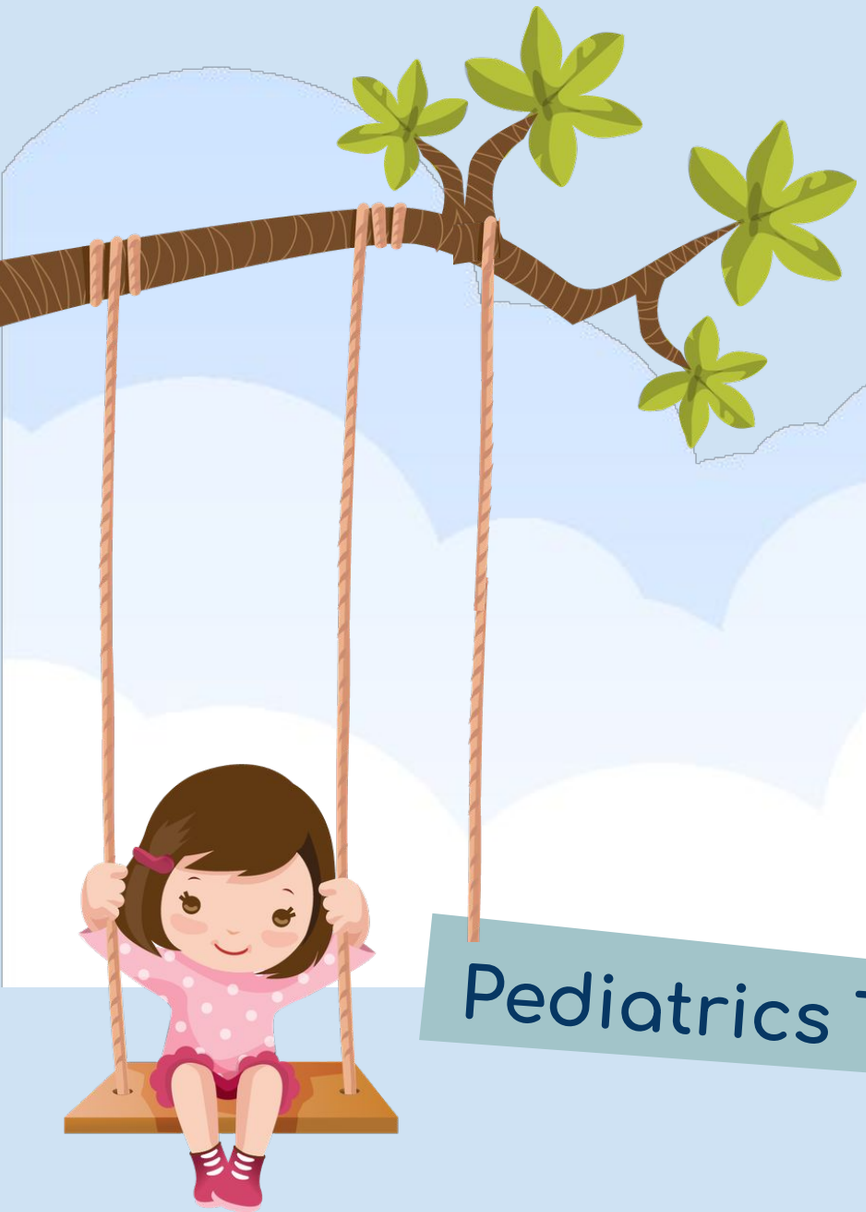

Pediatrics TeamWork 437

CAKUT & UTI

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Notes | Previous Notes | Book | Important!

Congenital Anomalies of the Kidney & Urinary Tract

Overview

- Congenital anomalies of the kidney and urinary tract (CAKUT) constitute approximately 20 to 30% of all anomalies identified in the prenatal period.
- Defects can be bilateral or unilateral, and different defects often coexist in an individual child (multiple level: kidney, UPJ, ureter, UVJ obstruction, bladder, urethra PUV). Thus if there is a defect look for another defect and also look at the other side.
- The overall rate of CAKUT in live and stillborn infants is 0.3 to 1.6 per 1000 .
- The incidence is higher in women with a family history of CAKUT.
- Of all antenatal renal anomalies, the most frequent abnormality is hydronephrosis, (ie, upper urinary tract dilatation).
- Renal malformations are associated with non-renal congenital anomalies in about 30 % of cases, Classically preauricular tags (Extrarenal anomaly)

Kidney

Renal Hypoplasia

- A lower number of structurally normal nephrons, is a distinct entity separate from renal dysplasia
- Unknown causes
- Normally there is 1 million nephron in one kidney.
- The clinical diagnosis of renal hypoplasia is suggested when all of the following criteria are met:
    - Reduction of renal size by 2 standard deviations for the mean size by age
    - Exclusion of renal scarring by 99mTc-dimercaptosuccinic acid (DMSA) radionuclide scan.
    - In cases of unilateral renal hypoplasia, compensatory hypertrophy of the contralateral kidney

Small kidney by US it could be either a scar or hypoplasia, we can not tell

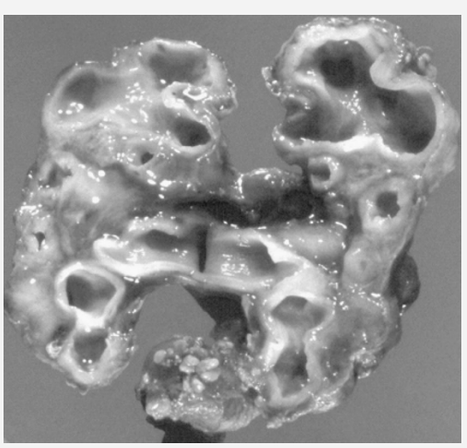
Kidney

Renal Dysplasia

- Renal dysplasia is characterized by the presence of malformed kidney tissue elements
- Dysplastic kidneys are variable in size but most are smaller than normal. Size is often determined by the presence or absence of cysts.
- Renal dysplasia may be unilateral or bilateral
- Renal dysplasia may be discovered during routine antenatal screening or postnatally when renal ultrasonography is performed in a dysmorphic infant.
- Bilateral dysplasia is likely to be diagnosed earlier than unilateral dysplasia especially if oligohydramnios is present. (Non functional kidney)(These type of patients will have pulmonary hypoplasia and renal dysplasia which will lead to **potter syndrome**)
- The classical example of renal dysplasia is MCDK (Multicystic dysplastic kidney). Many think that MCDK is secondary to renal obstruction
- Infants with bilateral dysplasia may have impaired renal function at birth and subsequent progressive renal failure may occur.
- Associated urological findings include abnormalities of the renal pelvis and calyces (congenital hydronephrosis) and ureters (duplicating collecting system), megaureter, ureteral stenosis, and vesicoureteral reflux (VUR). Investigate the other side and multilevel defects.
- Because of the frequent association of renal dysplasia with a collecting system anomaly, voiding cystourethrography should be considered in all patients with renal dysplasia.
- The prognosis of renal dysplasia depends on whether there is unilateral versus bilateral disease. In general, the long-term outcome of unilateral renal dysplasia is excellent, particularly if there is a normal contralateral kidney.
- In the past they used to do nephrectomy to the dysplastic kidney because they thought it has a relation to tumor but now they do not do it

Multicystic Dysplasia

- Multicystic dysplastic kidney (MCDK) is a nonfunctioning dysplastic kidney with multiple cysts, which is thought to arise from an alteration in renal parenchymal differentiation. MCDK consists of a non reniform mass of cysts and connective tissue, and is most commonly detected by routine antenatal screening
- 50% will have involuted by 2 years of age. Nephrectomy is indicated only if it remains large or hypertension develops



Dysplasia

Kidney

Renal Agenesis

- Renal agenesis is defined as congenital absence of renal parenchymal tissue and results from major disruption of **metanephric development at an early stage**.
- Unilateral RA accounts for 5 percent of renal malformations .
- The incidence of renal agenesis is approximately 1 per 2900 births
- Usually unilateral. Can live normal if the other kidney is normal.
- Multiple factors are thought to be implicated in the pathogenesis of renal agenesis including mutations in genes important in renal development, and teratogenic and environmental agents (eg, retinoic acid and cocaine exposure)
- Other urological abnormalities have been reported in up to 33 to 65 percent of unilateral cases
- **Vesicoureteral reflux (VUR)** is the most commonly identified urological abnormality,
- Nonrenal associated anomalies include cardiac anomalies (most commonly septal anomalies), genital tract, and gastrointestinal, respiratory, and skeletal malformations

