19

Kidney and urinary tract disorders

Features of kidney and urinary tract disorders in children are:

- many structural abnormalities of the kidneys and urinary tract are identified on antenatal ultrasound screening
- urinary tract infection, vesicoureteric reflux, and urinary obstruction have the potential to damage the growing kidney
- nephrotic syndrome is usually steroid sensitive and only rarely leads to chronic kidney disease
- chronic renal disorders may affect growth and development.

Assessment of the kidneys and urinary tract

The glomerular filtration rate (GFR) is low in the newborn infant and is especially low in premature infants; the GFR at 28 weeks' gestation is only 10% of the term infant. In term infants, the corrected GFR (15–20 ml/min per 1.73 m^2) rapidly rises from 1-year to 2-years of age when the adult rate of 80 ml/min to 120 ml/min per 1.73 m^2 is achieved (Fig. 19.1). The assessment of renal function in children is listed in Table 19.1. The radiological investigations of the kidneys and urinary tract are presented in Table 19.2.

Congenital abnormalities

Before antenatal ultrasound scanning became routine, few congenital abnormalities of the kidneys and urinary tract were diagnosed until they caused symptoms in infancy, childhood, or occasionally, adult life. Now the majority are identified in utero and can be managed prospectively. Abnormalities are identified in 1 in 200 to 1 in 400 births. They are potentially important because they may:

- be associated with abnormal renal development or function (chronic kidney disease)
- predispose to postnatal infection
- involve urinary obstruction which requires surgical treatment.

The antenatal detection and early treatment of urinary tract anomalies provide an opportunity to minimize or prevent progressive renal damage. A disadvantage is that minor abnormalities are also detected, most commonly mild unilateral pelvic dilatation, which do not require intervention but may lead to over-investigation, unnecessary treatment, and unwarranted parental anxiety.

Anomalies detectable on antenatal ultrasound screening

Absence of both kidneys (*renal agenesis*) – As amniotic fluid is mainly derived from fetal urine, there is severe

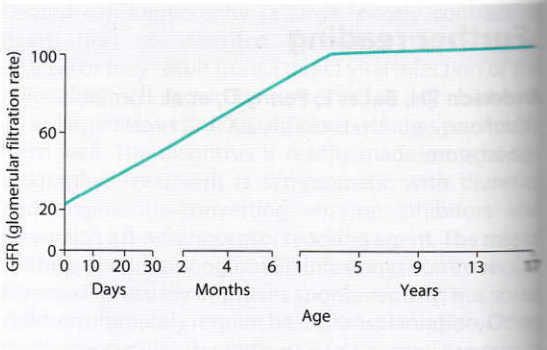


Figure 19.1 Increase in renal function (glomerular filtration rate, ml/min per 1.73 m^2) with age.

Table 19.1 Assessment of renal function in children

Plasma creatinine concentration	Main test of renal function. Rises progressively throughout childhood according to height and muscle bulk. May not be outside laboratory 'normal range' until renal function has fallen to less than half normal
Estimated glomerular filtration rate (eGFR)	The formula eGFR = k × height (cm) ÷ creatinine (μmol/L) provides estimate of GFR. Better measure of renal function than creatinine and useful to monitor renal function serially in children with renal impairment (k is 31 if measured enzymatically or 40 if creatinine measured using older Jaffe method)
Inulin or EDTA (ethylenediaminetetraacetic acid) glomerular filtration rate	More accurate as clearance from the plasma of substances freely filtered at the glomerulus, and is not secreted or reabsorbed by the tubules. Need for repeated blood sampling over several hours limits use in children
Creatinine clearance	Requires timed urine collection and blood tests. Rarely done in children as inconvenient and often becomes inaccurate
Plasma urea concentration	Increased in renal failure, often before creatinine starts rising, and raised levels may be symptomatic. Urea levels also increased by high protein diet, in catabolic states, or due to gastrointestinal bleeding

Table 19.2 Radiological investigation of the kidneys and urinary tract

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: noninvasive, mobile
	Disadvantages: operator dependent, will not detect all renal scars
	Static scan of the renal cortex
DMSA scan (^{99m}Tc dimercaptosuccinic acid)	Detects functional defects, such as scars or areas of nonfunctioning renal tissue, but very sensitive, so need to wait at least 2 months after a urinary tract infection to avoid diagnosing false '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
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 is used to identify VUR (indirect cystogram)
Plain abdominal X-ray	Identifies unsuspected spinal abnormalities
	May identify renal stones, but poor at showing nephrocalcinosis

oligohydramnios resulting in Potter syndrome (Fig. 19.2a,b), which is fatal.

Multicystic dysplastic kidney – Results from the failure of union of the ureteric bud (which forms the ureter, pelvis, calyces, and collecting ducts) with the nephrogenic mesenchyme. It is a non-functioning structure with large fluid-filled cysts with no renal tissue and no connection with the bladder (Fig. 19.3). Half will have involuted by 2 years of age, and nephrectomy is indicated only if it remains very large or hypertension develops, but this is rare. Because they produce no urine, Potter syndrome will result if the lesion is bilateral. Other causes of large cystic kidneys are *autosomal recessive polycystic kidney disease* (ARPKD; Fig. 19.4), *autosomal dominant polycystic kidney disease* (*ADPKD*; Fig. 19.5), and tuberous sclerosis. In contrast to a multicystic dysplastic kidney, in these disorders some or normal renal function is maintained but both

