Chapter objectives

After studying this chapter you should be able to:

1. Describe the structure and embryological origins of the major anatomical components of the urinary tract, namely kidneys, ureters, bladder and urethra.
2. Understand the clinical distinction between upper and lower urinary tract infections.
3. Describe the organisms commonly associated with urinary infections and the mechanisms which make these organisms uropathogenic.
4. Describe the underlying factors associated with complicated urinary tract infections.
5. Select the most appropriate imaging techniques for the urinary tract when structural abnormalities are suspected.
6. Understand the principles of treatment of upper and lower urinary tract infections.
7. Describe the anatomical abnormalities and complications occurring in patients with vesicoureteric reflux.
Introduction

The kidneys are highly specialized organs that function to regulate the volume and chemical composition of the body fluids. In carrying out this function, they excrete most water-soluble waste products in urine. Once the urine is formed, it is collected and stored in the bladder. The bladder then empties intermittently during the process known as micturition.

When the normal processes of embryological development are disturbed, defects may develop in the structure of the urinary tract that interfere with the normal production and flow of urine. As a consequence, urinary tract infection may occur, and may be the initial clue that a structural abnormality of the urinary tract exists. This chapter, illustrated by the case of such an infection in a child, will introduce the basic structure and development of the kidneys and urinary tract, and discuss the common problem of urinary tract infection.

Normal anatomy of the urinary tract

The urinary tract is made up of the kidneys, ureters, bladder and urethra (Fig. 1.1). The kidneys are normally considered to be the upper urinary tract, whereas the remaining structures may be considered to be the lower urinary tract. There are normally two kidneys, each placed retroperitoneally in the posterior abdominal wall on either side of the spine at the level of the upper lumbar vertebrae. Each kidney is 10–14 cm in length in adults and is surrounded by a fibrous capsule within perirenal fat. The renal hilus on the concave medial aspect of the kidney is the point of entry for the arteries, veins and nerves, and exit for the urine drainage system. The urine formed by the kidney initially drains into the renal pelvis, which may be considered as the dilated portion of the ureter which links the kidney to the bladder. The urine in the renal pelvis is propelled by peristaltic action along the length of the ureter into the bladder. The ureters run medially and insert into the posterior base of the bladder, with the terminal end of the ureter tunnelled submucosally to form the vesicoureteric junction. The normal intrinsic musculature of the bladder surrounding the oblique course of the intravesical segment of the ureter is thought to be responsible for ureteric competence during bladder emptying, thus preventing the reflux of urine from the bladder back into the ureter. Abnormalities in the development of this intravesical segment are thought to predispose to the development of vesicoureteric reflux (see later in this chapter).

The bladder is an elastic organ consisting of connective tissue and smooth muscle, known as detrusor, loosely arranged in outer longitudinal, middle circular and inner longitudinal layers. This muscle arrangement results in the bladder’s ability to empty during contraction. The dome of the bladder is covered by parietal peritoneum and is in apposition to other organs in the pelvis. The proximal urethra lies between the bladder neck and the pelvic diaphragm, and functionally consists of two sphincter mechanisms composed of both smooth and striated muscle. In women, the pelvic diaphragm is responsible for most of the sphincter mechanism. In men, the sphincter mechanism is largely incorporated into the prostate, with minimal sphincteric function incorporated into the bulbar and penile urethra.

Thus the kidneys and ureters are bilateral and paired, whereas the bladder and urethra are centrally placed and form a single structure. As a general principle, damage to a single kidney has minimal impact on overall renal excretory function provided the remaining kidney is normal. However, structural abnormalities of a single kidney or ureter may still predispose to infection, and may be relevant to Tommy’s presentation, as will be discussed later in the chapter.