Genetic Cystic Diseases

Genetic cystic renal diseases are disorders of terminal epithelial differentiation

A. Autosomal Recessive Polycystic Kidney Disease (ARPKD):

- It is caused by mutations in the, which codes for fibrocystin.
- ARPKD is characterized by multiple microscopic cysts, principally involving the distal collecting ducts Of both kidneys
- Kidneys are usually greatly enlarged and contain small cysts; renal failure is common in childhood. The baby born can't breath due to huge kidneys.
- The liver is enlarged and has periportal fibrosis and scattered cysts.
- Fibrosis produces portal hypertension by age 5 to 10 yr.
- Disease severity and progression vary. Severe disease may manifest prenatally or soon after birth or in early childhood with **renal-related symptoms**; less severely affected patients present in late childhood or adolescence with hepatic-related symptoms.
- Severely affected neonates commonly have pulmonary hypoplasia secondary to the in utero effects of renal dysfunction and oligohydramnios (potters syndrome).
- If the patient presents in adolescence, nephromegaly is less marked, renal insufficiency may be mild to moderate, and the major symptoms are those related to portal hypertension
- Diagnosis may be difficult, especially without a family history. Ultrasonography may demonstrate renal or hepatic cysts; definitive diagnosis may require biopsy.
- Ultrasonography in late pregnancy usually allows presumptive in utero diagnosis.
- Clinical manifestations include oligohydramnios, pulmonary hypoplasia, hypertension, congestive cardiac failure, liver disease, and renal failure.
- The perinatal prognosis depends on the pulmonary status

Genetic Cystic Diseases

B. Autosomal Dominant Polycystic Kidney Disease (ADPKD):

- ADPKD is characterized by bilateral renal enlargement secondary to multiple cysts.
- It is caused by mutations in either PKD1 (85 percent of patients) or PKD2 genes (15 percent)
- There is a greater variability in clinical manifestations of ADPKD with most patients having significant clinical findings only in adulthood.
- There are a subset of children who have an early onset of disease (in utero or in the first year of life) with symptoms similar to those with ARPKD.
- These include gross or microscopic hematuria, hypertension, proteinuria, cyst infection, and renal insufficiency
- What distinguishes it from recessive is that is has extra-renal manifestations. First, they will have cysts everywhere; cysts in the ovaries, pancreas, liver everywhere. Also, they have cranial aneurysms as well as mitral valve prolapse. So, in the history of autosomal dominant, you have to ask about sudden death in the family. Sudden death would indicate CVA due to aneurysms.
- What is important in the autosomal recessive history? Skipped generations. Autosomal dominant does not skip generations; AD will be in every generation.

Table 17.4 Extrarenal manifestations of autosomal dominant polycystic kidney disease

Cardiovascular
Mitral valve prolapse
Aortic aneurysms
Hypertension
Intracranial aneurysms

Extrarenal cysts
Hepatic cysts:
Pancreatic cysts
Ovarian cysts
Testicular cysts:
Arachnoid cysts
Splenic cysts
Pineal cysts
Seminal vesicle cysts

Other
Hernias
Colonic diverticula
Cholangiocarcinoma
Congenital hepatic fibrosis

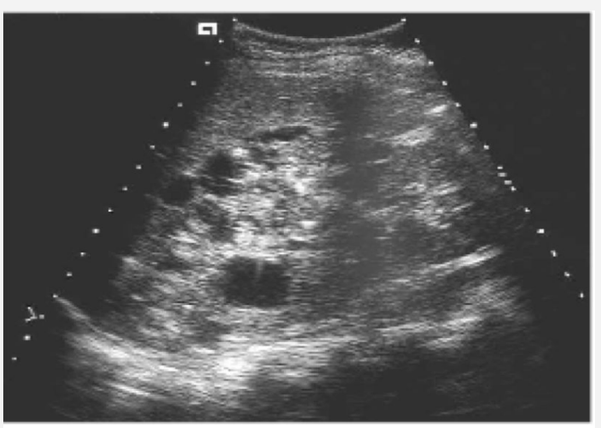


Figure 17.2 Sonogram of a 17-year-old patient with autosomal dominant polycystic kidney disease. Cysts of varying sizes are located in the cortex and the medulla.

How to tell whether this is a cyst or hydronephrosis? Communicating cyst > hydronephrosis, non communicating > just a cyst

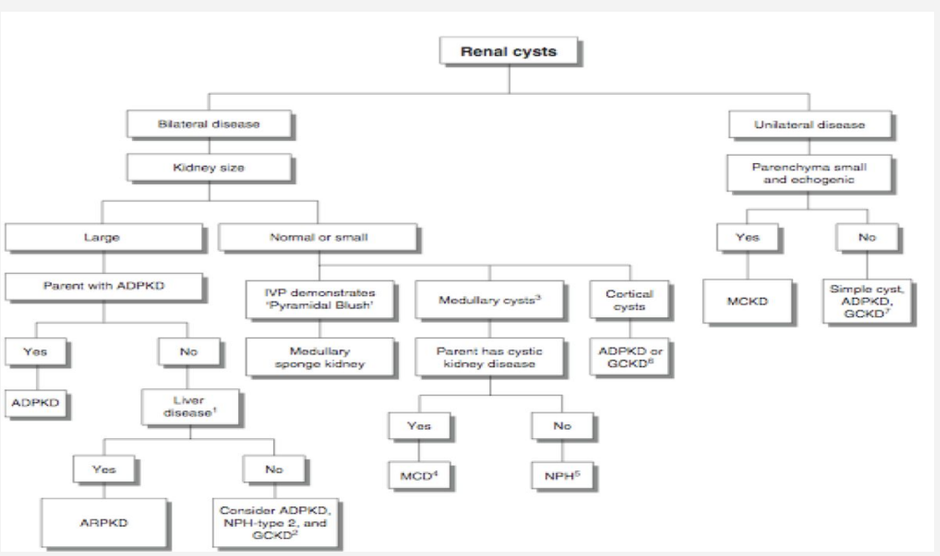


Table 1. Indications to Screen for Intracranial Aneurysm in Patients with ADPKD

Before major elective surgery
Central nervous system signs or symptoms (e.g., nausea and vomiting, lethargy, photophobia, focal signs, seizure, transient ischemic attack, loss of consciousness)
Family history of intracranial aneurysm or intracranial hemorrhage
High-risk occupation (e.g., airline pilot)
New-onset severe headache

ADPKD = autosomal dominant polycystic kidney disease.

Information from references 29, 31, and 32.

EXTRA (not from slides or dr notes)

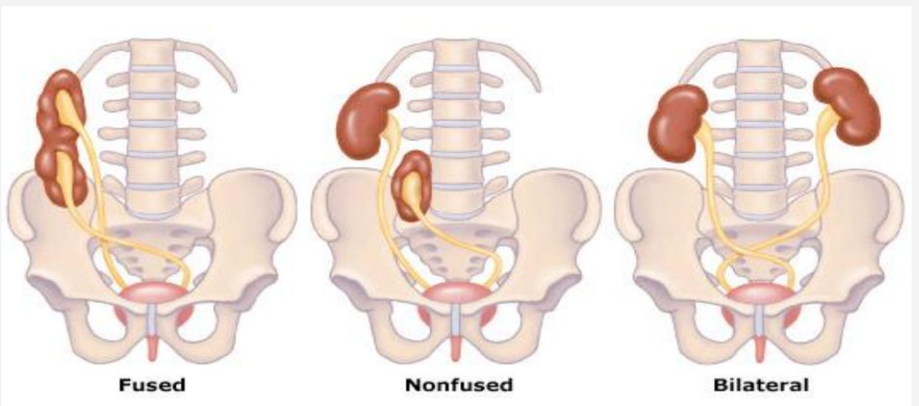
Kidney

Renal Ectopia

- Renal ectopia occurs when the kidney does not normally ascend to the retroperitoneal renal fossa (level of the second lumbar vertebra).
- Simple congenital ectopy refers to a kidney that lies on the correct side of the body but lies in an abnormal position.

