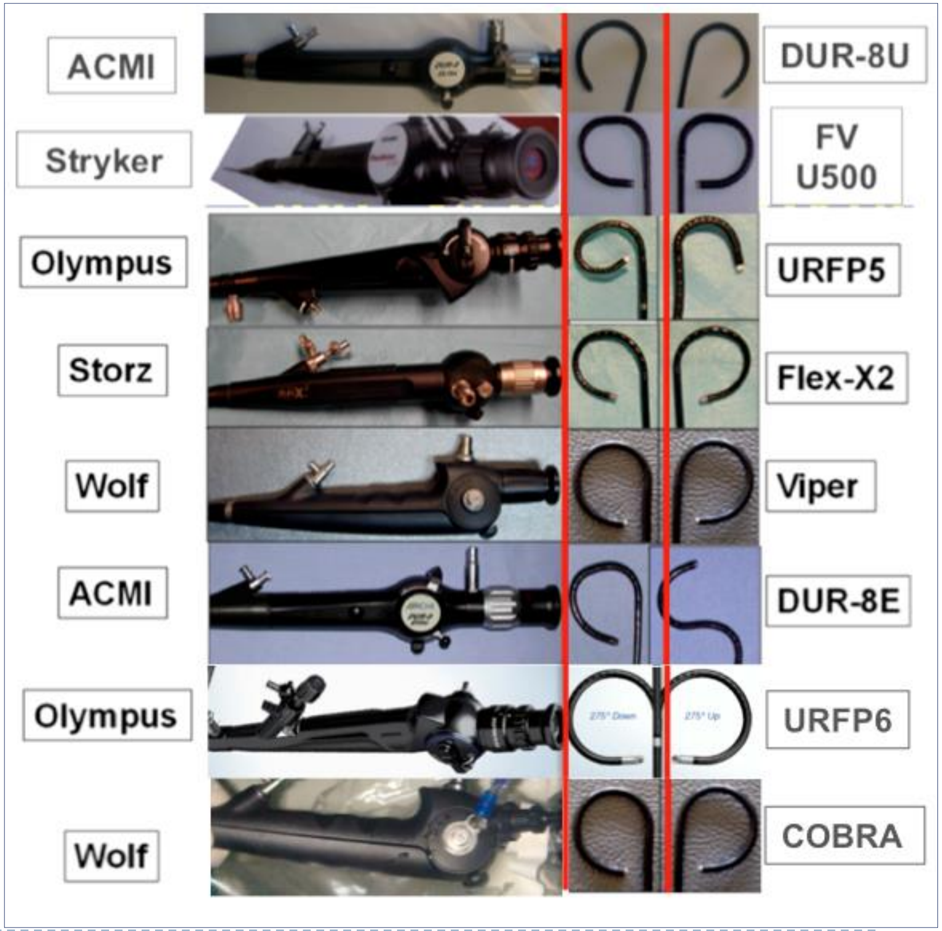
Ureterorenoscopy (URS)

Rigid ureteroscopes

Flexible ureteroscopes



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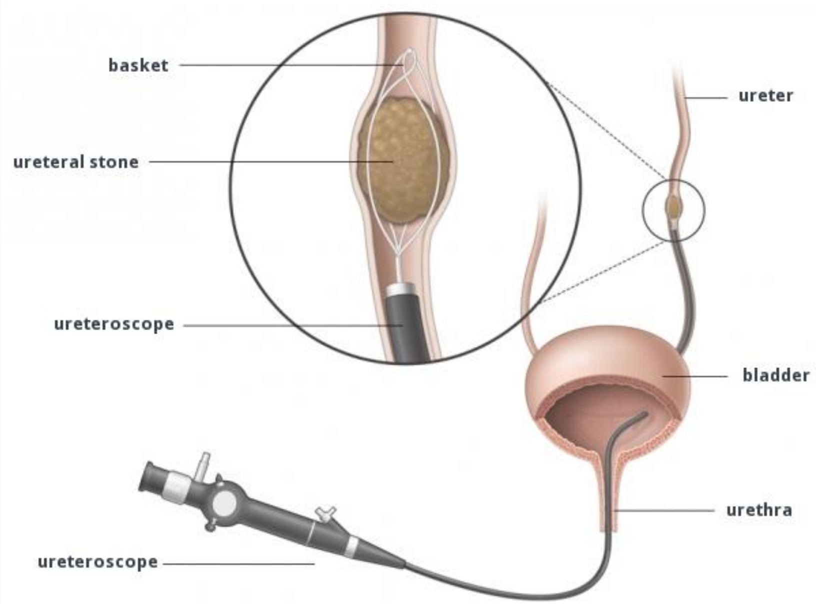
Ureterorenoscopy (URS)