Some congenital abnormalities of the kidneys and urinary tract

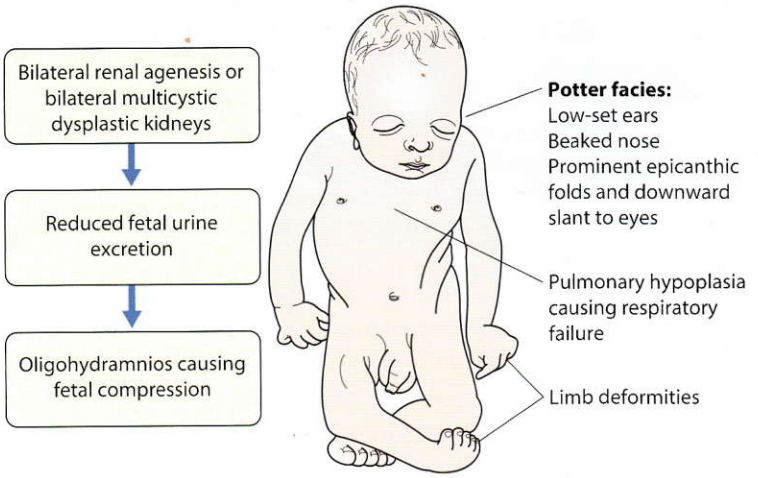


Figure 19.2a Potter syndrome. Intrauterine compression of the fetus from oligohydramnios caused by lack of fetal urine causes a characteristic facies, lung hypoplasia, and postural deformities including severe talipes. The infant may be stillborn or die soon after birth from respiratory failure.

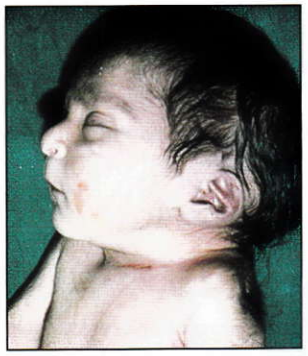


Figure 19.2b Facies in Potter syndrome.

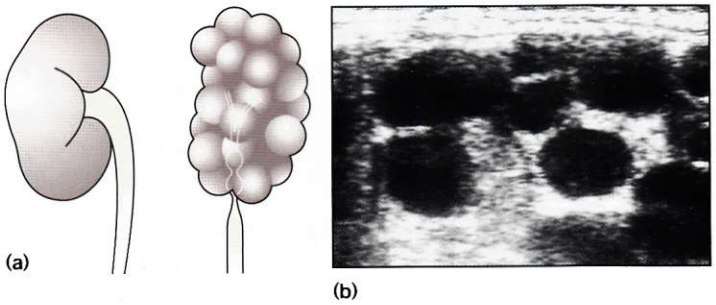


Figure 19.3 (a) Multicystic renal dysplasia. The kidney is replaced by cysts of variable size, with atresia of the ureter; and (b) renal ultrasound showing discrete cysts of variable size.

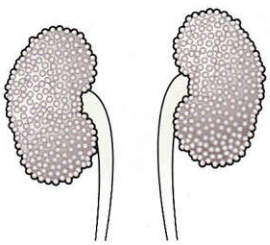


Figure 19.4 Autosomal recessive polycystic kidney disease (ARPKD). There is diffuse bilateral enlargement of both kidneys.

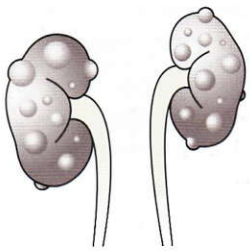


Figure 19.5 Autosomal dominant polycystic kidney disease (ADPKD). There are separate cysts of varying size between normal renal parenchyma. The kidneys are enlarged.

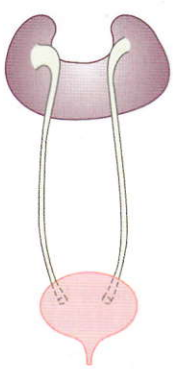


Figure 19.6 Horseshoe kidney.

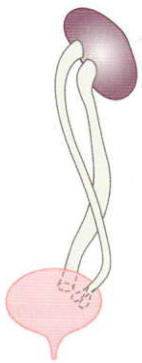


Figure 19.7 Duplex kidney showing ureterocele of upper moiety and reflux into lower pole moiety.

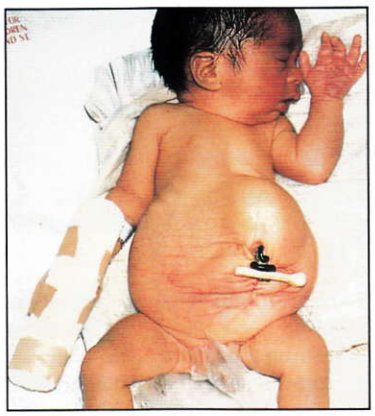


Figure 19.8 Prune-belly syndrome (absent musculature syndrome). The name arises from the wrinkled appearance of the abdomen. It is associated with a large bladder, dilated ureters, and cryptorchidism. (Courtesy of Jane Deal.)