Structure of the kidney

The functional renal tissue, known as the renal parenchyma, is loosely divided into cortex and medulla. Each kidney contains about one million functional units, or nephrons, each consisting of a glomerulus and a tubule (Fig. 1.2). The glomerulus is responsible for filtering the blood, providing a barrier to the passage of protein and red blood cells into the urine. It is this filtrate which ultimately forms urine. After its production in the glomerulus, the filtrate enters the tubule, which functions to reabsorb and secrete fluid and electrolytes to adjust the urinary composition as necessary to maintain homeostasis of the body fluids. All nephrons have their glomeruli

Case 1.1 Urinary tract structure and infection: 1

A febrile child

Tommy Baron is a 2-year-old boy who presents with a fever up to 39°C of 24 h duration. Although initially complaining of abdominal pain and unable to be comforted, he is now clearly ill, with lethargy and diffuse abdominal tenderness. His blood pressure is normal at 70/40 mm Hg. Examination is otherwise unremarkable. Urinalysis shows blood ++++, protein ++ and is positive for leucocyte esterase (markers of white cells) and nitrites (markers of bacterial action).

We can infer from this information that Tommy is systematically unwell, with infection being the likely problem. The urinary abnormalities suggest the urinary tract is a source of the sepsis.

To understand the structural basis of this illness, we should initially familiarize ourselves with the anatomic components of the urinary tract. We can then consider whether Tommy is likely to have any abnormality that may predispose him to infection.
located in the cortex, which comprises the outer one-third of the kidney. Approximately 15% of nephrons arise in the deepest part of the cortex (the juxtamedullary area). The inner two-thirds of the kidney consists of dark, striated areas known as pyramids, and the intervening renal columns, which together comprise the renal medulla. The apices of the pyramids are the renal papillae which project into the calyces, which are cuplike structures joining within the kidney to form the renal pelvis.

The glomerulus consists of a network of capillaries which invaginates the blinded end of the associated tubule, forming the Bowman’s capsule. From this arises, in succession, the proximal tubule, the descending and ascending limbs of the loop of Henle, the distal tubule (including an early convoluted segment, a short connecting segment, and a late segment), the cortical collecting duct, the outer medullary and, subsequently, the inner medullary collecting duct, which opens at the tip of the renal papilla into the renal pelvis. The structure and function of the renal tubular system and glomerulus are described in more detail in Chapters 2 and 5, respectively.

At least one renal artery supplies each kidney, but often multiple renal arteries are present. Each renal artery typically divides into five segments which subsequently branch up the sides of the pyramids, forming the interlobar arteries. At the junction of the medulla and cortex, the interlobar arteries divide into arcuate arteries. These then divide into interlobular arteries, giving rise to the afferent arterioles which feed into the glomeruli. The vessels emanating from the glomeruli are known as the efferent arterioles. The majority of efferent arterioles form a capillary network surrounding the proximal tubules within the cortex. However, the juxtamedullary glomeruli give rise to long, meshed capillary networks, the vasa recta, which participate in the countercurrent mechanism of urinary concentration in the kidney (see Chapter 3).
Innervation of the urinary tract

The neurological supply to the kidney is largely involved with regulation of vasomotor tone and hence renal blood flow. Sympathetic fibres originate in the lower splanchnic nerves and travel through the lumbar ganglion to the kidney. Stimulation of the sympathetic nervous system reduces renal blood flow by causing intrarenal vasoconstriction. It also enhances sodium reabsorption and stimulates the local renin-angiotensin system (see Chapter 2). However, denervated kidneys continue to function, usually without significant perturbations in major functional parameters.

Both sympathetic and parasympathetic nerve fibres supply the ureter. The spinal segments subtending this supply are the L1 and L2 nerve roots. Sympathetic fibres arising from the renal and intermesentericplexuses supply the upper part of the ureter, the superior hypogastric plexus supplies the middle part, and the inferior hypogastric plexus (lying at the side of the bladder and prostate) supplies the lower part. Vagal fibres supply parasympathetic innervation to the kidney and ureter via the coeliac plexus and pelvic splanchnic nerves.

The bladder and urethra are innervated by both parasympathetic and sympathetic pathways. The parasympathetic fibres arise in the second to the fourth sacral nerve roots. They function to stimulate bladder emptying, vasodilatation and penile erection. The bladder is less densely innervated by sympathetic fibres which arise from T11–L3 nerve root segments. Stimulation of the sympathetic nervous system decreases bladder tone and inhibits the parasympathetic system. The base of the bladder and the proximal urethra are more richly innervated by sympathetic fibres which act to facilitate closure of the bladder neck and the proximal urethral sphincter. Drugs which block noradrenergic alpha-receptors (such as the antihypertensive prazosin) may inhibit periurethral sphincter function, resulting in incontinence. However, these drugs are useful for relief of bladder outflow obstruction in benign prostatic hypertrophy, and for the relief of pain caused by ureteric spasm in the presence of an obstructing stone. The pelvic diaphragm is innervated by somatic motor neurones that allow voluntary contraction and relaxation. These neurones arise from the S2–S4 segments. The pelvic diaphragm is largely responsible for maintaining continence.