- Aim of URS is **complete stone removal**:

  - stones can be extracted by **endoscopic forceps or baskets**

  - stones that cannot be extracted directly must be disintegrated with **intracorporeal lithotripsy**

  - The most effective lithotripsy system is the **Holmium laser**, which has become the **gold standard for ureteroscopy and flexible nephroscopy**



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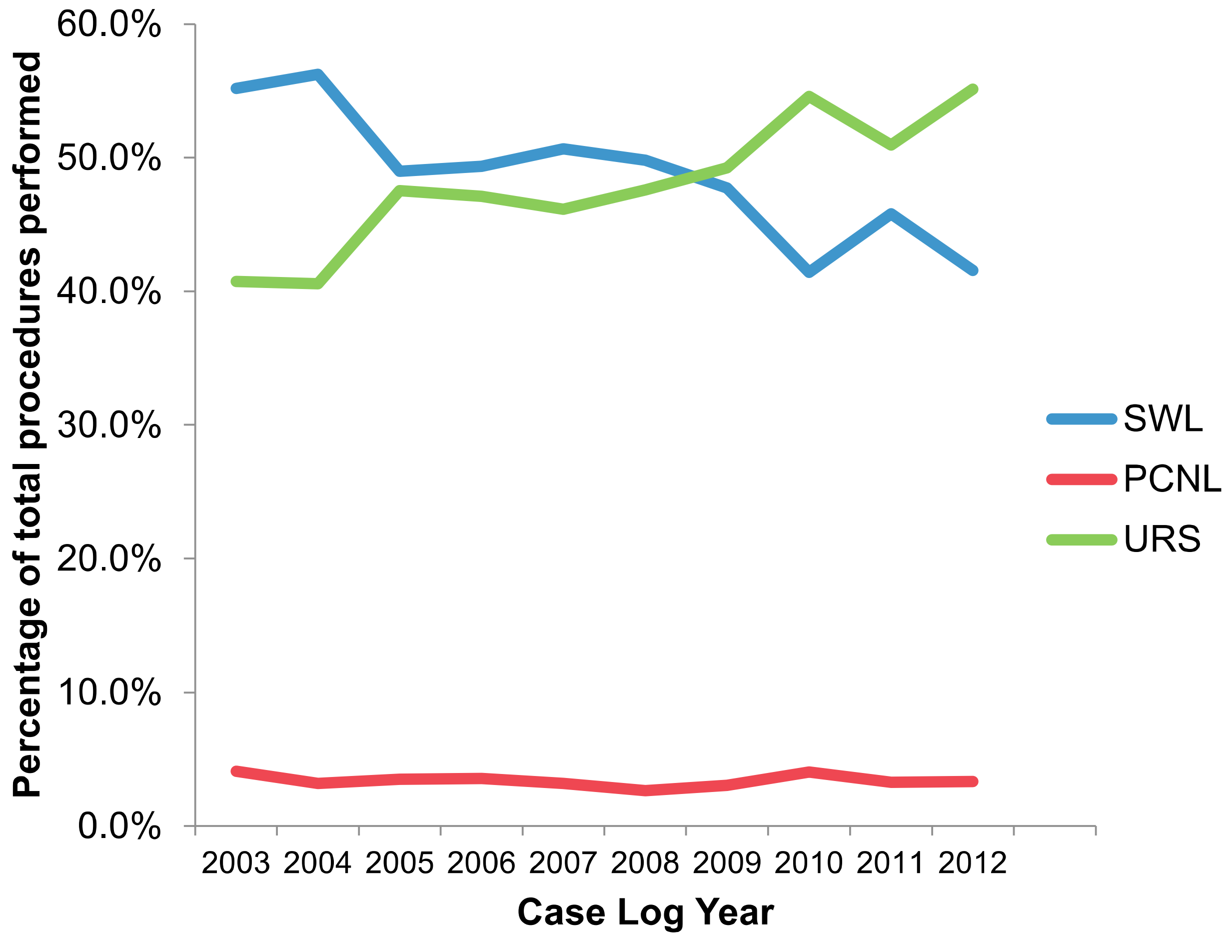
Active Stone Removal : surgical trends in US