Urinary tract obstruction

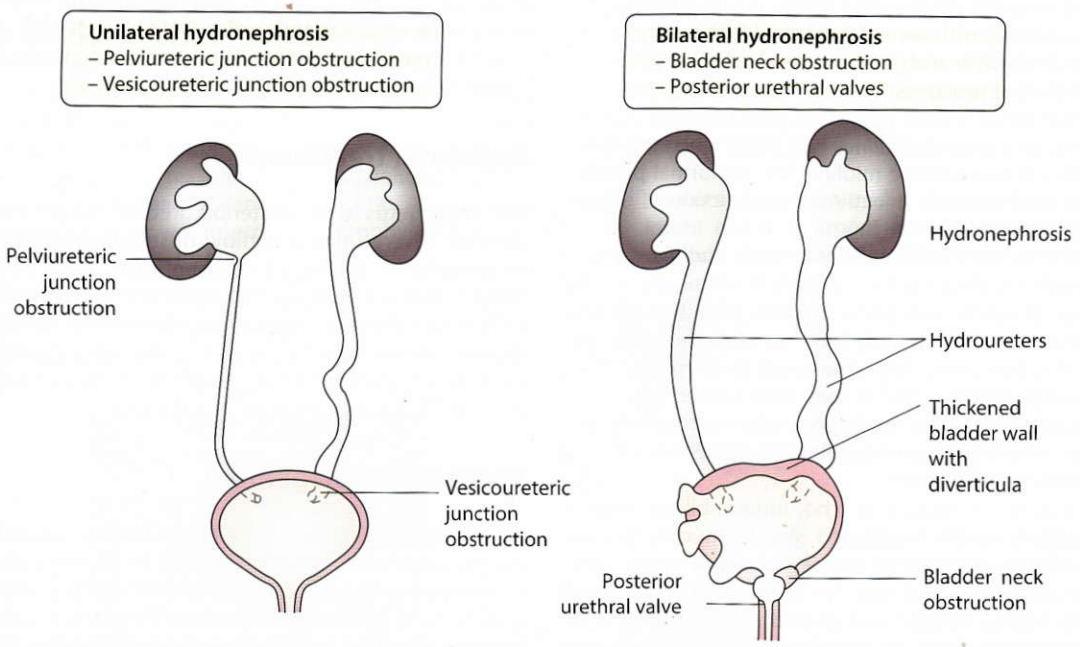


Figure 19.9a Obstruction to urine flow results in dilatation of the urinary tract proximal to the site of obstruction. Obstruction may be at the pelviureteric or vesicoureteric junction (left), the bladder neck, or urethra (right).

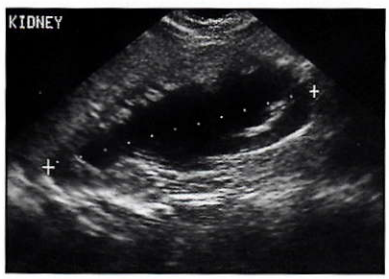


Figure 19.9b An ultrasound showing a dilated renal pelvis from pelviureteric junction obstruction.

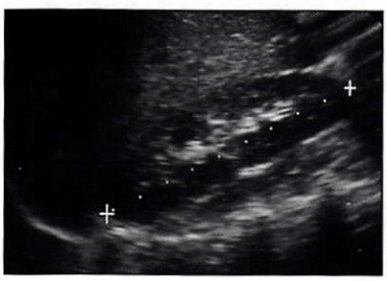


Figure 19.9c A normal ultrasound of the kidney is shown for comparison.

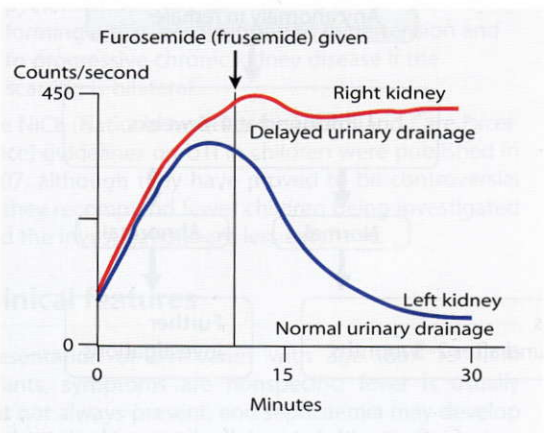


Figure 19.9d Graph from dynamic nuclear medicine scan MAG3 showing delayed excretion from a pelviureteric junction obstruction.

kidneys are always affected. ADPKD has an incidence of 1 in 1000; the main symptoms in childhood are hypertension and it causes renal failure in late adulthood. It is associated with several extrarenal features including cysts in the liver and pancreas, cerebral aneurysms, and mitral valve prolapse.

Abnormal caudal migration may result in a *pelvic kidney* or a *horseshoe kidney* (Fig. 19.6), when the lower poles are fused in the midline. The abnormal position may predispose to infection or obstruction of urinary drainage.

Premature division of the ureteric bud gives rise to a *duplex system*, which can vary from simply a bifid renal pelvis to complete division with two ureters. These ureters frequently have an abnormal drainage so that the ureter from the lower pole moiety often refluxes, whereas the upper pole ureter may drain ectopically into the urethra or vagina or may prolapse into the bladder (ureterocele) and urine flow may be obstructed (Fig. 19.7).

Failure of fusion of the infraumbilical midline structures results in exposed bladder mucosa (*bladder exstrophy*). Absence or severe deficiency of the anterior abdominal wall muscles is frequently associated with a large bladder and dilated ureters (megacystis-megaureter) and cryptorchidism, the *prune-belly syndrome* (*absent musculature syndrome*; Fig. 19.8).

Obstruction to urine flow may occur at the pelviureteric or vesicoureteric junction, at the *bladder neck* (e.g. due to disruption of the nerve supply, *neuropathic bladder*), or at the *posterior urethra* in a boy due to mucosal folds or a membrane, known as *posterior urethral valves*. The consequences of obstruction to urine flow are shown in Fig. 19.9a–d. At worst, this results in a *dysplastic kidney* which is small, poorly functioning, and may contain cysts. In the most severe and bilateral cases Potter syndrome is present. Renal dysplasia can also occur in association with severe intrauterine vesicoureteric reflux (VUR), in isolation, or in certain rare, inherited syndromes affecting multiple systems.

Antenatal treatment

The male fetus with posterior urethral valves may develop severe urinary outflow obstruction resulting in progressive bilateral hydronephrosis, poor renal growth, and declining liquor volume with the potential to lead to pulmonary hypoplasia. Intrauterine bladder drainage procedures to prevent severe renal damage have been attempted but results have been disappointing. Early delivery is rarely indicated.

Postnatal management

An example of a protocol for infants with antenatally diagnosed anomalies is shown in Fig. 19.10. Prophylactic antibiotics may be started at birth to try to prevent urinary tract infection (UTI), although practice varies between centres. As the newborn kidney has a low GFR, urine flow is low and mild outflow obstruction may not be evident in the first few days of life. The ultrasound scan should therefore be delayed for a few weeks. However, bilateral hydronephrosis in a male infant warrants investigations including an ultrasound and micturating cystourethrogram (MCUG) shortly after birth to exclude posterior urethral valves, which always requires urological intervention such as cystoscopic ablation (Case History 19.1).