The bladder distends as urine is drained into it, resulting in the maintenance of low bladder pressures. This distension is essential to prevent urinary incontinence, which will occur if bladder pressures exceed the resistance of the urethral sphincter.
Micturition is therefore a complex process of coordinated stimulation of the parasympathetic nervous system which results in bladder contraction, and inhibition of sympathetic tone which results in sphincter relaxation. Voluntary control of voiding via the somatic nervous system is essential for regular drainage of the urinary tract to occur, as well as for social and hygiene reasons.

**Embryology of the kidney and urinary tract**

The development *in utero* of the urinary and reproductive tracts is closely related in both males and females. In the early stages of development, the urinary and genital ducts open into a common tract or cloaca, which is the dilated portion of the hindgut (see Fig. 1.3). In males, the urinary and genital systems continue to share a common distal excretory duct system, i.e. the distal urethra. However, in females the primitive excretory duct undergoes regression and does not form part of the reproductive tract in adults.

The fetus produces and excretes urine into the allantoic or amniotic fluid sac, where it is reabsorbed. The excretory function of the kidney is not essential until after delivery. However, if developmental anomalies of the urinary tract occur, they are often detected on fetal ultrasound because of the obstructed passage of urine.

Human kidneys are derived from the sequential development of the embryonic mesodermal kidney structures: the pronephros, mesonephros and metanephros. The pronephros degenerates in embryos of about 5 mm in length before full embryonic development. The mesonephros functions for a short time *in utero* as a provisional kidney before largely degenerating into the mesonephric tubule that persists to form part of the ductal system of the male reproductive tract. The metanephros remains and develops into the functional human kidney.

The excretory part of the metanephros develops from the portion of the nephrogenic cord caudal to the mesonephros. The functional human kidney is formed by invasion of the collecting tubules arising from the ureteric bud into the metanephric mesenchyme (Fig. 1.3). The branching and invasion of the ureteric bud into the mesenchyme is highly structured, showing several repeating patterns of division. As a result of this invasion, each tip of the branching collecting tubule has a ‘cap’ of approximately 100 mesenchymal cells, which are induced to survive, proliferate and undergo mesenchymal–epithelial transformation. These mesenchymal cells are effectively stem cells, capable of undergoing differentiation to form the glomeruli and the proximal, loop and distal tubular segments of the nephron. This then joins the collecting tubule derived from the ureteric bud. In addition, the metanephric mesenchyme produces non-epithelial cells that are stromal in distribution. The cells of the mesenchyme and ureteric bud also produce factors which control the growth, differentiation and migration of endothelial, mesangial, smooth muscle and interstitial cells, as well as the deposition of extracellular matrix. These nephrons are grouped into lobules, which persist until birth and then generally disappear. However, some lobulation may persist into adult life.

During the development of the metanephros, the kidneys undergo an upward change in position, which is due partly to the cranial growth of the ureter and partly to the diminution of body curvature. Fusion of the lower poles of the kidney during this ascent results in the defect known as horseshoe kidney.

The impact that interference with the normal development of the kidney will have on the kidney and urinary tract depends on the stage of development at which the insult occurs. During the first few weeks of embryogenesis, an injury or insult may result in congenital absence of the kidney. If the same event occurs during the second or third month of gestation, parenchymal disruption may occur. This results in cystic or hypoplastic kidneys or abnormalities of the collecting systems, such as urethral atresia, posterior urethral valves or calyceal distortion. Vestigial tubules derived from metanephric tissue which fail to join the collecting ducts may result in closed secretory loops and form renal cysts. Early separation of the ureteric bud into two or more parts may result in duplex collecting systems. Beyond the fourth month of gestation, an insult is unlikely to affect the pelvicalyceal system, as it is well defined anatomically by this stage.
The genetic and molecular basis of the processes that govern these regulated phases of renal embryonic development remain largely unknown. A number of genes, which produce a variety of molecules that may be potential regulators of renal development, have been identified. Disruption of these processes may result in a variety of developmental renal abnormalities.