Oberlin DT. Contemporary surgical trends in the management of upper tract calculi. J Urol 2015

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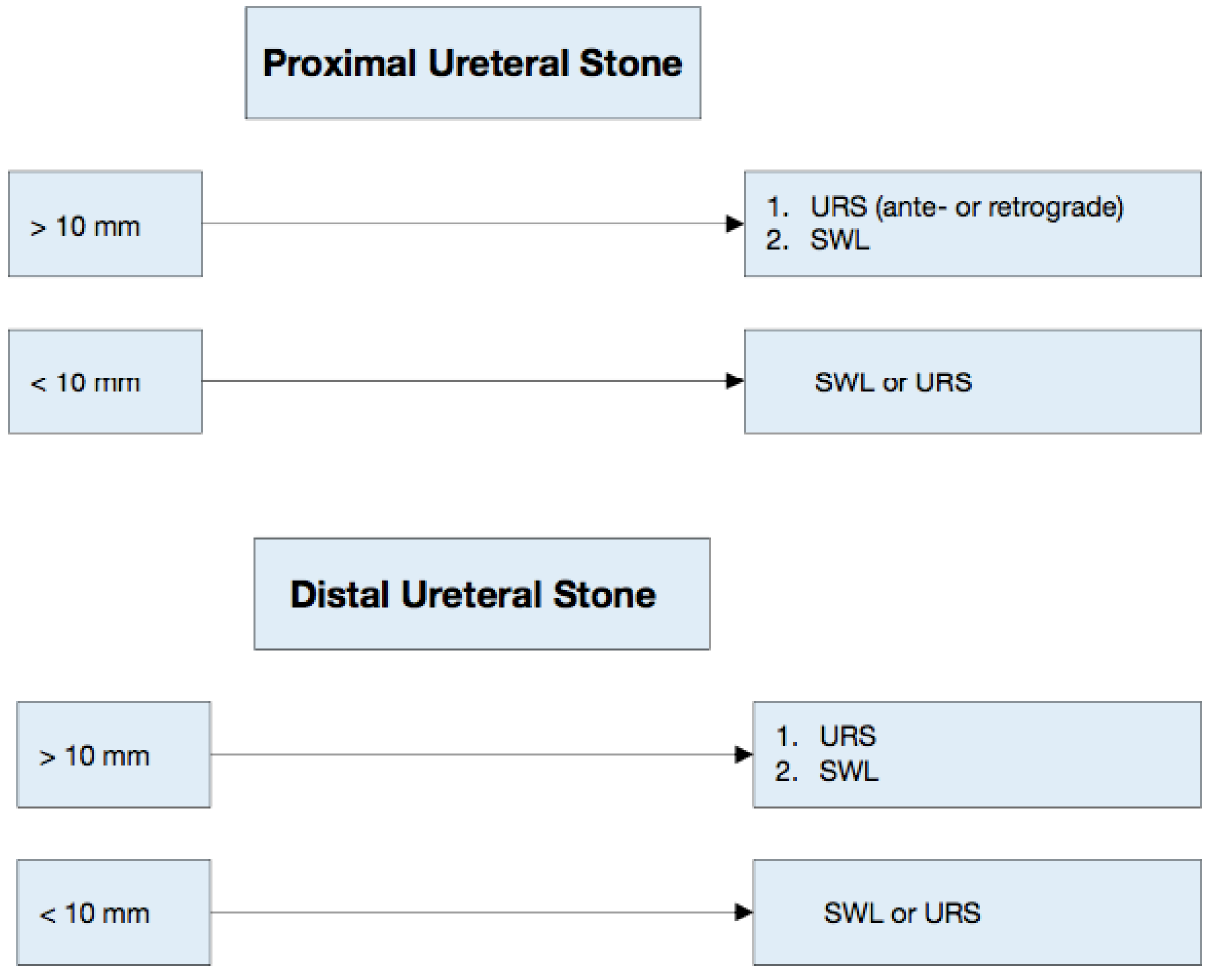
Figure 3.1: Treatment algorithm for ureteral stones (if active stone removal is indicated)