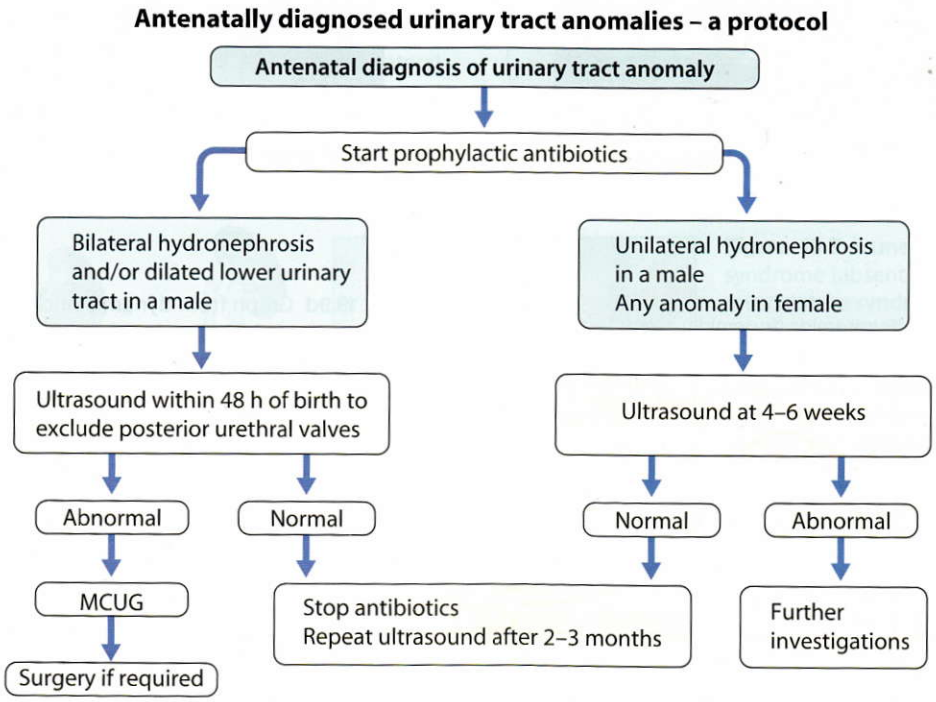


Figure 19.10 An example of a protocol for the management of infants with antenatally diagnosed urinary tract anomalies. MCUG, micturating cystourethrogram.

Case history 19.1

Posterior urethral valves

Bilateral hydronephrosis was noted on antenatal ultrasound at 20 weeks' gestation in a male fetus. There was progressive hydronephrosis, poor renal growth with reduced renal cortex, and decreasing volume of amniotic fluid on repeated scans (Fig. 19.11a). After birth, a urethral catheter was inserted and prophylactic antibiotics were started. An urgent ultrasound showed bilateral hydronephrosis with small dysplastic kidneys and cyst formation. A micturating cystourethrogram showed severe, bilateral vesicoureteric reflux, a small thickened bladder, and a dilated posterior urethra (Fig. 19.11b). Posterior urethral valves were confirmed on cystoscopy and ablated surgically. Caden's subsequent progress is described in Case history 19.4.

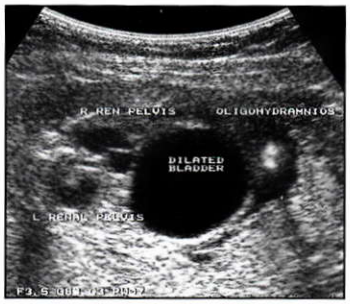


Figure 19.11a Antenatal ultrasound scan in an infant with urinary outflow obstruction from posterior urethral valve. (Courtesy of Karl Murphy.)

Bilateral hydronephrosis in a male infant requires urgent investigation to exclude posterior urethral valves

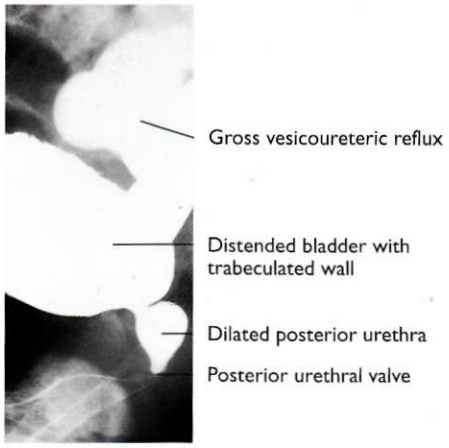


Figure 19.11b Micturating cystourethrogram (MCUG) in the same patient.

Urinary tract infection

About 3–7% of girls and 1–2% of boys have at least one symptomatic UTI before the age of 6 years, and 12–30% of them have a recurrence within a year. UTI may involve the kidneys (pyelonephritis), when it is usually associated with fever and systemic involvement, or may be due to cystitis, when there may be no fever. UTI in childhood is important because:

- up to half of patients have a structural abnormality of their urinary tract
- pyelonephritis may damage the growing kidney by forming a scar, predisposing to hypertension and to progressive chronic kidney disease if the scarring is bilateral.

The NICE (National Institute for Health and Care Excellence) guidelines on UTI in children were published in 2007, although they have proved to be controversial as they recommend fewer children being investigated and the investigations are less extensive.

Box 19.1 Presentation of urinary tract infection in infants and children

Infants

- Fever
- Vomiting
- Lethargy or irritability
- Poor feeding/ faltering growth
- Jaundice
- Septicaemia
- Offensive urine
- Febrile seizure (>6 months)

Children

- Dysuria, frequency and urgency
- Abdominal pain or loin tenderness
- Fever with or without rigors (exaggerated shivering)
- Lethargy and anorexia
- Vomiting, diarrhoea
- Haematuria
- Offensive/cloudy urine
- Febrile seizure
- Recurrence of enuresis

Clinical features

Presentation of UTI varies with age (Box 19.1). In infants, symptoms are nonspecific; fever is usually but not always present, and septicaemia may develop rapidly. The classical symptoms of dysuria, frequency, and loin pain become more common with increasing age. Serious illness from septicaemia is described in Chapter 6. Dysuria alone is usually due to cystitis, or vulvitis in girls or balanitis in uncircumcised boys. Symptoms suggestive of a UTI may also occur following sexual abuse.

