Urinary tract obstruction

Renal obstruction remains a common cause of renal failure. This article reviews the aetiopathogenesis, clinical features, investigations and management of urinary tract obstruction. It highlights the importance of prompt intervention to prevent long-term complications.

Urinary tract obstruction is a common cause of acute kidney injury and chronic kidney disease. It can occur anywhere along the urinary tract. Long-term consequences of obstruction (chronic kidney disease) may be prevented by rapid intervention to relieve the obstruction.

Obstructive uropathy refers to the structural or functional change in the urinary tract that impedes urinary flow. Obstructive nephropathy refers to the consequent renal disease. Hydronephrosis describes the dilation of the upper urinary tract – this most commonly results from obstruction, but can also occur without an obstructed renal system (for example in pregnancy or vesicoureteric reflux). Conversely, renal obstruction can occur without hydronephrosis (e.g. early obstruction or in retroperitoneal fibrosis). Hydronephrosis and obstructive uropathy are therefore not strictly synonymous.

Obstructive uropathy can be acute, causing reversible functional changes in the kidney (acute kidney injury), or chronic when irreversible kidney damage may occur (chronic kidney disease). It can be complete (high grade) or partial (low grade). Lower urinary tract obstruction is obstruction occurring distal to the vesico-ureteric junction which inevitably affects the function of both kidneys simultaneously.

Epidemiology

The epidemiology of urinary tract obstruction varies with age and sex.

Renal pelvis dilatation, diagnosed by antenatal ultrasound scan, occurs in 1% of fetuses, with severe cases being associated with other urinary tract pathology (Hothi et al, 2009). Congenital obstructive uropathy accounts for 16% of all cases of end-stage renal disease in childhood (Ingelfinger, 2003). Posterior urethral valve is the commonest cause of congenital obstructive uropathy in the newborn male (Brown et al, 1987).

Obstructive uropathy is more common in males below 10 years of age as a result of congenital obstructive uropathy. The prevalence is about the same in males and females between 10 and 20 years of age but beyond 20 years of age, obstruction becomes more common in females as a result of pregnancy and pelvic malignancy. In the elderly, obstruction becomes more common in males as a result of prostatic hypertrophy or carcinoma. Other common causes of obstruction in the elderly include retroperitoneal or pelvic neoplasms, and calculi (Lameire et al, 2005).

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Pathophysiology

Urinary tract obstruction results in an alteration in both glomerular and tubular function. This does not necessarily lead to renal failure, unless the obstruction is bilateral or unilateral in a solitary functioning kidney. Unilateral obstruction does not produce an easily measurable effect on renal function because of compensatory hyperfiltration in the contralateral normal kidney. Sustained obstruction leads to irreversible nephron loss, interstitial fibrosis and chronic kidney disease.

Glomerular filtration is determined by the glomerular ultrafiltration coefficient and capillary pressure (which is dependent on renal plasma flow and resistance), intratubular hydraulic pressure and the oncotic pressure gradient across the glomerular wall.

Immediately following obstruction, back pressure results in a rise in pressure in the proximal tubules and Bowman's capsule and glomerular filtration rate falls. Although there is an initial increase in renal plasma flow resulting from efferent arteriolar vasodilation, subsequently there is intrarenal vasoconstriction and a decrease in renal plasma flow mediated by vasoconstrictors such as thromboxane A2 and angiotensin and reduction in vasodilators like nitric oxide (Klahr et al, 1988). At this stage, the consequent decrease in glomerular filtration rate is potentially reversible if the obstruction is relieved. However, chronic renal ischaemia causes local inflammatory changes (infiltration with macrophages) and eventually irreversible nephron loss and tubulo-interstitial fibrosis and atrophy will occur.

Abnormalities in tubular function may include altered renal handling of electrolytes, changes in the regulation of water excretion, impairment of urinary concentrating ability and urinary acidification defects. Recovery of tubular function following release of obstruction is slow and it may remain abnormal even after whole kidney glomerular filtration rate has returned to normal (Klahr et al, 1988).

Aetiology

The causes and location of renal obstruction vary according to age and sex.