Crossed renal ectopia

- Different forms of crossed renal ectopia
  1. Fused: Ectopic kidney moves across the midline and fuses to the lower pole of the normally positioned contralateral kidney.
  2. Nonfused: Ectopic kidney moves across the midline without fusion and positioned at the rim of the pelvis (pelvic kidney).
  3. Bilateral: Both kidneys are ectopic and cross the midline with the ureters maintaining their normal bladder insertion.

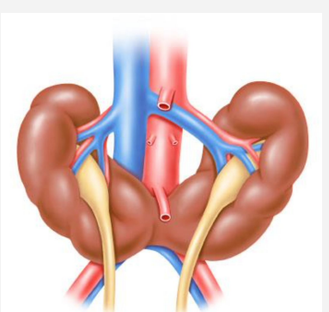


Crossed fused renal ectopia

Bilateral crossed non fused renal ectopia

Renal Fusion

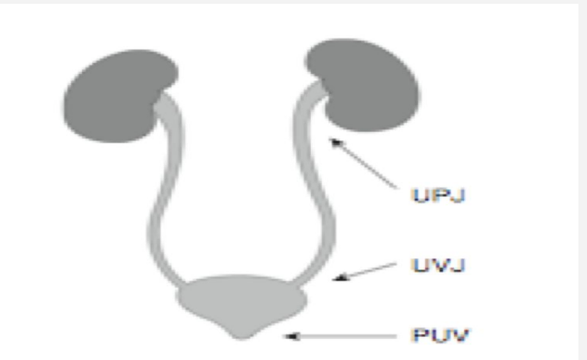
- Renal fusion occurs when a portion of one kidney is fused to the other.
- The most common fusion anomaly is the horseshoe kidney, which involves abnormal migration of both kidneys (ectopy), resulting in fusion.
- This differs from crossed fused renal ectopia, which usually involves abnormal movement of only one kidney across the midline with fusion of the contralateral noncrossing kidney
- Horseshoe kidney can be a feature of many syndromes including genetic disorders such as Turner syndrome, Trisomy 13, 18 and 2
- Pancake kidney: when the fusion occur in the upper middle and lower parts of the kidney
- Patients with a horseshoe kidney appear to have an increased risk for Wilms tumor (not 100% of course).
- Most patients with an ectopic or fused kidney(s) are asymptomatic and are diagnosed coincidentally, often by antenatal ultrasonography. No hydronephrosis, no reflux.
- In patients diagnosed symptomatically with either anomaly, symptoms at presentation are generally related to associated complications including urinary tract infection (with or without VUR), obstruction, and renal calculi.



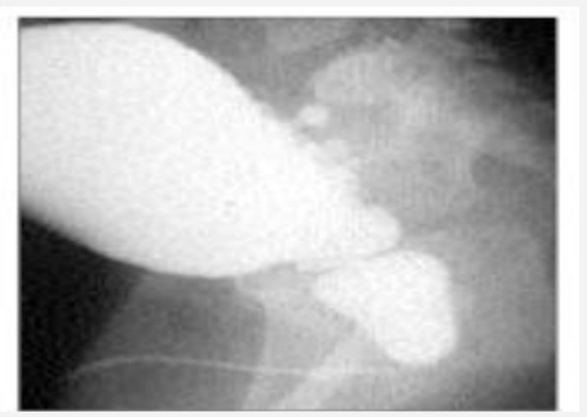
Horseshoe kidney

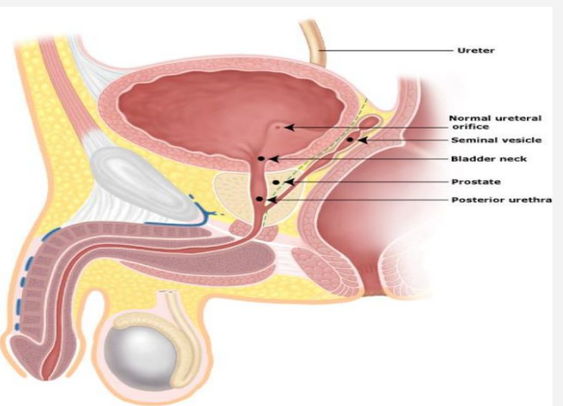
Ureter & Bladder

- UPJ and UVJ Obstruction, diagnosed using:
  - US (hydronephrosis)
  - DTPA (like DMSA but DMSA shows anatomy while DTPA is excreted and thus shows the function especially in older children)
- Complete obstruction > pyeloplasty



- **Posterior Urethral Valve:**
  - 1/3rd are born with bilateral renal failure.
  - Few centers do intrauterine shunting of urine to amniotic fluid
  - Diagnosis: MCUG done in lateral position with removed catheter (old keyhole sign) Gold standard is scope
  - Bilateral hydronephrosis in a male infant requires urgent investigation to exclude posterior urethral valves



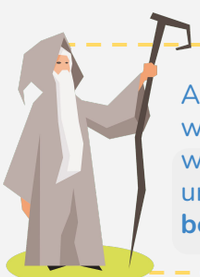


Location of ectopic ureteral orifices in boys

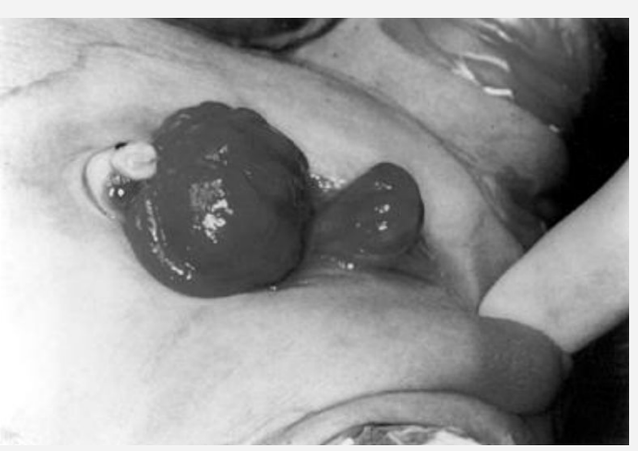
Bladder Exstrophy

Physical findings characteristic of bladder exstrophy in both boys and girls include:

- Open bladder plate
- Low set umbilicus
- Diastasis of the symphysis pubis
- Anteriorly displaced anus
- Inguinal hernia



Absence of the anterior abdominal wall muscles is frequently associated with a large bladder and dilated ureters and cryptorchidism (**prune belly syndrome**)



Urinary Tract Infections

Overview

- Urinary tract infection (UTI) is a leading cause of serious bacterial illness in febrile infants, because they have specific issues compared to adults.
- Throughout childhood the cumulative incidence is approximately 10% in girls and 3% in boys, more common in girls due to short urethra
- Urinary infection usually is ascending, with inoculation of fecally derived organisms from the urethra and peri-urethral tissues into the bladder. Rarely hematogenous.
- The most prevalent pathogens in several recent pediatric studies were:
    - Escherichia coli (54%-67%) E. coli is gram negative, it surrounds the perineal area with other gram negative organisms.
    - Klebsiella (6%-17%) Proteus (5%- 12%)
    - Enterococcus (3%-9%)
    - Pseudomonas (2%-6%)(It can indicate an abnormal urinary tract structure, plastic catheters and presence of ureteral stents)
- Among patients with urinary tract anomalies or impaired immune system, less virulent organisms such as staph epidermidis, H influenza, and group B strept, may be responsible
- The hematogenous route of infection is far less common with generally different causal organisms, such as Staph Aureus, Candida and Salmonella; Pseudomonas Aeruginosa and Proteus can infect by either route

-Why UTI is more dangerous in pediatrics that adults? Once it invade the blood it can go to so many places, for example to meninges and causes meningitis, or to joints and causes septic arthritis or to bone and causes osteomyelitis so in young children we get worry whenever these babies are having bacteremia so treat early.
-Proteus infection leads to phosphate stones (alkalinizing the urine)

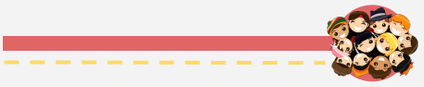
Signs & Symptoms

Non-toilet-trained & Non-vocalized Child	Toilet trained & Verbelized Child
General symptoms; fever, lethargy, irritability. Therefore, u don't know does the child have UTI, or meningitis, or bacteremia. When they have the bug in the urinary tract it can easily go to the blood or seed to the brain (meningitis) or to the bone (osteomyelitis). It is sometimes very serious especially in little children.	Like adult symptoms more or less. Dysuria Frequency Urgency Flank pain (pyelonephritis) Fever and vomiting Easier to pick-up than younger children

We start to train the child for toilet at 18 months but we don't force him/her. After five years, if still wet it is enuresis.