Table 19.3 Methods and interpretation of dipstick testing in children

Methods of dipstick testing	
Nitrite stick testing	Positive result useful as very likely to indicate a true urinary tract infection (UTI)
	But some children with a UTI are nitrite negative
Leucocyte esterase stick testing (for white blood cells)	May be present in children with UTI but may also be negative
	Present in children with febrile illness without UTIs
	Positive in balanitis and vulvovaginitis
Interpretation of results	
Leucocyte esterase and nitrite positive	Regard as UTI
Leucocyte esterase negative and nitrite positive	Start antibiotic treatment if clinical evidence of UTI
	Diagnosis depends on urine culture
Leucocyte esterase positive and nitrite negative	Only start antibiotic treatment if clinical evidence of UTI
	Diagnosis depends on urine culture
Leucocyte 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

Collection of samples

The most common error in the management of UTI in children, and especially in infants, is failure to establish the diagnosis properly in the first place. If the diagnosis of a UTI is not made, the opportunity to prevent renal damage may be missed, or, if incorrectly diagnosed, may lead to unnecessary invasive investigations.

For the child in nappies, urine can be collected by:

- a 'clean-catch' sample into a waiting clean pot when the nappy is removed. This is the recommended method
- an adhesive plastic bag applied to the perineum after careful washing, although there may be contamination from the skin
- a urethral catheter if there is urgency in obtaining a sample and no urine has been passed
- suprapubic aspiration, when a fine needle attached to a syringe is inserted directly into the bladder just above the symphysis pubis under ultrasound guidance; it may be used in severely ill infants requiring urgent diagnosis and treatment, but it is an invasive procedure, and is increasingly replaced by urethral catheter sampling.

In the older child, urine can be obtained by collecting a midstream sample. Careful cleaning and collection are necessary, as contamination with both white cells and bacteria can occur from under the foreskin in boys, and from reflux of urine into the vagina during voiding in girls.

Ideally, the urine sample should be observed under a microscope to identify organisms and cultured straight away. This is indicated in all infants and children under the age of 3 years with a suspected UTI. If this is not possible, the urine sample should be refrigerated to prevent the overgrowth of contaminating bacteria. Urinary white cells are not a reliable feature of a UTI, as they may lyse during storage and may be present in febrile children without a UTI and in children with balanitis or vulvovaginitis. Dipsticks can be used as a screening test. Urine culture should still be performed unless both leucocyte esterase and nitrite are negative or if the clinical symptoms and dipstick tests do not correlate (Table 19.3).

A bacterial culture of more than 10^5 colony-forming units (CFU) of a single organism per millilitre in a properly collected specimen gives a 90% probability of infection. If the same result is found in a second sample, the probability rises to 95%. A growth of mixed organisms usually represents contamination, but if there is doubt, another sample should be collected. Any bacterial growth of a single organism per millilitre in a catheter sample or suprapubic aspirate is considered diagnostic of infection.

A urine sample should be tested in all infants with an unexplained fever >38°C

Bacterial and host factors that predispose to infection

Infecting organism

UTI is usually the result of bowel flora entering the urinary tract via the urethra, although it can be haematogenous, e.g. in the newborn. The most common organism is *Escherichia coli*, followed by *Klebsiella, Proteus, Pseudomonas,* and *Streptococcus faecalis*. *Proteus* infection is more commonly diagnosed in boys than in girls, possibly because of its presence under the prepuce. *Proteus* infection predisposes to the formation of phosphate stones by splitting urea to ammonia, and thus alkalinizing the urine. *Pseudomonas* infection may

indicate the presence of some structural abnormality in the urinary tract affecting drainage and it is also more common in children with plastic catheters.

Antenatally diagnosed renal or urinary tract abnormality

Increases risk of infection and investigation of a UTI may lead to urinary tract abnormality being detected if antenatal diagnosis was not made or missed to follow-up.

Incomplete bladder emptying

Contributing factors in some children are:

- infrequent voiding, resulting in bladder enlargement
- vulvitis
- incomplete micturition with residual postmicturition bladder volumes
- obstruction by a loaded rectum from constipation
- neuropathic bladder
- vesicoureteric reflux.

Vesicoureteric reflux

VUR is a developmental anomaly of the vesicoureteric junctions. The ureters are displaced laterally and enter directly into the bladder rather than at an angle, with a shortened or absent intramural course. Severe cases may be associated with renal dysplasia. It is familial, with a 30% to 50% chance of occurring in first-degree relatives. It may also occur with bladder pathology, e.g. a neuropathic bladder or urethral obstruction, or temporarily after a UTI. Its severity varies from reflux into the lower end of an undilated ureter during micturition to the severest form with reflux during bladder filling and voiding, with a distended ureter, renal pelvis, and clubbed calyces (Fig. 19.12). Mild reflux is unlikely to be of significance, but the more severe degrees of VUR may be associated with *intrarenal reflux*, which is the backflow of urine from the renal pelvis into the papillary collecting ducts and is associated with a particularly high risk of renal scarring if UTIs occur. The incidence of renal defects increases with increasing severity of reflux. There is considerable controversy as to whether renal scarring is a congenital abnormality already present in children with reflux and which predisposes to infection or if children with reflux have normal kidneys at birth which are damaged by UTIs and that preventing UTIs in these children prevents scars. VUR tends to resolve with age, especially lower grades of VUR.

VUR-associated ureteric dilatation is important as:

- urine returning to the bladder from the ureters after voiding results in incomplete bladder emptying which encourages infection
- the kidneys may become infected (pyelonephritis) especially if there is intrarenal reflux
- bladder voiding pressure is transmitted to the renal papillae which may contribute to renal damage if voiding pressures are high.