SWL = shock wave lithotripsy; URS = Ureteroscopy.

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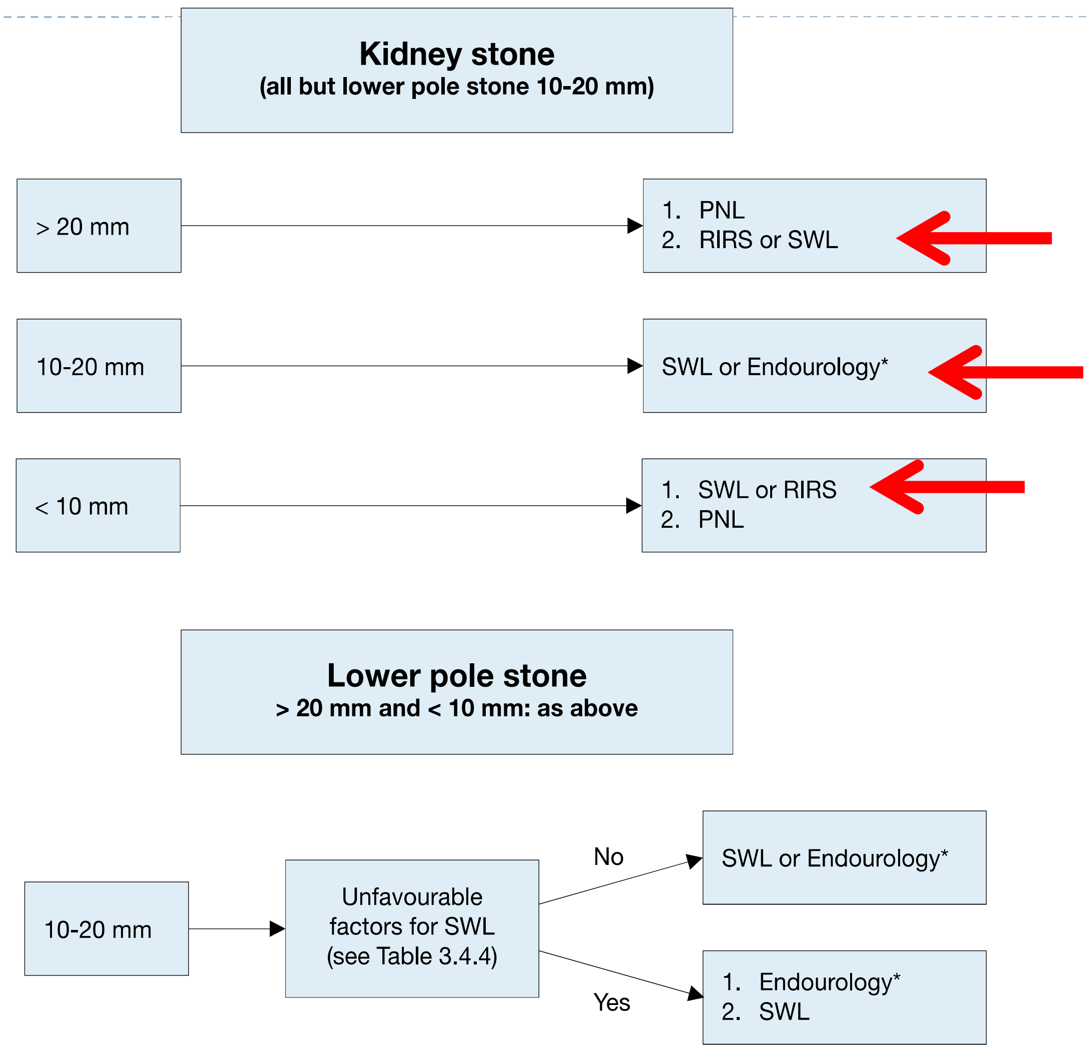
Figure 3.4.1: Treatment algorithm for renal calculi