-Dysuria **ALONE** is usually due to cystitis, or vulvitis in girls or balanitis in boys. It can be also secondary to bladder neck compression due to constipation
-UTI symptoms in pediatrics can also occur following **sexual abuse**!!

Urinary Tract Infections



Presentation

- Young infants often present with fever alone (38°C); irritability, vomiting, lethargy, or poor feeding variably may be present.
- For those younger than 3 months there is an **increased risk of bacteremia** and a greater possibility of undiagnosed congenital urologic malformations.
- Older children generally have more explicit symptoms of bladder and/or pain.
- For infants, any of the following increased the positive likelihood ratio of UTI to 2 or more: history of prior UTI, fever of more than 24 hours duration or higher than 40°C, absence of circumcision in males, and suprapubic tenderness.
- Combinations of these findings amplified probability.
- For verbal children, the following symptoms were most reliable: abdominal pain with fever higher than 38°C, back pain), new onset urinary incontinence, dysuria, and frequency.

Diagnosis

- Specimen Collection : A non contaminated urine sample is fundamental.
- For older children: Midstream urine collection.
- For infants and non-toilet-trained children, the most accurate method of collection is suprapubic bladder aspiration, however, it rarely is practical. It is safe but urethral catheterization or spontaneously voided clean catch midstream samples (usually obtained as you change the diaper if lucky the baby starts passing urine) are the most reliable alternatives.
- Perineal urine bag collection has a high rate of contamination and should be avoided for culture, but may help in screening infants for suprapubic bladder aspiration or urethral catheterization.
- For toilet-trained children, appropriate cleansing of the perineal/genital area before midstream urine collection is essential.
- Suprapubic aspiration can be used in severely ill infant requiring urgent treatment and diagnosis
- A urine sample should be tested in all infants with unexplained fever > 38 C
- You do urinalysis, gram stain, and culture.

- Urinalysis:
    - Although urine culture is the gold standard for UTI diagnosis, more rapid screening may be required for preliminary clinical decision making. Start empirical treatment once you take the sample.
    - Urine Gram stain is the single most sensitive and specific test.
    - For older infants and children, urine dipstick testing for both leukocyte esterase (means there is WBCs) and nitrites may be used if microscopy is unavailable, however, urine still must be sent for culture and symptomatic children must be treated pending the results because the dipstick false-negative rate is high (if negative nitrite doesn't exclude UTI as not all bacteria produce nitrite. Also babies pass urine frequently it's not kept in the bladder, thus nitrate is not reduced to nitrite).
    - No role of RBC as it doesn't role in or role out.

Urinary Tract Infections

Diagnosis

- Urine Culture:
  - Bacterial colony count criteria to distinguish urine infection from contamination are optional, not absolute.
  - Although 10^5 colony forming units (CFU) per mL (10^8 CFU/L) is the generally accepted diagnostic cut-off level for midstream urine samples, true infection with a lower colony count occurs (eg, reduced bladder incubation time owing to urinary frequency or high urine flow rate, presence of an antibacterial agent in the urine). In children with clear symptoms we diagnose even if CFU is < 10^5
  - For small babies (<1 year) you have to do full septic analysis, blood culture and LP because symptoms are cot specific. Then adm

Table 2. Urine Culture: Diagnostic Criteria for Urinary Tract Infection

Urine Collection Technique	CFU/mL (pure growth)	Probability of Infection
Suprapubic aspiration	Gram negative rod, any	>99%
	Gram positive cocci, more than a few thousand	>99%
Catheterization	$>10^5$	95%
	10^4-10^5	Likely
	10^3-10^4	Suspicious
Clean void (male)	$>10^4$	Likely
Clean void (female)	3 samples $>10^5$	95%
	2 samples $>10^5$	90%
	1 sample $>10^5$	80%

Treatment

Don't wait for the result, start empirical treatment (something that cover gram -ve like 3rd generation cephalosporins > cefixime) immediately then change it to definitive treatment to prevent pyelonephritis it may cause renal impairment (by scar)

Younger than 3 months

All febrile neonates should be treated with IV antibiotics pending urine, blood, and CSF culture results.
If the fever subsided and patient can eat and looks well, -ve urine culture and can take oral ABx you can discharge him

Older than 3 months

10 to 14 days of oral treatment with cefixime, or amoxicillin/ clavulanic acid is effective as 2 to 4 days of intravenous therapy followed by oral, to complete 7 to 21 days of antibiotic treatment (discharged if blood culture is negative).

- For older stable children (no dehydration or vomiting) no need for admission (oral Abx.)
- Final antibiotic choice should be based on culture and sensitivity results. Nitrofurantoin is used for prophylaxis. We usually give 3rd generation cephalosporin, if not available, Augmentin.
- Prompt antimicrobial therapy generally is believed necessary to diminish risk of renal scarring
- If you treated a patient as an outpatient he must be followed up 3 days later to check antibiotic sensitivity

Urinary Tract Infections

Recurrence

- You have to investigate further in boys and recurrent infection in girls.
- Recurrent UTIs develop in approximately 75% of children whose first infection occurs before the age of 1 year, and in about 40% of girls and 30% of boys presenting after this age (more in girls)
- Risk factors identified include dilating VUR, family history of UTI, infrequent voiding (also voiding dysfunction especially in females), and inadequate fluid ingestion. Constipation as well
- Strategies that may help prevent recurrence include management of voiding dysfunction and increase fluid intake.
- Do US looking for hydronephrosis, MCUG for posterior urethral valve and VUR (it cause recurrent UTI and deteriorating renal function by scarring (especially pyelonephritis))

Long-Term Outcomes

- Approximately 70% of infants and children with their first febrile UTI have pyelonephritis and renal scars may follow in 15% to 30%.
- With timely appropriate therapy most infants and children recover promptly without major long-term sequelae, but a small number are at risk for significant morbidity, profressive renal damage and renal insufficiency.
- **How to diagnose renal scar?** Nuclear medicine (DMSA)
  - Done after 6 weeks of the UTI (NOT BEFORE) to avoid false positive
- Blood pressure should be checked annually if renal dysplasia and scars are present

-Infants presenting with a first UTI should have an US to look for structural abnormalities and obstruction, and also renal defects (although it is **NOT** the gold standard to detect renal scars)
-Further investigations for UTI is needed if **recurrent UTIs** or **atypical features**:
1.seriously ill or septicemia
2.poor urine flow **3.**abdominal pain or mass
4.raised creatinine
5.failure to respond to suitable antibiotics within 48 hrs
6.infection with atypical organisms (non-e.coli)

Vesicoureteral Reflux

Overview

- Retrograde flow of the urine from the urinary bladder into the ureters is prevented during micturition by a functional valvemechanism at the level of the ureterovesical junction (UVJ). Incompetence of the UVJ valve leads to flow of urine upstream into the ureter and the kidney, a condition known as vesicoureteral reflux or VUR.
- The association of VUR and predisposition to UTI is well established.
- Functional anatomy the UVJ lacks a traditionally defined valve to prevent retrograde flow of urine from the bladder into the ureter.
- The antireflux mechanism operative at this location is dependent on the unique anatomic configuration of the ureteral insertion into the bladder.
- There is an increased risk of hypertension in childhood or early adulthood

Classification

- Primary VUR is the commonest congenital anomaly affecting the urinary tract.
- VUR can be seen in 25□50% of asymptomatic siblings of index children diagnosed as having VUR.
- The familial pattern of VUR have been well documented, but the mode of inheritance is unclear.
- It is well known that the prevalence of VUR decreases with increasing age of children, suggesting that there is a trend towards improvement of VUR, even without any intervention throughout the childhood age spectrum
- Secondary is usually secondary to obstruction.