One consequence of abnormal development of urinary tract structures may be impaired urinary drainage, and hence predisposition to infection. This possibility will be explored in relation to our febrile child.

**Infection of the urinary tract**

Infection of the urinary tract is one of the most common bacterial infections in both children and adults. The clinical features, diagnosis, treatment and significance of the infection vary depending on the site of infection and the presence or absence of structural and/or functional abnormalities within the urinary tract. Recurrent urinary infection, when complicated by major structural abnormalities, can lead to chronic kidney disease. In the presence of underlying kidney disease, superimposed infection often accelerates functional decline. However, recurrent uncomplicated urinary infection, although common and debilitating, generally has no long-term deleterious consequences.

**Asymptomatic bacteriuria**

Asymptomatic bacteriuria is defined as the presence of bacteria in the urinary tract in the absence of symptoms attributable to infection. Contamination of urine by organisms normally residing in the female periurethral area at the time of collection is common. Thus it is generally considered that ‘significant bacteriuria’ is present when $10^5$ or more of the same organisms per millilitre are present in two voided urinary specimens (or in one ‘in–out’ catheter specimen) in a woman, or in one voided specimen in a man. In general, antibiotic treatment of asymptomatic bacteriuria is only indicated in the presence of factors leading to potentially complicated urinary infection (including pregnancy). In many circumstances, asymptomatic bacteriuria is a recurrent problem and antibiotic therapy may lead to antibiotic resistance that may cause infection to be more difficult to eradicate.

**Acute urinary tract infection**

Acute infection of the urinary tract can generally be divided on clinical grounds into upper or lower tract infection (Table 1.1).

<table>
<thead>
<tr>
<th>Table 1.1 Clinical features of acute lower and upper urinary tract infection in adults</th>
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<tr>
<td><strong>Lower urinary tract infection</strong></td>
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<tr>
<td>Dysuria</td>
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<tr>
<td>Frequency</td>
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<tr>
<td>Suprapubic pain</td>
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<td>Malodorous urine</td>
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<td>Haematuria</td>
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<td>Normal temperature</td>
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<tr>
<td><strong>Upper urinary tract infection</strong></td>
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<tr>
<td>Systemically unwell</td>
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<tr>
<td>Fever ± rigors</td>
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<tr>
<td>Loin pain and tenderness</td>
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<td>Nausea and vomiting</td>
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<td>Hypotension or shock</td>
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<td>± Features of lower urinary tract infection</td>
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*Acute infection of the upper urinary tract is also referred to as acute pyelonephritis.*
involved in ascending infection, this is also referred to as acute pyelonephritis.

These arbitrary divisions have implications for treatment and prognosis, and guide decisions regarding further investigation. If the kidneys and urinary tract are normal anatomically and functionally, infection is unlikely to result in significant renal impairment, even when persistent and/or recurrent. However, if there is impaired renal function, reduced systemic resistance to infection, or abnormal drainage of the urinary tract, an infection is likely to become complicated, with the risk of renal damage, abscess formation or septicaemia. As dilatation and impaired drainage of the urinary tract is inevitable in pregnancy, all urinary infection in pregnant women should be treated as a potentially complicated infection (see also Chapter 11).

Aetiology and pathogenesis of urinary tract infection

There are numerous differences in the clinical features, response to therapy and prognosis of urinary infection according to the age of the patient, site of infection and whether the infection is complicated or uncomplicated. However, the microbial aetiology of infections is similar throughout the urinary system regardless of clinical setting.

Bacteria are by far the most common cause of urinary infection, with most other infecting organisms occurring in patients with underlying systemic illness (Box 1.2).

E. coli accounts for approximately 85% of community-acquired and 50% of hospital-acquired urinary infection. However, almost every organism has been associated with urinary tract infection, especially in the immunocompromised inpatient population and in those with urological instrumentation. Organisms not traditionally regarded as urological pathogens may also occur in this population in whom natural host defence mechanisms are compromised. These organisms include lactobacilli, Gardnerella vaginalis and mycoplasma species, including Ureaplasma urealyticum. Staphylococcal pyelonephritis (almost always S. aureus) should always raise the possibility of haematogenous spread from distant foci as this is an unusual organism to colonize the periurethra and cause ascending infection.