**The term 'Endourology' encompasses all PNL and URS interventions.*
PNL = percutaneous nephrolithotomy; RIRS = retrograde renal surgery; SFR = stone-free rate; SWL = shockwave lithotripsy; URS = ureterorenoscopy;

Unfavorable conditions for ESWL:

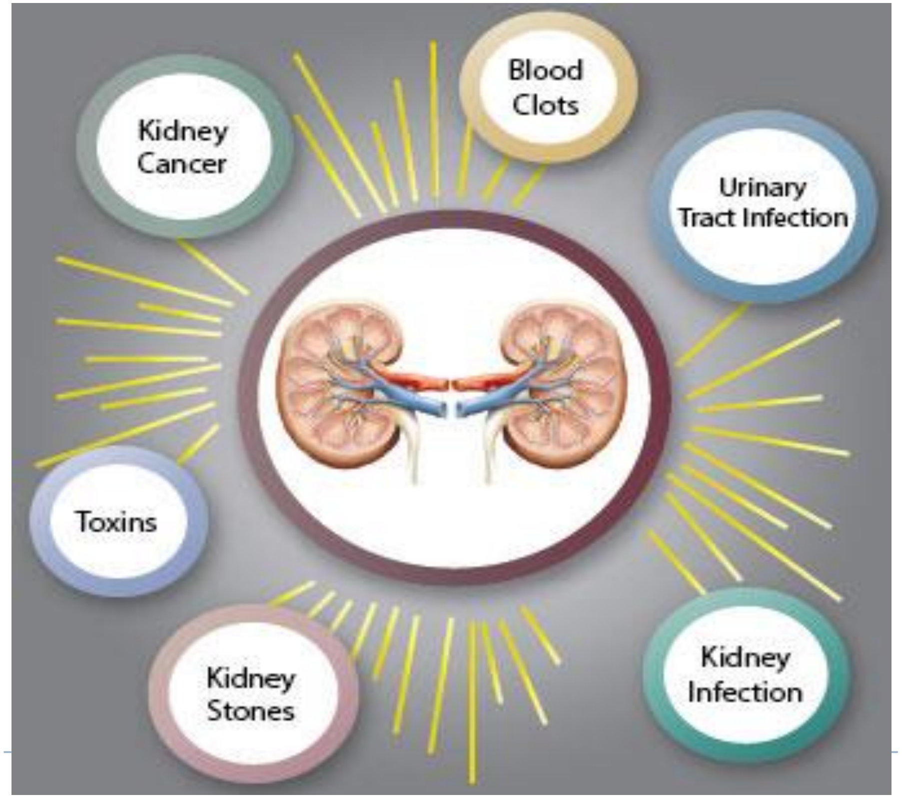
- Hard stones (Calcium Oxhalate Mnohydrate, cystine brushite)
- Steep infundibular–pelvic angle
- Long calyx (> 10 mm)
- Narrow infundibulum (< 5 mm)

Unfavorable conditions for URS:

- None

Summary

- UTO is an important urologic disorder and a common cause of acute and chronic renal failure
- Multiple causes, high clinical suspicion and acumen necessary



Summary

- UTO is a potentially reversible process
  - Prompt recognition
  - Prompt treatment
  - Prompt consultation/referral