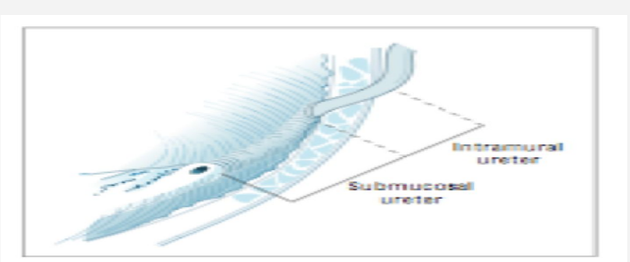
Table 36.1 Classification of vesicoureteral reflux (VUR)

Primary
Congenital VUR resulting from malimplantation of the ureter in the bladder – associated with urinary tract infection

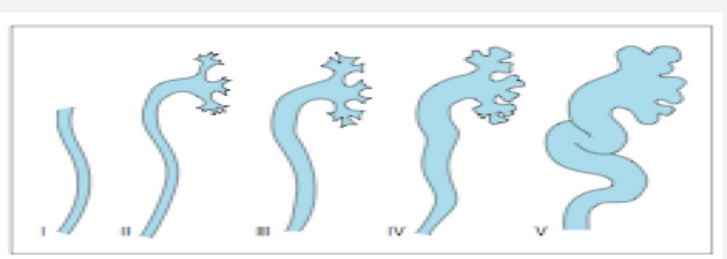
Secondary
Bladder outlet obstruction:
- Posterior urethral valves
- Bladder neck obstruction
- Severe urethral stricture

Neurogenic bladder:
- Spina bifida–meningomyelocele

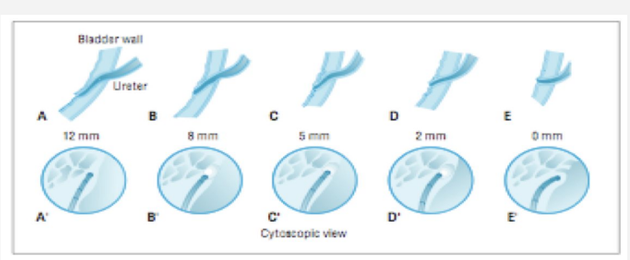
Chronic bladder inflammation
Urinary tract infection
Traumatic:
- Following bladder surgery
- Following ureteral calculus extraction



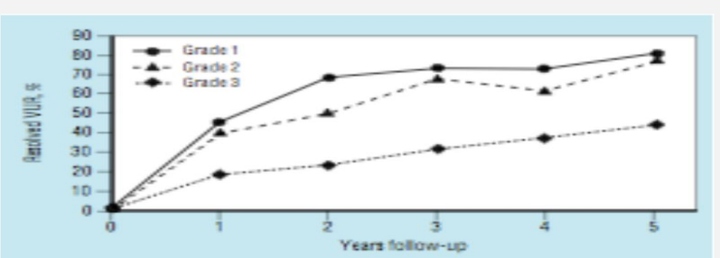
A part of the ureter is in the wall of the bladder before opening. Once the bladder is full, the increased pressure pushes and closes the valve.



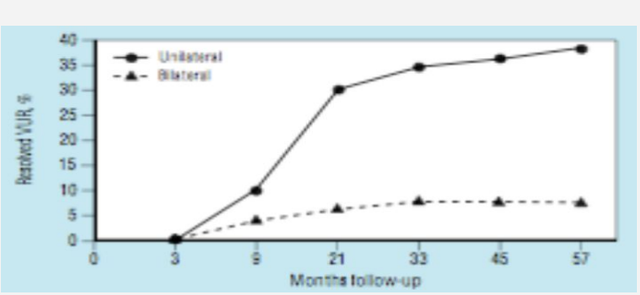
Grade 1: retrograde flow to half of ureters.
Grade 2: backflow up to pelvis.
Grade 3: up to pelvis with dilation of ureters.
Grade 4: up to pelvis with torturous dilation of ureters.
Grade 5: torturous dilation, hydronephrosis & blunting of the calyces



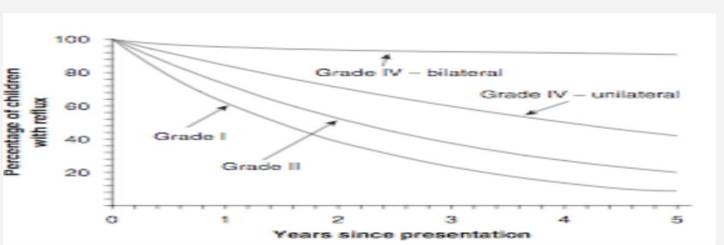
Staging; A: normal, E: when the bladder is full urine will go up (very high stage of reflux.



Do they outgrow VUR? Yes, but not always.
This graph shows the number of resolved VUR cases by years of follow up. Grade 1 85-90% of them almost always resolve.
It's much less as the grade is more



Unilateral vs Bilateral Resolution of grades III to V vesicoureteral reflux (VUR)

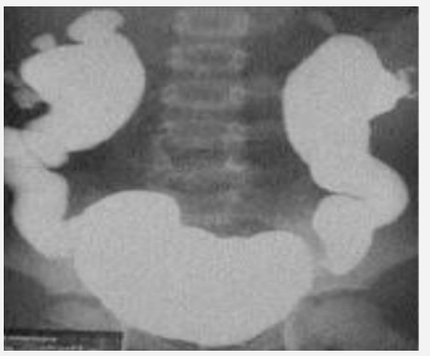


The other important thing is unilateral vs. bilateral. If it's bilateral VUR the chances it gets resolved is less, especially if it's high grade.

Vesicoureteral Reflux

Diagnosis

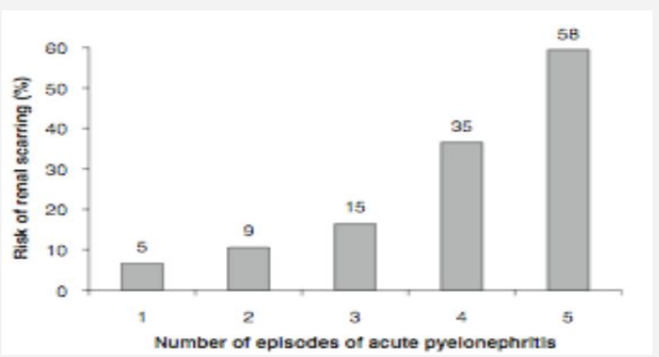
- The gold standard for evaluation of children for VUR is contrast vesico cystourethrogram (VCUG), especially in male children, but nuclear cystogram is recommended in females.
- VCUG IS A DYNAMIC STUDY sometimes we can use US don't use VCUG unless the urine culture is -ve because if you do it the infection will go to the kidney causing pyelonephritis



Grade 5 bilateral reflux on MCUG. The ureters are dilated up to the pelvis and tortuous ureter with blunting of calyces.

Renal Scarring

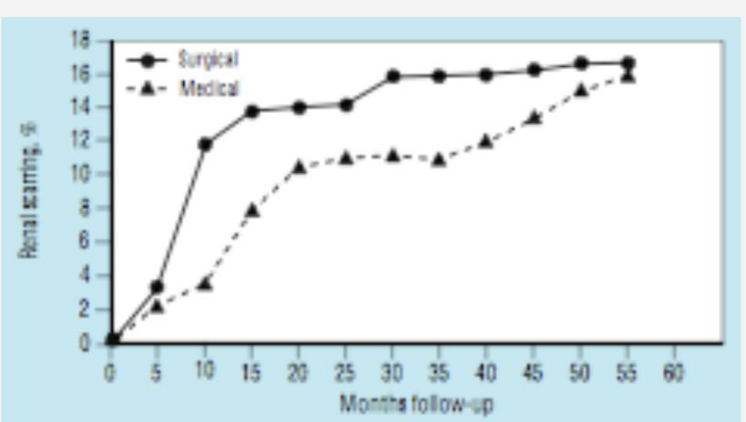
- VUR is well recognized to be associated with renal scar formation.
- Renal scar is diagnosed using DMSA. But you have to wait 3 months after the UTI resolves because if there is pyelonephritis it can be mistaken as scar.
- In general, the incidence and severity of renal scars associated with VUR increase with the grade of VUR.
- The incidence of renal parenchymal scars is also higher in those with recurrent febrile UTIs
- Such renal scars were termed (reflux nephropathy) as a designation for renal scars associated with VUR and pyelonephritis.
- Unfortunately we still see it either delayed diagnosis or the patient in a rural area and the family is not compliant with treatment or follow up. A patient may need dialysis.



- More pyelonephritis = more scarring.
- Almost 60% scarring when you have 5 pyelonephritis.