Most episodes of urinary sepsis are caused by ascending infection, with a small percentage of upper urinary infections arising from the haematogenous (bloodborne) route. The vaginal introitus is normally colonized with a variety of non-virulent streptococci, staphylococci and lactobacilli, which are only occasionally responsible for urinary infection. Gram-negative bacteria, which are much more likely to cause urinary infection, normally reside in the bowel and colonize the introitus in a proportion of women. Factors thought to be responsible for periurethral colonization by colonic bacteria and subsequent bacterial entry into the bladder include previous antibiotic therapy, the use of a diaphragm and spermicide for contraceptive purposes, and sexual activity. In many instances an alteration in sexual activity (either sexual partner or frequency of intercourse) will predispose to urinary infection in women.

Different factors operate to prevent urinary infection at each anatomical level in the urinary tract. The common uropathogens are able to overcome the normal host defence mechanisms that protect against urinary infection. The relative contribution of bacterial virulence factors to infection depends on the site of infection as well as the normality or otherwise of the urinary tract. In the presence of an anatomically abnormal urinary tract, organisms of low virulence may still be able to establish
URTINARY TRACT STRUCTURE AND INFECTION

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The laboratory diagnosis of urinary tract infection depends on microbiological confirmation of infection. This is usually taken to mean a bacterial count of greater than $10^5$ colony-forming units (CFU) per millilitre. The technique of collection of the urine specimen is critical. In men the collection of a midstream sample is usually successful and contamination is rare. In women, the introitus should be cleaned with saline (not antiseptic as this may inhibit bacterial growth and cause a falsely negative culture result). A midstream urine is collected with the labia spread apart. Collection in infants and children is difficult as adhesive bags are likely to become contaminated. In these circumstances suprapubic aspiration is a safe alternative that provides a definitive diagnosis. Urine can be stored at $4^\circ C$ for up to 48h before culture.

Although the laboratory cut-off for significant infection is regarded as $10^5$CFU/mL, infection may be present when colony counts are between $10^2$ and $10^3$CFU/mL, particularly in the case of less common organisms such as Gram-positive bacteria and some fungi. Mixed cultures, particularly in the presence of low colony counts in females, are usually the result of contamination.

Because of the delay inherent in microbiological confirmation of urinary tract infection, urinalysis is often used as a first line screen in individuals with symptoms suggestive of urinary infection (Fig. 1.4). Biochemical reagent strips will detect nitrites, which are produced by common uropathogens, and also leukocytes. The finding of pyuria (increased leucocyte excretion) does not always correlate with infection, since it may occur with other causes of urogenital inflammation and in normal pregnancy. Microscopic haematuria and proteinuria on urinalysis may be indicative of urinary tract inflammation, but are unreliable as markers of infection when additional renal or urinary tract pathology is present. Urine microscopy may demonstrate red cells, white cells and bacteria characteristic of infection. Evidence of white cell casts is suggestive of renal parenchymal infection. Additional tests have been developed to localize the site of infection to the upper or lower urinary tract, but these are not routinely used in clinical practice. In patients presenting with systemic features of pyelonephritis, septicaemia is possible and, in this clinical setting, blood should be taken for culture.

In otherwise healthy sexually active women, isolated lower urinary infection in the absence of systemic or structural factors predisposing to complicated infection (see Box 1.1) requires no further investigation, unless it is recurrent (more than three episodes per year). Urinary infection in males should be regarded as being potentially complicated, and underlying abnormalities of the urinary tract, particularly those causing obstruction of urine flow, should be sought. In younger males, congenital abnormalities of the urinary tract predominate, including vesicoureteric reflux and the presence of urethral valves, while in older males, bladder neck obstruction caused by prostatic hypertrophy or urethral stricture is more likely. In appropriate male patients, it is important also to exclude active prostatitis or sexually transmitted disease. Further imaging investigations are necessary in cases where structural abnormality in the urinary tract
The next step

The severity of the systemic features in Tommy's case suggest that an underlying abnormality of the urinary tract may account for the infection. Indeed, the above discussion would suggest that, if free drainage of the urinary tract existed, infection is unlikely to have taken hold, particularly in a male.