Congenital urinary tract obstruction

Posterior urethral valve is the commonest cause of congenital urinary obstruction, occurring in newborn males with a prevalence of 1:5000 to 1:8000 pregnancies. It is an obstructing membranous fold occurring in the posterior urethra (Brown et al, 1987). Of these cases, 15–20% progress to end-stage renal disease as a result of associated renal dysplasia, recurrent urinary tract infections and poor bladder function (DeFoor et al, 2008).

Congenital ureteropelvic junction obstruction could be intrinsic (from stenosis, mucosal folds or polyps) or caused by extrinsic compression (from an aberrant artery across the lower renal pole).

Other causes of congenital obstructive uropathy include prune belly syndrome, meatal stricture and retrocaval ureter.

Acquired urinary tract obstruction

This accounts for 3–5% of cases of end-stage renal disease over 65 years of age in Europe (Sacks et al, 1989). The causes are either extrinsic or intrinsic. Intrinsic causes can be intraluminal or intramural (*Table 1*).

Clinical features

The clinical features of obstruction depend on age, the site and duration of obstruction. Obstructive uropathy can be asymptomatic. It should therefore always be considered in the setting of unexplained renal failure.

With advances in antenatal ultrasound, congenital obstructive uropathy is frequently detected prenatally. Clinical features of congenital obstructive uropathy include oligohydramnios, failure to thrive, vomiting, haematuria or fever.

Flank pain is a feature of acute complete upper urinary tract obstruction caused by distension of the collecting system or renal capsule. Pain is uncommon and minimal in partial or slowly occurring obstruction but may also occur when the increased urine output from a fluid load exceeds the flow rate across the site of obstruction. Bladder distension may cause lower abdominal pain.

Complete bilateral obstruction or unilateral obstruction in a single functioning kidney causes anuria. Patients with partial obstruction may notice a fluctuation in urine output and they may become polyuric over time because of tubular injury and consequent impaired urinary concentrating ability (Klahr, 1983).

Macroscopic (visible) haematuria may occur in obstruction caused by renal calculi and uroepithelial malignancy.

Lower urinary tract symptoms such as poor stream, terminal dribbling, intermittency or hesitancy suggest bladder outlet obstruction. Frequency, urgency and urge incontinence may occur as a result of incomplete bladder emptying.

Urinary stasis from obstructive uropathy increases the risk of urinary tract infections. Obstruction should always be excluded following a single urinary tract infection in men or young children of either sex, recurrent infections in women or infections with an atypical organism. Physical signs may include:

- Flank tenderness
- A flank mass (enlarged hydronephrotic kidney)
- A distended bladder (bladder outflow obstruction)
- Evidence of malignancy – a rectal and pelvic examinations are important (enlarged prostate and gynaecological malignancy)
- Hypertension (sodium and water retention and abnormal release of renin)
- Hypotension (polyuria and volume depletion).

Investigations

All patients with suspected urinary obstruction should have serum electrolytes, bone profile, bicarbonate and full blood count measured. Access to previous blood

Table 1. Causes of renal obstruction

Extrinsic causes	Females	Carcinoma of the cervix: direct extension of the tumour to involve the urinary tract occurs in up to 30% of patients
		Benign and malignant uterine and ovarian masses
		Pelvic pathology: abscesses, endometriosis and pelvic inflammatory disease
		Inadvertent ligation of the ureter during surgical procedures
		Pressure from a gravid uterus on the pelvic rim: usually asymptomatic and the changes resolve rapidly following delivery
	Males	Benign prostatic hyperplasia: commonest cause
		Carcinoma of the prostate: either from direct extension of the tumour to the bladder outlet or ureters or from metastases to the ureter or lymph nodes
	Either sex	Retroperitoneal malignancy: either primary (lymphoma and sarcoma) or metastases
		Retroperitoneal fibrosis
		Vascular abnormalities: aneurysmal dilatation of the aorta or iliac vessels, aberrant vessels
Intraluminal causes		Renal calculi – common sites are the pelviureteric junction or vesicoureteric junction
		Intrarenal intraluminal obstruction from crystal nephropathy or protein casts (myeloma)
		Sloughed papilla from papillary necrosis
		Blood clots – causes include bleeding renal tumours, polycystic kidney and renal trauma
Intramural causes		Functional causes include vesicoureteric reflux, neurogenic bladder from spinal cord injury, multiple sclerosis or medications
Anatomic causes		Uroepithelial malignancy
		Ureteric strictures from retroperitoneal surgery, radiotherapy, schistosomiasis or renal tuberculosis
		Urethral strictures – following instrumentation or infection

test results may allow patients with chronic kidney disease to be identified.