Management

- Effectiveness of medical versus surgical treatment: new scar formation at follow-up examinations over 5 years in children with high-grade VUR
- By the end of follow up (60 months) there is no difference in outcome! So I'd go with non-invasive



1. Medical:
   a. Prophylaxis Abx. Usually 1/3 of the dose, once per day at night, usually ceftrine or Nitrofurantoin. It usually resolves because the angulation of the ureter to the bladder changes as the child grow up.
2. Surgery:
   a. Reserved for patients with high grade and bilateral reflux, or having break through in any grade (infection continues despite giving Abx.)
   b. De-flux injection (inject bulking agents to the wall to change the angulation, unfortunately these agents get absorbed after few months and thus you have to inject twice)
   c. Ureteral reimplantation (very invasive, you have to cut the ureter and reimplant it in a de-reflux way. Last choice)

Book!

Urinary Tract Infections

Summary

A 2-year-old child with a urinary tract infection

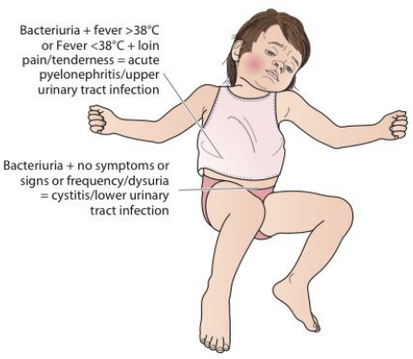
Why important?
Up to half have a structural abnormality of their urinary tract
Pyelonephritis may damage the growing kidney by forming a renal scar, which may result in hypertension and chronic kidney disease

Diagnosis secure?
- Suggestive clinical features?
- Upper or lower urinary tract infection?
- Urine sample properly collected and processed?
- Culture of single organism >10^5/ml if clean catch or mid-stream urine or else any organisms on suprapubic aspirate or catheter sample?

Predisposing factors?
Incomplete bladder emptying
Constipation
Vesicoureteric reflux

Why investigate?
To identify serious structural abnormalities, urinary obstruction, renal scars, vesicoureteric reflux

What investigation?
- Ultrasound of kidneys and urinary tract
- Further investigations if atypical features or urethral obstruction in boy on ultrasound



Management
Treat infection with antibiotics:
- Upper UTI and sepsis – IV then oral
- No sepsis or lower UTI – oral

Advice about medical preventative measures to consider:
- High fluid intake
- Regular voiding, double micturition
- Prevent or treat constipation
- Good perineal hygiene
- *Lactobacillus acidophilus*

Advise to check urine culture if develops clinical features suggestive of non-specific illness

If renal scarring or reflux on investigation, or develops recurrent UTIs:
- Consider low-dose antibiotic prophylaxis
- Monitor blood pressure, renal growth

Box 19.1 Presentation of urinary tract infection in infants and children

Infants	*Children*
• Fever	• Dysuria, frequency and urgency
• Vomiting	• Abdominal pain or loin tenderness
• Lethargy or irritability	• Fever with or without rigors (exaggerated shivering)
• Poor feeding/ faltering growth	• Lethargy and anorexia
• Jaundice	• Vomiting, diarrhoea
• Septicaemia	• Haematuria
• Offensive urine	• Offensive/cloudy urine
• Febrile seizure (>6 months)	• Febrile seizure
	• Recurrence of enuresis

Table 19.1 Radiological investigations of the kidneys and urinary tract

Radiology	
Ultrasound	Standard imaging procedure of the kidneys and urinary tract. Provides anatomical assessment but not function. Excellent at visualizing urinary tract dilatation, stones, and nephrocalcinosis (small, multiple calcium deposits within renal parenchyma)
	Advantages: non-invasive, mobile
	Disadvantages: operator dependent, may not detect all renal scars
Micturating cystourethrogram (MCUG)	Contrast introduced into the bladder through urethral catheter
	Can visualize bladder and urethral anatomy. Detects vesicoureteric reflux (VUR) and urethral obstruction
	Disadvantages: invasive and unpleasant investigation especially beyond infancy, high radiation dose, and can introduce infection
CT scan kidneys and ureters	To accurately identify position of kidney stones. Intravenous urograms are not performed in children
Plain abdominal X-ray	Identifies unsuspected spinal abnormalities
	May identify renal stones, but poor at showing nephrocalcinosis
Nuclear medicine	
DMSA scan (^{99m}Tc dimercaptosuccinic acid)	*Static* scan of the renal cortex
	Detects functional defects, such as scars or areas of non-functioning renal tissue, but very sensitive, so need to wait at least 2 months after a urinary tract infection to avoid diagnosing false 'scars'
MAG3 renogram (mercapto-acetyl-triglycine, labelled with ^{99m}Tc)	*Dynamic* scan, isotope-labelled substance MAG3 excreted from the blood into the urine. Measures drainage. Best performed with a high urine flow so furosemide often given.
	In children old enough to cooperate (usually >4 years of age), scan during micturition can be used to identify VUR (indirect cystogram)
Functional test	
Bladder flow urodynamics	To assess how well bladder is emptying together with flow rates. Bladder abnormalities can contribute to recurrent UTIs

Urinary Tract Infections

Table 19.2 Interpretation of results of dipstick testing in children 3 years and older

Leukocyte esterase and nitrite positive	Regard as UTI
Leukocyte esterase negative and nitrite positive	Start antibiotic treatment if clinical evidence of UTI Diagnosis depends on urine culture
Leukocyte esterase positive and nitrite negative	Only start antibiotic treatment if clinical evidence of UTI Diagnosis depends on urine culture
Leukocyte esterase and nitrite negative	UTI unlikely. Repeat or send urine for culture if clinical history suggests UTI
Blood, protein, and glucose present on stick testing	Useful in any unwell child to identify other diseases, e.g. nephritis, diabetes mellitus, but will not discriminate between children with and without UTIs

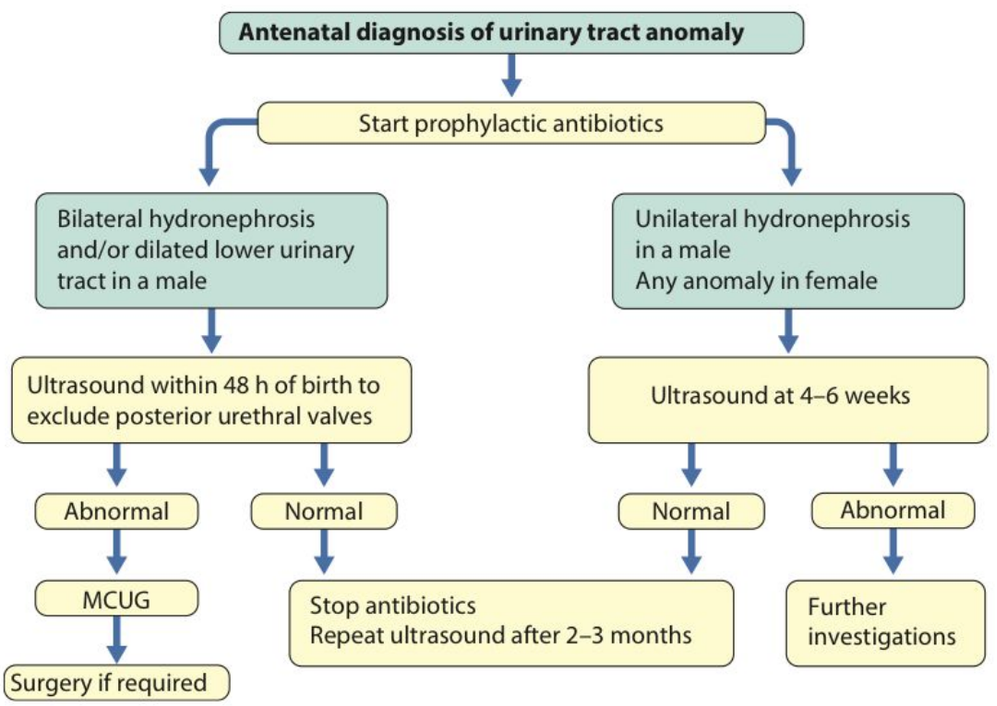


Figure 19.10 An example of a protocol for the management of infants with antenatally diagnosed urinary tract anomalies. MCUG, micturating cystourethrogram.

Book!