In light of Tommy's age, the most likely underlying cause is a congenital abnormality of the urinary tract. In an older person, acquired abnormalities of the urinary tract are more commonly found. The nature of the structural abnormality is often easily determined by simple imaging of the urinary tract. This raises the issue of what techniques are available to gain a view of the anatomy of the urinary tract in different clinical settings.

is suspected, as in any child with UTI, or any patient with complicated or upper urinary tract infection.

Imaging of the urinary tract

Renal ultrasound is the initial screening test used for imaging the urinary tract in children, in men, or in the presence of complicated infection. It will define whether urinary tract dilatation is present and whether the underlying renal size and parenchymal thickness is normal (Fig. 1.5). The level of obstruction is suggested but the result may not be definitive, and computed tomography (CT scanning) may be indicated subsequently (Fig. 1.6). CT is rarely indicated in the acute setting of infection, but is frequently performed as a follow-up investigation especially where resolution is slow or incomplete. CT is also the best imaging modality if abscess formation is suspected, both to define the intrarenal mass as well as to monitor the response to therapy.

Intravenous pyelography (IVP) provides a functional and anatomical assessment of drainage of the urinary tract, particularly after correction of obstructive pathology or in the investigation of pelvicalyceal disease (see Fig. 1.9). However, it is now less commonly undertaken, and has largely been superseded by CT scanning and magnetic resonance imaging (see Table 12.2) where these newer modalities are available.

A radionuclide blood flow scan is of use in assessing renal perfusion (see Chapter 10) and avoids exposure to potentially nephrotoxic contrast agents.

Cystoscopy (direct inspection of the interior of the bladder) should be performed if primary bladder or prostate pathology is suspected. It is rarely indicated in patients with urinary infection who have normal upper tracts demonstrated on ultrasound. If impaired bladder function is suspected, urodynamic studies which record changes in pressure during bladder filling and emptying may be indicated.

All children presenting with urinary infection should be investigated with imaging of the urinary tract since up to 50% will be found to have a urological abnormality. In the majority of these children, vesicoureteric reflux
(see Box 1.4) will be confirmed. In infants who are acutely unwell with pyelonephritis, both ultrasound and micturating cystonehrothrogram (MCU) should be performed. The MCU demonstrates the presence of backflow of urine from the bladder into the ureters during micturition (vesicoureteric reflux). In older children an MCU is not always considered necessary in the presence of a good quality ultrasound view of the upper urinary tract, with visualization of the ureteric orifices and ureteric peristalsis. A radionuclide scan using DMSA (dimercaptosuccinic acid) is performed to detect renal parenchymal scarring (Fig. 1.7). This is not generally undertaken within 6–12 months of acute pyelonephritis to avoid false positive results.

**Vesicoureteric reflux**

Vesicoureteric reflux (VUR) is caused by incompetence of the vesicoureteric junction. In most instances the defect is one of shortness of the submucosal segment because of
lateral ectopia (displacement) of the ureteric orifice. This results in loss of the normal valvelike action associated with the oblique path of the terminal segment of ureter through the bladder wall (Fig. 1.8).

In the majority of infants, VUR presents with a complicating urinary infection. However, signs localizing the infection to the urinary tract may not always be present, especially in the very young. In males particularly, infection may not always occur, and more subtle signs of renal damage caused by retrograde urine flow (reflux nephropathy) may be present (Box 1.4).

If enuresis (bed-wetting) persists until after primary school age (10 years), reflux should be excluded with renal ultrasonography. Enuresis in this setting is caused by the presence of residual urine after voiding as the upper urinary tract empties into the bladder, and also by impaired tubular function with loss of the ability to concentrate the urine which leads to increased urine volumes. In adults, enuresis rarely persists but nocturia may be a prominent symptom.

It has recently been recognized that reflux nephropathy is inherited as an autosomal dominant condition. Thus current recommendations advise routine ultrasound in neonates of parents known to have reflux nephropathy independent of the grade of reflux in the affected parent. Recent research also suggests that a small and scarred kidney may be the primary congenital abnormality in at least some cases, with abnormalities of the vesicoureteric junction an associated or secondary development.