Urine dipstick may give clues to the cause of obstruction. Renal stones may result in microscopic (non-visible) haematuria (Argyropoulos et al, 2004).

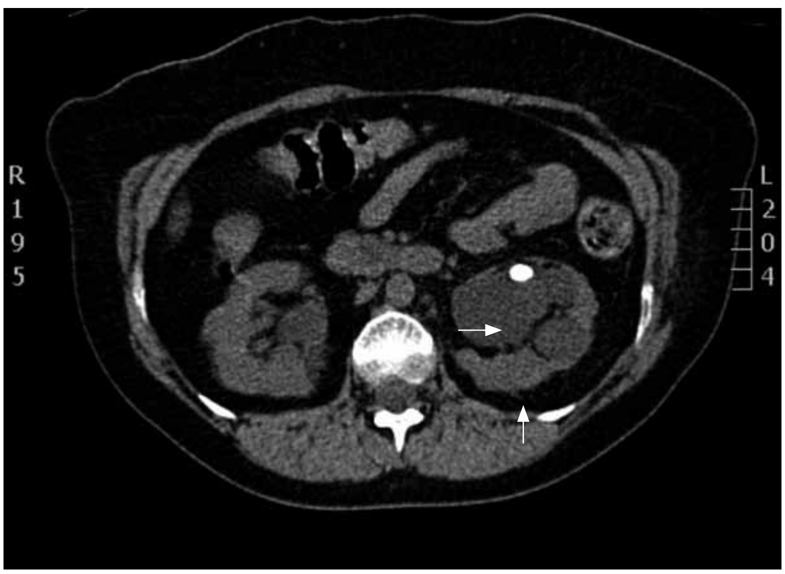
Imaging

Renal ultrasound

A renal ultrasound scan (*Figure 1*) is safe, easily accessible and can be used to assess kidney size and the renal parenchyma, as well as to detect hydronephrosis (Rosenfield, 1982). The presence of unilateral hydronephrosis suggests upper tract obstruction where as bilateral hydronephrosis may suggest pelvic or lower outflow tract pathology. However, ultrasound imaging alone rarely gives enough information to diagnose the precise cause (Dawson and Nethercliffe, 2012). The presence of hydronephrosis does not give an indication of the extent or severity of obstruction, and cannot differentiate between partial or complete obstruction (King, 1995). Ultrasound may also fail to detect hydronephrosis if the obstructions has developed acutely (Mostbeck et al, 2001). Doppler ultrasound scan can measure blood flow resistance (resistive index) through the kidney and this correlates with ongoing obstruction (Patti et al, 2000). However, any parenchymal disease can alter the resistive index and resistive index is not used in routine assessment of native kidneys (Drudi et al, 2004).

Figure 1. A longitudinal ultrasound scan of a moderately hydronephrotic kidney showing well-preserved parenchyma and a dilated renal pelvis.

Figure 2. Computed tomography of the abdomen showing hydronephrosis of the left kidney and a calculus in the renal pelvis (highlighted by arrows).



Although interpretation of ultrasound images is very operator dependent (Morse et al, 2000), ultrasound continues to be a valuable first-line investigation to rule out obstructive nephropathy in patients presenting with acute kidney injury in the UK (Lewington and Kanagasundaram, 2011).

Intravenous urography

This can be used to diagnose hydronephrosis and give information regarding pathology (DeFelippo et al, 1984). However, a fear about exposing patients with already impaired renal function to a large contrast load and the advent of other better imaging modalities means it is now rarely used.