Infection may destroy renal tissue, leaving a scar, resulting in a shrunken, poorly functioning segment of kidney (reflux nephropathy). If scarring is bilateral and severe, progressive chronic kidney disease may develop. The risk of hypertension in childhood or early adult life is variously estimated to be up to 10%.

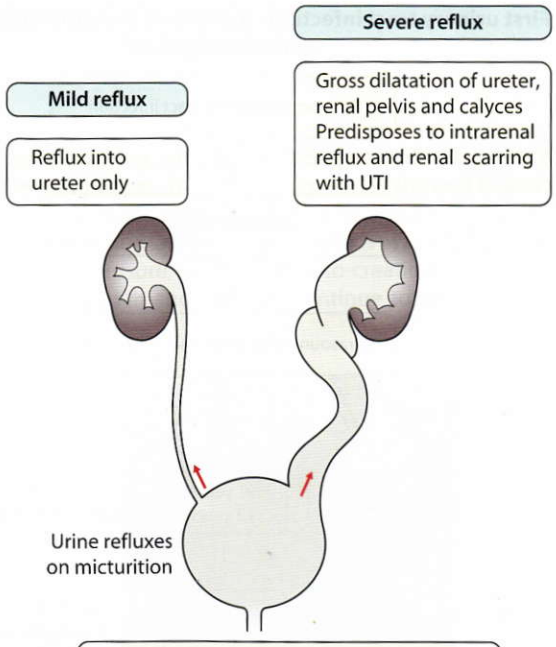


Figure 19.12 Vesicoureteric reflux.

Investigation

The extent to which a child with a UTI should be investigated is controversial. This is not only because of the invasive nature and radiation burden of the tests but also because of the lack of an evidence base to show that outcome is improved (unless urinary obstruction is demonstrated). Mild VUR usually resolves spontaneously and operative intervention to stop mild VUR has not been shown to decrease renal damage. Furthermore, there is no evidence that antibiotic prophylaxis is any better than prompt treatment. There has, therefore, been a move away from extensive investigation of all children with UTIs to those who have had atypical or recurrent UTIs. Atypical UTI includes:

- seriously ill or septicaemia
- poor urine flow
- abdominal or bladder mass
- raised creatinine
- failure to respond to suitable antibiotics within 48 hours
- infection with atypical (non-*E. coli*) organisms.

An initial ultrasound will identify:

- serious structural abnormalities and urinary obstruction
- renal defects (although it is not the gold standard for detecting renal scars).

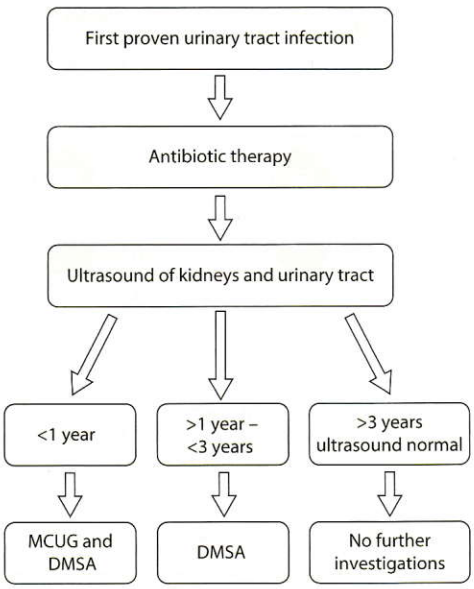


Figure 19.13 An example of a protocol for the initial management and investigation of a first urinary tract infection. This is controversial. The 2007 UK NICE (National Institute for Health and Care Excellence) guidelines do not recommend ultrasound examination for first urinary tract infection if there was response to antibiotic treatment within 48 hours, unless under 6 months of age or atypical or recurrent, but many paediatric nephrologists consider this approach too minimalistic and follow protocols like the one shown here.

Subsequent investigations will depend on the results of the ultrasound. The need for any investigations in a child with only bladder symptoms (lower UTI/cystitis) is also controversial. If urethral obstruction is suspected (abnormal bladder in a boy), MCUG should be performed promptly. Functional scans should be deferred for 3 months after a UTI, unless the ultrasound is suggestive of obstruction, to avoid missing a newly developed scar and because of false-positive results from transient inflammation. Medical measures for the prevention of UTI should be initiated.

A suggested schema for investigation of the first proven UTI is shown in Fig. 19.13, but there is significant variation of practice.

Management

All infants under 3 months of age with suspicion of a UTI or if seriously ill should be referred immediately to hospital. They require intravenous antibiotic therapy (e.g. co-amoxiclav) for at least 5–7 days at which point oral prophylaxis can then be commenced (see Case History 19.2).

Infants aged over 3 months and children with acute pyelonephritis/upper UTI (bacteriuria and fever ≥38°C or bacteriuria and loin pain/tenderness even if fever is <38°C) are usually treated with oral antibiotics (e.g. trimethoprim for 7 days); or else intravenous antibiotics, e.g. co-amoxiclav, are given for 2–4 days followed by oral antibiotics for a total of 7–10 days. The choice of antibiotic is adjusted according to sensitivity on urine culture.

Children with cystitis/lower UTI (dysuria but no systemic symptoms or signs) can be treated with oral antibiotics such as trimethoprim or nitrofurantoin for 3 days.

Medical measures for the prevention of UTI

The aim is to ensure washout of organisms that ascend into the bladder from the perineum; and to reduce the presence of aggressive organisms in the stool, perineum, and under the foreskin:

- high fluid intake to produce a high urine output
- regular voiding
- ensure complete bladder emptying by encouraging the child to try a second time to empty his bladder after a minute or two, commonly known as double voiding, which empties any urine residue or refluxed urine returning to the bladder
- treatment and/or prevention of constipation
- good perineal hygiene
- *Lactobacillus acidophilus*, a probiotic to encourage colonization of the gut by this organism and reduce the number of pathogenic organisms that might potentially cause invasive disease
- antibiotic prophylaxis, although this is controversial. It is often used in those under 2 years to 3 years of age with a congenital abnormality of the kidneys or urinary tract or who have had an upper UTI and those with severe reflux until out of nappies. Trimethoprim (2 mg/kg at night) is used most often, but nitrofurantoin or cephalexin may be given. Broad-spectrum, poorly absorbed antibiotics such as amoxicillin should be avoided.