The diagnosis of VUR is based on demonstration of reflux on an MCU or real time ultrasound. There may also be radiological findings of focal scarring in the

**Box 1.4 Features of vesicoureteric reflux and reflux nephropathy**

**Vesicoureteric reflux**
- Ultrasound *in utero* (incidental finding)
- Enuresis
- Double voiding
- Loin pain on micturition
- Urinary tract infection
- Family screening

**Reflux nephropathy**
- Hypertension
- Proteinuria
- Renal impairment
- Impaired urine concentration *with or without features of VUR*

Fig. 1.8 Vesicoureteric junction (VUJ): (A) normal; (B) defective, with reflux.
Kidneys, generally at the upper pole, with calyceal clubbing. If more severe VUR is present, the kidney may be diffusely damaged with generalized loss of parenchymal tissue (Fig. 1.9).

After starting antibiotics (ceftiraxone), Tommy became afebrile with improved appetite over the ensuing 72h. Intravenous antibiotics were continued for a total of 7 days, after which he was given oral cefaclor for a further week. Tommy was subsequently maintained on a preventative dose of trimethoprim/sulfamethoxazole at night. A repeat urine culture 3 weeks after his initial presentation was sterile.

It was recommended that his two siblings, aged 5 and 7 years, who were asymptomatic, should undergo screening urine culture and ultrasonography for the detection of vesicoureteric reflux.

It is clear that an underlying anatomical abnormality has contributed to Tommy’s infection. Vesicoureteric reflux is one of the commonest congenital abnormalities of the urogenital tract. The following questions are likely to be raised by Tommy’s parents and will be discussed:

1. What causes vesicoureteric reflux?
2. How is it diagnosed?
3. What treatment is indicated?

Most episodes of uncomplicated lower urinary tract infection are isolated events affecting sexually active women. Suitable antibiotics for use in this setting include trimethoprim, cefalexin and amoxicillin/clavulanate. In most cases, a 3-day course of therapy provides adequate treatment. In relapsing infection, a 10–14-day course of antibiotics should be prescribed and if infection persists or recurs investigation should be undertaken. Recurrent infection (more than three episodes per year) is best treated with prophylactic low-dose antibiotics. However, in patients with a clear relation between infection and sexual activity, single dose therapy after intercourse may be effective. Generally, follow-up cultures are not needed in otherwise uncomplicated urinary infection.

The treatment of acute upper urinary tract infection (acute pyelonephritis) is generally performed in hospital. Intravenous fluids and empiric antibiotic treatment (e.g. intravenous third generation cephalosporin such as ceftriaxone, with or without an aminoglycoside such as gentamicin) should be commenced before culture results
Follow-up
At review 12 months later, Tommy’s urine remains sterile with no proteinuria, and his growth and milestones appear normal. His blood pressure is at the upper limit of normal at 90/60 mm Hg. Repeat renal ultrasound is unchanged from that performed during the acute phase of his illness, although the right renal parenchyma is now less oedematous and the kidney measures 2.5 cm smaller than the left. A DMSA scan is performed which shows diffuse parenchymal cortical scars on the right, but none in the left kidney.

The management plan for Tommy is to maintain the prophylactic antibiotic until he is 5 years of age, and then repeat the ultrasound and DMSA scan. In the absence of new scar formation, it is planned that antibiotics will be ceased at that stage. Regular follow-up of blood pressure and urinalyses are advised to detect any increase in urinary protein excretion.

His 7-year-old sister has sterile urine, but renal ultrasonography and subsequent DMSA scan are suggestive of a right upper pole scar. There is no ultrasound evidence of ongoing reflux, with ureteric peristalsis and ureteric jets appearing normal. The management plan is to have 6-monthly urinalyses and a repeat DMSA scan in 1 year. In the absence of infection and progressive renal scarring, her blood pressure and urinalysis will be monitored on a 2-3-yearly basis. The risks of infection in pregnancy and potential for developing hypertension, particularly in pregnancy, are explained to her mother for future information. The remaining sibling is normal.

become available. An appropriate oral antibiotic with good renal parenchymal penetration, such as amoxicillin/clavulanate or norfloxacin, may be substituted when the fever subsides. The total duration of antibiotic treatment is generally 2 weeks. If no significant improvement is observed within 48h, the diagnosis and choice of antibiotic therapy should be reviewed, and imaging of the kidney undertaken to exclude obstruction or abscess.