Non-contrast helical computed tomography

Computed tomography scans are now the first-line imaging modality for patients with suspected renal colic (Worster et al, 2002). Computed tomography can often identify the pathology causing hydronephrosis as exemplified by *Figure 2*, but its potential can be limited when scans are carried out without contrast. It is important to remember that computed tomography scans expose patients to a significant radiation dose which may limit their repetitive use (Homer et al, 2001).

Magnetic resonance urography

Magnetic resonance urography is an alternative when patents cannot have iodine-based contrast or when exposure to radiation is undesirable. Magnetic resonance urography is particularly effective in diagnosing pathology when non-contrast computed tomography has been unhelpful and renal stone disease has been ruled out (Shokeir et al, 2004). When dynamic studies using magnetic resonance urography are combined with ultrasound scan imaging and plain abdominal film X-rays, the underlying pathology causing obstruction can be found in the majority of cases and a highly accurate functional assessment can be made of each kidney at the same time (Abou El-Ghar et al, 2008). In patients with impaired renal function there is a risk of developing nephrogenic systemic fibrosis after exposure to gadolinium contrast which is required for magnetic resonance urography scans and this may limit the use of this technique (Othersen et al, 2007).

Cystoscopy and retrograde pyelography
This can be used to identify the site and cause of obstruction. It avoids exposure to intravenous contrast agents, and may be helpful when non-dilated urinary tract obstruction is suspected (Charasse et al, 1991). However, it is relatively contraindicated in the presence of urinary tract sepsis.

Radioisotope testing
This can be carried out in patients with hydronephrosis in situations where it is unclear if the hydronephrosis is clinically significant (Powers et al, 1980). A radioisotope is administered and a diuretic is given (diuresis renogram). Delayed clearance of the radioisotope by the kidneys indicates functional obstruction. However, the results can be hard to interpret in chronic kidney disease (Aktas et al, 2006).

Patients who present with symptoms consistent with outflow obstruction or with bilateral hydronephrosis, where no other cause is found, can undergo urodynamic studies to assess for possible prostatic disease (el Din et al, 1996).

Management
Management of urinary tract obstruction depends on the cause of obstruction, degree of renal impairment and imaging findings (*Figure 3*).

Acute kidney injury secondary to partial or complete obstruction will resolve if the obstruction is treated promptly. Every effort should be made to avoid exposing a patient to the inherent risks associated with renal replacement therapy such as haemodialysis (Hata et al, 1983). However, dialysis may be required to correct life-threatening electrolyte anomalies or fluid overload.

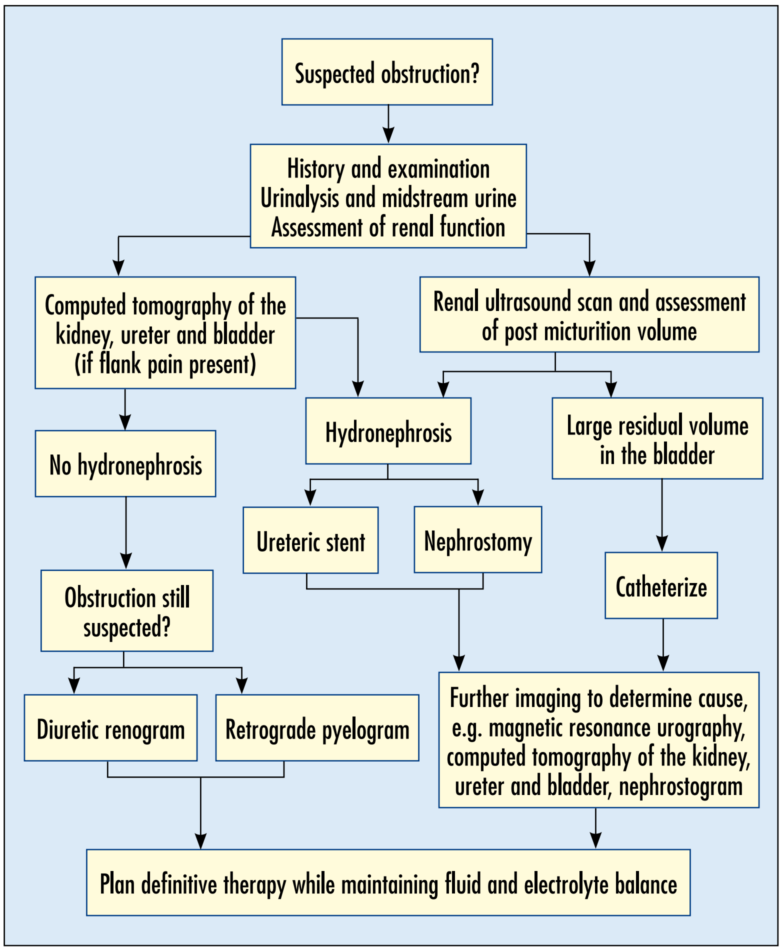
There is divided opinion regarding how best to relieve acute obstruction of the upper renal tract. Both percutaneous nephrostomy and retrograde ureteric stenting are well-established methods. However, currently there are no clear guidelines regarding when to use either method. There is no consensus view among urologists and radiologists in the UK regarding this issue (Lynch et al, 2006). In practice, local resources and experience will dictate management.