Follow-up of children with recurrent UTIs, renal scarring, or reflux

In these children:

- urine should be dipsticked with any nonspecific illness in case it is caused by a UTI and urine sent for microscopy and culture if suggestive of UTI

Case history 19.2

Urinary tract infection

Jack, a 2-month-old infant, stopped feeding and had a high, intermittent fever. He was referred to hospital, where he had an infection screen. Urine microscopy showed more than 100 white blood cells and cultured more than 10^5 *E. coli* CFU/ml. He was treated with intravenous antibiotics. An ultrasound showed that the left kidney was smaller than the right kidney with dilated ureters. He was started on prophylactic antibiotics. A DMSA (dimercaptosuccinic acid) scan (Fig. 19.14) performed 3 months later confirmed bilateral renal scarring, with the left kidney contributing 33% of renal function. The MCUG (Fig. 19.15) showed bilateral vesicoureteric reflux. At 4 years of age, the reflux had resolved and antibiotic prophylaxis was stopped. His blood pressure, urine protein-to-creatinine ratio, and renal growth and function continue to be monitored in clinic.

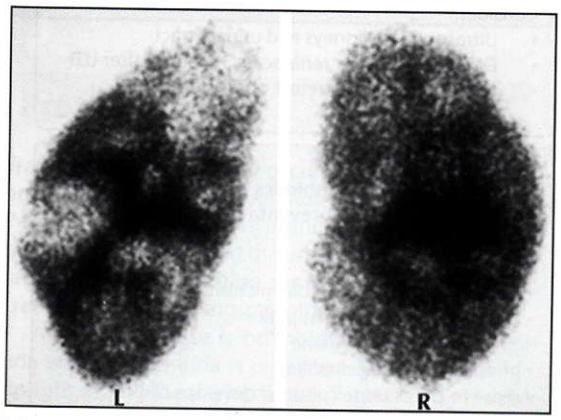


Figure 19.14 DMSA (Dimercaptosuccinic acid) scan showing bilateral renal scarring, more severe on left upper pole.

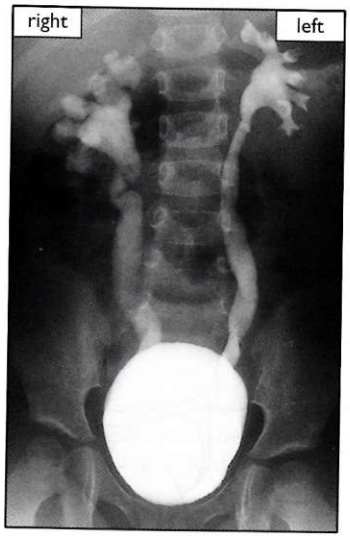


Figure 19.15 Micturating cystourethrogram (MCUG) showing bilateral vesicoureteric reflux with ureteric dilatation and dilated clubbed calyces on the right.

- long-term, low-dose antibiotic prophylaxis can be used. There is no evidence for when antibiotic prophylaxis should be stopped
- circumcision in boys may sometimes be considered as there is evidence that it reduces the incidence of UTI
- anti-VUR surgery may be indicated if there is progression of scarring with ongoing VUR but it has not been shown to improve outcome in mild VUR
- blood pressure should be checked annually if renal defects are present
- urinalysis to check for proteinuria which is indicative of progressive chronic kidney disease
- regular assessment of renal growth and function is necessary if there are bilateral defects because of the risk of progressive chronic kidney disease.

If there are further symptomatic UTIs in younger children, investigations may be required to determine whether there is new scar formation and if so whether there is ongoing VUR, which may require prophylactic antibiotic therapy or surgical anti-VUR treatment.

Enuresis

Primary nocturnal enuresis

This is considered in Chapter 24. Child and Adolescent Mental Health.

Daytime enuresis

This is a lack of bladder control during the day in a child old enough to be continent (over the age of 3–5 years). Nocturnal enuresis is also usually present. It may be caused by:

- lack of attention to bladder sensation: a manifestation of a developmental or psychogenic problem, although it may occur in otherwise normal children who are too preoccupied with what they are doing to respond to the sensation of a full bladder
- detrusor instability (sudden, urgent urge to void induced by sudden bladder contractions)
- bladder neck weakness
- a neuropathic bladder (bladder is enlarged and fails to empty properly, irregular thick wall, and is

Summary

A child with a first urinary tract infection

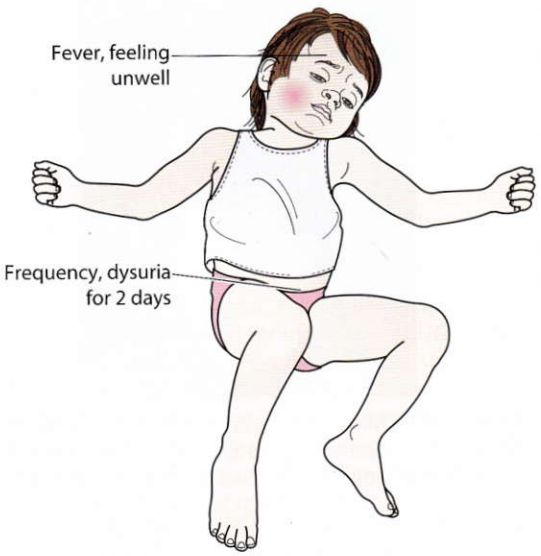
Why important?
Up to half have a structural abnormality of their urinary tract
Pyelonephritis may damage the growing kidney by forming a renal scar, which may result in hypertension and chronic renal failure

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?
Consider:
- Ultrasound of kidneys and urinary tract
- DMSA to check for renal scars 3 months after UTI
- MAG3 or MCUG to detect obstruction and vesicouretic reflux.