Some congenital anomalies of the kidneys and urinary tract (CAKUT)

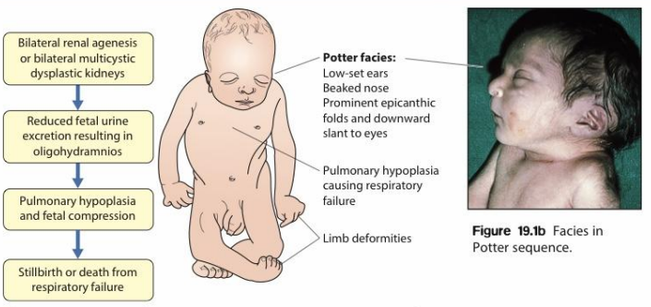


Figure 19.1a Features of Potter sequence. Intrauterine compression of the fetus from oligohydramnios caused by lack of fetal urine causes a characteristic facies, lung hypoplasia, and postural deformities including severe talipes. The infant may be stillborn or die soon after birth from respiratory failure.

Figure 19.1b Facies in Potter sequence.

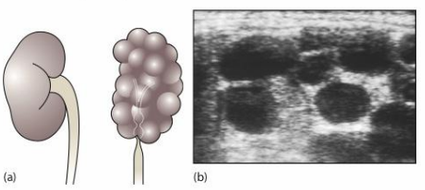


Figure 19.2 (**a**) Normal left kidney and multicystic dysplastic kidney (MCDK) on right. The kidney is replaced by cysts of variable size, with atresia of the ureter; and (**b**) renal ultrasound showing multiple discrete cysts of variable size.

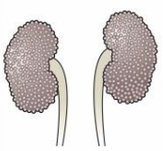


Figure 19.3 Autosomal recessive polycystic kidney disease (ARPKD). There is diffuse bilateral enlargement of both kidneys.

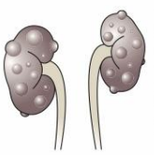


Figure 19.4 Autosomal dominant polycystic kidney disease (ADPKD). There are bilateral separate cysts of varying size between normal renal parenchyma. The kidneys are enlarged.

Figure 19.5 Horseshoe kidney.

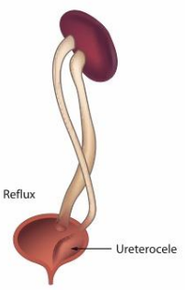


Figure 19.6 Duplex kidney showing ureterocele of upper moiety and reflux into lower pole moiety.

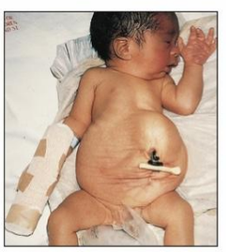


Figure 19.7 Prune-belly syndrome (absent musculature syndrome). The name arises from the wrinkled appearance of the abdomen. It is associated with a large bladder, dilated ureters, and cryptorchidism. (Courtesy of Jane Deal.)

Urinary tract obstruction

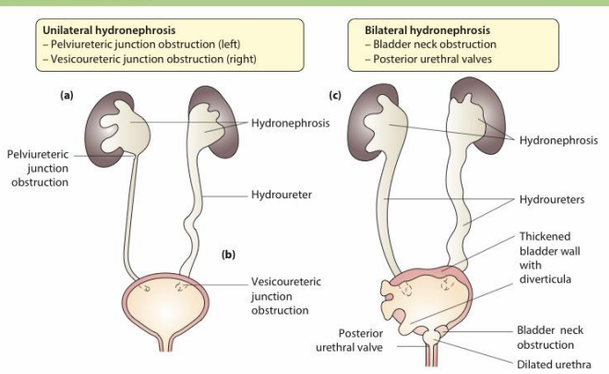


Figure 19.8 Obstruction to urine flow results in dilatation of the urinary tract proximal to the site of obstruction. Obstruction may be at the pelviureteric (labeled **a**) or vesicoureteric junction (labeled **b**) causing unilateral hydronephrosis, or at the bladder neck or urethra (labeled **c**) causing bilateral hydronephrosis.

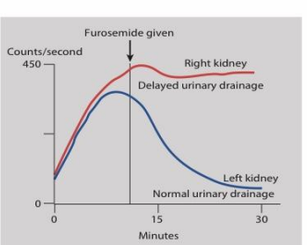


Figure 19.9 Graph from dynamic nuclear medicine scan MAG3 showing delayed excretion from a pelviureteric junction obstruction.

Box 19.8 Causes of palpable kidneys

Unilateral

- Multicystic dysplastic kidney
- Compensatory hypertrophy of normal kidney
- Obstructed hydronephrosis
- Renal tumour (Wilms tumour)
- Renal vein thrombosis

Bilateral

- Autosomal recessive polycystic kidneys
- Autosomal dominant polycystic kidneys
- Tuberous sclerosis
- Renal vein thrombosis

Renal calculi

Renal stones are uncommon in childhood (Fig. 19.20). When they occur, predisposing causes must be sought:

- UTI
- structural anomalies of the urinary tract
- metabolic abnormalities.

The most common are phosphate stones associated with infection, especially with *Proteus*. Calcium-containing stones occur in idiopathic hypercalciuria, the most common metabolic abnormality, and with increased urinary urate and oxalate excretion. Deposition of calcium in the parenchyma (nephrocalcinosis) may occur with hypercalciuria, hyperoxaluria, and distal renal tubular acidosis. Nephrocalcinosis may be a complication of furosemide therapy in the neonate. Cystine and xanthine stones are rare.

Presentation may be with haematuria, loin or abdominal pain, UTI, or passage of a stone. Stones that are not passed spontaneously should be removed, by either lithotripsy or surgery, and any predisposing structural anomaly repaired if possible. A high fluid intake is recommended in all affected children. If the cause is a metabolic abnormality, specific therapy may be possible.

Box 19.9 Causes of Fanconi syndrome

Idiopathic

Secondary to inborn errors of metabolism

- Cystinosis (an autosomal recessive disorder causing intracellular accumulation of cystine)
- Glycogen storage disorders
- Lowe syndrome (oculocerebrorenal dystrophy)
- Galactosaemia
- Fructose intolerance
- Tyrosinaemia
- Wilson disease (hepatolenticular degeneration)

Acquired

- Drugs and toxins, e.g. gentamicin, amphotericin
- Heavy metals

Renal tubular disorders

Abnormalities of renal tubular function may occur at any point along the length of the nephron and affect any of the substances handled by it (see Fig. 19.22).

Fanconi syndrome (generalized proximal tubular dysfunction)

Proximal tubule cells reabsorb essential salts, ions and small molecules which have been filtered out by the glomerulus. They are among the most metabolically active in the body, so are especially vulnerable to cellular damage. The cardinal features are excessive urinary loss of amino acids, glucose, phosphate, bicarbonate, sodium, calcium, potassium, and magnesium. The causes are listed in Box 19.9. Fanconi syndrome should be considered in a child presenting with:

- polydipsia and polyuria
- salt depletion and dehydration
- hyperchloraemic metabolic acidosis
- rickets
- faltering or poor growth.