Lower urinary tract obstruction causing acute retention of urine (for example prostatic disease) can be rapidly relieved with a urinary catheter, while more definitive therapy is planned. When the obstruction is the result of prostatic disease further assessment should be undertaken to exclude malignancy. Treatment of prostatic disease can be medical or surgical, and patients should be fully involved in developing an appropriate management plan most relevant to each individual (Liu et al, 2004).

Acute obstruction of the renal tract with associated infection and systemic sepsis (pyonephrosis) needs urgent decompression. This can be done by either percutaneous methods (nephrostomy tube insertion) or by ureteric stenting (Joshi et al, 2001). If the obstruction is secondary to urolithiasis, removal of the offending stone is usually planned once infection is controlled. The best method of stone removal will depend on stone size, location and composition (Worster et al, 2002). Any patient with urolithiasis should be given advice about lifestyle changes and treatments to reduce the risk of future stone formation.

Post-obstructive diuresis often develops after obstruction is relieved. This results from an appropriate excretion of water and electrolytes that were retained during the obstruction but also from an acquired tubular dysfunction and loss of concentrating ability as a result of obstruction. Since the concentrating abilities of renal tubules may take several weeks to return to normal, large amounts of electrolytes may be inappropriately lost in the urine. Careful monitoring of serum electrolytes is needed to ensure complications do not develop as a result of hypokalaemia or hypomagnesaemia. The patient's fluid status needs to be assessed on a regular basis to ensure that circulating blood volume is adequate and if needed, intravenous fluids (with ongoing monitoring of serum electrolytes) can be started. Care must be taken to ensure patients do not receive over-zealous replacement fluids (Peterson et al, 1975).

Figure 3. A flow chart for investigating and managing urinary tract obstruction.



Conclusions

Urinary tract obstruction has a large number of causes and affects all age groups. If left untreated patients can develop end-stage renal failure requiring renal replacement therapy. There is no single investigation for obstruction; the most appropriate imaging modality will vary from patient to patient depending on the differential diagnosis, renal function and available resources. All patients presenting with acute kidney injury and renal obstruction need to undergo urgent decompression of their renal tract to preserve renal function. Post-obstructive diuresis can occur after relief of obstruction, and must be carefully managed to avoid volume and electrolyte depletion. **BJHM**

Conflict of interest: none.

KEY POINTS

- Urinary tract obstruction is a common preventable cause of acute kidney injury and chronic kidney disease.
- Ultrasound scan of the renal tract is a valuable first-line investigation to exclude urinary tract obstruction.
- Computed tomography of the kidney,ureter and bladder is the preferred form of imaging in the presence of renal colic.
- Hydronephrosis is most commonly caused by urinary tract obstruction but both terms are not synonymous.
- Renal failure occurs only in the setting of bilateral obstruction or obstruction of a unilateral solitary kidney.
- Whatever the cause, prompt decompression of the obstructed system prevents long-term complications.
- Dialysis may be required to correct life-threatening fluid overload and electrolyte imbalance but otherwise should not be considered an alternative to urgent decompression of the renal tract.
- Post-obstructive diuresis should be carefully managed to avoid volume and electrolyte depletion.

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