Management
Treat infection with antibiotics
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 and function

associated with spina bifida and other neurological conditions)
- a UTI (rarely in the absence of other symptoms)
- constipation
- an ectopic ureter, causes constant dribbling and child is always damp.

Examination may reveal evidence of a neuropathic bladder, i.e. the bladder may be distended, there may be abnormal perineal sensation and anal tone, or abnormal leg reflexes and gait. Sensory loss in the distribution of the S2, S3, and S4 dermatomes should be sought. A spinal lesion may be present. Girls who are dry at night but wet on getting up are likely to have pooling of urine from an ectopic ureter opening into the vagina.

A urine sample should be examined for microscopy, culture, and sensitivity. Other investigations are performed if indicated. An ultrasound may show bladder pathology, with incomplete bladder emptying or thickening of the bladder wall. Urodynamic studies may be required. An X-ray of the spine may reveal a vertebral anomaly. A MRI scan may be required to confirm or exclude a spinal defect such as tethering of the cord.

Affected children in whom a neurological cause has been excluded may benefit from star charts, bladder training, and pelvic floor exercises. Constipation should be treated. A small portable alarm with a pad in the pants, which is activated by urine, can be used when there is lack of attention to bladder sensation. Anticholinergic drugs, such as oxybutynin, to dampen down bladder contractions, may be helpful if other measures fail.

Secondary (onset) enuresis

The loss of previously achieved urinary continence may be due to:
- emotional upset, which is the most common cause
- UTI
- polyuria from an osmotic diuresis in diabetes mellitus or a renal concentrating disorder, e.g. sickle cell disease or chronic kidney disease or very rarely diabetes insipidus, which can be central or nephrogenic.

Investigation should include:
- testing a urine sample for infection, glycosuria, and proteinuria using a dipstick

- assessment of urinary concentrating ability by measuring the osmolality of an early morning urine sample. Rarely, a formal water deprivation test may be needed to exclude a urinary concentrating defect
- ultrasound of the renal tract.

Summary

Enuresis

Daytime enuresis

- Consider possible causes: developmental or psychogenic, bladder instability or neuropathy, UTI, constipation, ectopic ureter.

Secondary (onset) enuresis

- Consider – emotional upset, UTI, polyuria from an osmotic diuresis in diabetes mellitus or a renal concentrating disorder.

Proteinuria

Transient proteinuria may occur during febrile illnesses or after exercise and does not require investigation. Persistent proteinuria is significant and should be quantified by measuring the urine protein-to-creatinine ratio in an early morning sample (normal protein-to-creatinine ratio <20 mg/mmol).

A common cause is orthostatic (postural) proteinuria when proteinuria is only found when the child is upright during the day. It can be diagnosed by measuring the urine protein-to-creatinine ratio in a series of early morning urine specimens. The prognosis is excellent and further investigations are not necessary. Other causes of proteinuria, which need further evaluation, are listed in Box 19.2.

Box 19.2 Causes of proteinuria

- Orthostatic proteinuria
- Glomerular abnormalities
  - Minimal change disease
  - Glomerulonephritis
  - Abnormal glomerular basement membrane (familial nephritides)
- Increased glomerular filtration pressure
- Reduced renal mass in chronic kidney disease
- Hypertension
- Tubular proteinuria

Nephrotic syndrome

In nephrotic syndrome, heavy proteinuria results in a low plasma albumin and oedema. The cause of the condition is unknown, but a few cases are secondary to systemic diseases such as Henoch–Schönlein purpura and other vasculitides, e.g. SLE (systemic lupus erythematosus), infections (e.g. malaria) or allergens (e.g. bee sting).

Clinical signs of the nephrotic syndrome are:

- periorbital oedema (particularly on waking) which is often the earliest sign
- scrotal or vulval, leg, and ankle oedema (Fig. 19.16)
- ascites
- breathlessness due to pleural effusions and abdominal distension
- infection such as peritonitis, septic arthritis, or sepsis due to loss of protective immunoglobulins in the urine.

Case history 19.3 shows typical presentation, and initial investigations are listed in Box 19.3.

Steroid-sensitive nephrotic syndrome

In 85–90% of children with nephrotic syndrome, the proteinuria resolves with corticosteroid therapy (steroid-sensitive nephrotic syndrome). These children do not progress to chronic kidney disease. It is more common in boys than in girls, in Asian children than in Caucasians, and there is an association with atopy. It is often precipitated by respiratory infections. Features suggesting steroid-sensitive nephrotic syndrome are:

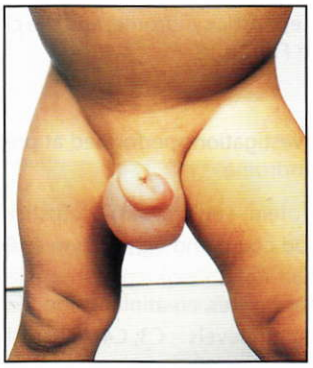


Figure 19.16 Gross oedema of the scrotum and legs as well as abdominal distension from ascites.

- age between 1–10 years
- no macroscopic haematuria
- normal blood pressure
- normal complement levels
- normal renal function.

Management

The most widely used protocol is to initially give oral corticosteroids (60 mg/m^2 per day of prednisolone), unless there are atypical features. After 4 weeks, the dose is reduced to 40 mg/m^2 on alternate days for 4 weeks and then weaned or stopped. The median time for the urine to become free of protein is 11 days. However, there is now good evidence that extending the initial course of steroids by gradually tapering the alternate day part of the course leads to a marked reduction in the proportion of children who develop a frequently relapsing or steroid-dependent course, although there are increased side-effects from steroid treatment. Children who do not respond to 4–6 weeks of corticosteroid therapy or have atypical features may have a more complex diagnosis and require a renal biopsy. Renal histology in steroid-sensitive nephrotic syndrome is usually normal on light microscopy but