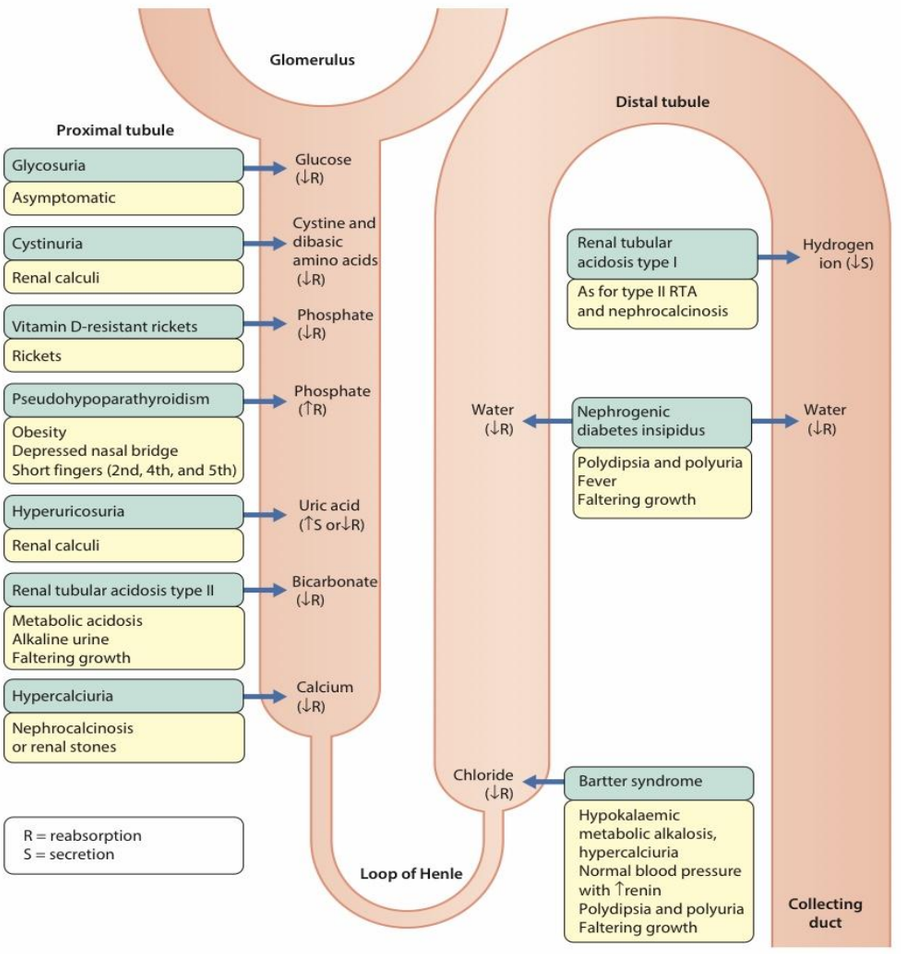


Figure 19.21 Schematic diagram of specific transport defects in some renal tubular disorders.

Enuresis: Evaluation

Enuresis = persistent nocturnal incontinence

- **persistent**: >2 episodes/week
- **nocturnal**: Occurs during **sleep**
- **incontinence**: Uncontrolled urinary voiding

- In children ≥**5** years old. Also known as "**bedwetting**"
- Occurs when child does not wake up from sleep to void
- Results from a combination of: **genetic factors, maturational delay, excessively deep sleep, reduced bladder capacity, nocturnal polyuria**

1° Primary Enuresis
Never previously achieved period of nighttime dryness. ~80% of nocturnal enuresis cases, high rate of spontaneous resolution

2° Secondary Enuresis
Enuresis developed after ≥**6 consecutive months** of nighttime continence. Often triggered by **stressors** (divorce, birth of sibling, school), sleep disordered breathing, constipation, suboptimal voiding habits.

***Goal:* rule out presence of underlying medical problem**
Such as urinary tract infection, constipation, obstructive sleep apnea, and diabetes insipidus.

Presentation

History

- **Frequency** (# /night, # /week, timing of episodes)
- **Trend** (improving vs. worsening)
- **Daytime** symptoms and/or **LUTS***
- **Constipation** or fecal incontinence
- Previous period of dryness (>6mths?)
- **Volume** voided (large volumes are indicative of nocturnal polyuria)
- **Fluid intake** (majority in evening?)
- Previous interventions? Were they successful?
- **PMHx** (sleep apnea, diabetes, UTIs, sickle cell, neurologic abnormalities, ADHD, ASD)
- Neurodevelopmental delays? Behavioural or psychologic concerns?
- **FHx** of nocturnal enuresis (what age did parent resolve enuresis?
- **SHx** (recent stressors?)
- **Impact** on child and family
- Review voiding diary if available

Physical Exam

- **Genital exam usually normal** in primary enuresis
- **Fever** may indicate UTI
- Abdominal palpation for **stool**
- **Lower back** for stigmata of spinal dysraphism (midline hair tufts, sacral dimple)
- **Lower limb** strength, tone, reflexes, sensation for evidence of neurogenic bladder

Investigations

If **reassuring** presentation…	If **concerning** history and physical exam…	
No routine tests are required	**Urinalysis & Culture** To **rule out** UTI, DM, DKA, DI	**Renal/Bladder Ultrasound** **Only if** otherwise indicated

Epidemiology & Natural History

Daytime bladder control expected ~age 4

Nighttime bladder control achieved **months-years** after daytime ~age 5 – 7

Age	Prevalence
5	15%
6	13%
7	10%
8	7%
10	5%
12-14	2-3%
≥15	1-2%

- Common!
- Resolves spontaneously ~15%/year
- Longer persistence = lower probability of spontaneous resolution

♂ 2 : 1 ♀
Male : Female

20% also have **daytime** symptoms

15% also have **fecal incontinence**

*Lower Urinary Tract Symptoms (LUTS)

Voiding
- Hesitancy
- Weak stream
- Intermittent stream
- Straining
- Incomplete emptying
- Dribbling

Storage
- Urgency
- Frequency ≥8 or ≤3 times/day

- Genital or lower urinary tract pain
- Holding maneuvers

Presence of daytime symptoms and/or LUTS is suggestive of dysfunctional voiding or anatomical abnormalities, thus should be **referred to Urology**

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Sarah Park (Medical Student C2022, University of Alberta), Dr. Peter Metcalfe (Pediatric Urologist, University of Alberta) for www.pedscases.com

Enuresis: Counselling & Management

Initial Management

1. **Determine if…**
   - **Both** child and parent see enuresis as problematic, and are **motivated** to participate in treatment
   - The child is **mature** enough to engage in and assume responsibility for treatment
2. **Treat co-existing conditions:**
   - **Constipation**, sleep disordered breathing, ADHD, underlying stressors, poor self-concept, psychologic
3. **Educate, emphasizing…**
   - **High prevalence** and generally **self-resolving** natural history
   - Child should <u>**NOT**</u> be punished for bedwetting
   - Usefulness of bed protection, absorbent undergarments, room deodorizers
   - Avoiding sugary and caffeinated beverages
4. **Establish goals and expectations:**
   - Determine family **priorities** (Reassurance? Staying dry for sleepovers? Decreasing # wet nights?)
   - May involve several methods, be prolonged, fail in short term, often relapses
   - **Slow, steady improvement** is more realistic

Voiding Diary

Should record:
- **Time** of void
- **Volume** voided
- **Relationship** to events (meals, school recess, play activities, stress)
- Episodes of **urgency** or **incontinence**

Personalized Calendar

Record:
- Daytime incontinence
- Enuresis events
- Encopresis
- Frequency & timing of bowel movements

- Helps to follow progress
- Parents should be cautious of implementing a reward system
- **AVOID** punishment and humiliation

Behavioural Therapy

***Goal:* <u>achieve good bladder and bowel habits</u>**

- Encourage **frequent voids**
  - Introduce timed voiding **every 2 hours**, regardless of if child feels the need to void
  - Avoid holding urine, urgency, and incontinence
  - Ensure easy access to toilets at school & home
  - Always have child void immediately before sleep
- Encourage **daily bowel movements**
  - Establish a schedule at specific time of day such as after breakfast before leaving for school
  - PEG 3350 for constipation
- Consume **majority of fluids in morning** and afternoon, minimize after dinner
- Encourage **physical activity** and discourage prolonged sitting
- Requires supportive environment, child motivation, patience, and time (average 6 months)

Active Therapy

Similar outcomes, choose based on patient preference and fit with family

Pharmacologic Therapy

- **Desmopressin:**

Goal: optimize oral medication to **reduce production of urine overnight** (ADH analogue).
- Take medication **60 minutes** before bedtime
- **No fluid intake** 1 hour prior to and 8 hours after taking medication
- <u>WATCH FOR</u>: signs of symptomatic hyponatremia with water intoxication: discontinue if developing headache, nausea, vomiting.

Can be used **intermittently**, thus a good option for **special occasions** such as sleepovers and camps.

- **Anticholinergics and tricyclic agents** (second and third line): may be considered if other therapeutic options have failed.

Bed Alarms

Goal: teach child to awaken from sensation of a full bladder. Sensors attached to child's undergarments are connected to an **alarm** that **awakens the child at the moment of bed wetting**.
- Should be using **every night**
- Initially, child may not awaken from alarm, requiring parent to awaken child instead
- Child should then void in the **washroom**
- Return to sleep

- Most effective in children **>7 years old**
- Generally see **initial response in 1 – 2 months**
- **3 – 4 month** trial of continuous therapy is recommended
- Discontinue when dry for 14 consecutive nights, or if no improvement at one month
- Effective long term in **< 50%** of children
- **Recommend for older, motivated children from cooperative families**

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Sarah Park (Medical Student C2022, University of Alberta), Dr. Peter Metcalfe (Pediatric Urologist, University of Alberta) for www.pedscases.com