In many ways the imaging of paediatric renal disease is not dissimilar to that in adults. After all, a kidney is a kidney. But in many ways it’s different too. While the core modalities of ultrasound, fluoroscopy, MR, CT and nuclear medicine are used across the age spectrum from the cradle to the grave, the way those modalities are used and the range of pathologies varies immensely. CT and MR have become the main tool for imaging adult kidneys; this is partly due to the exquisite images that these modalities produce and partly because ultrasound is becoming less useful in our increasingly girth-challenged adult population. Moreover, in adults many investigations will be either for trauma or to exclude malignancy, both of which need definitive imaging at the first examination, often in the acute setting.

In children the focus is heavily weighted to the investigation of congenital or developmental issues, although of course urinary tract infection, trauma and malignancy are still important concerns. As such, ultrasound is absolutely the cornerstone of imaging in children and in almost every indication this is the first modality to be used. CT is very rarely used; it may be used in multi-organ trauma or for assessing calculi in particularly difficult cases, but is not usually the tool of choice for other indications due to its heavy radiation burden and the chance that the child may need serial imaging. MRI (including MRU) is used for assessing complex anatomy that has not been resolved by ultrasound, and for the assessment of tumours. Fluoroscopy is used for micturating cystograms (usually only in infants) and occasionally for the demonstration of urethral strictures in boys. The intravenous urogram (IVU) is essentially obsolete. Nuclear medicine techniques (DMSA and MAG3) are still key in the assessment of renal function, drainage and reflux. Plain films are probably only indicated in stone disease if there is concern about ureteric stones or stones lurking in an augmented bladder which may be difficult to show on ultrasound.

Ultrasound technique
The first step in getting a decent ultrasound examination is having a compliant patient. Distraction techniques are invaluable and the use of iPads, DVDs, smartphones, TV and toys make all the difference. The room must be warm and ultrasound jelly should be warmed in a bottle warmer. In babies, make sure to leave the nappy partly on. In all children let them keep on as many of their own clothes as is practical and work around it. Try to be quick.

A linear probe is essential and a 6-9MHz linear probe is the tool of choice for younger children, only moving to a curvilinear probe in older children. The linear probe will also be used in patients of all ages for high resolution delineation of any specific parenchymal abnormality. Children of all ages should be scanned both supine and prone. This is a key difference in practice from adult imaging but the prone images add value in showing better detail as the kidney is nearer the skin surface, allow easier and more consistent measurements of kidney length and often clearer depiction of duplex kidneys, and allow more reliable assessment of kidney malrotation (which is nearly always missed on the supine images). Pre and post micturition images must be obtained in children who are toilet trained. The ultrasound report must include details of the size of each kidney (on every occasion), giving the 50th centile for age and either the 5th or 95th centile depending on whether the kidney is above or below the 50th centile.

Key things not to miss:
• It is crucial to differentiate between hydronephrosis and renal cystic disease, especially multicystic kidney disease (MCDK). This can be tricky but in hydronephrosis it is nearly always possible, with some perseverance, to show the dilated calyces connecting to the renal pelvis (figure 1). Other pointers are that in MCDK the intervening renal parenchyma is not normal and is usually rather echo bright, and in hydronephrosis the calyces are usually of fairly even size and in a fan-like distribution, unlike the varying size cysts in MCDK. If it really is impossible to differentiate between the two then functional imaging (usually a DMSA) will be needed.
• It is also important to always consider a duplex kidney in the context of hydronephrosis, especially if the hydronephrosis is subtly asymmetric between the upper and lower parts of the kidneys. If in any doubt scan in detail in the transverse plane, looking for two renal pelvices. Duplex kidneys are frequently missed.
• The renal pyramids in newborns can appear very dark (echo poor) and if one is not used to seeing this it is easy to misinterpret normal neonatal renal pyramids as dilated calyces in hydronephrosis. Adjusting the gain or using Doppler can help in this respect; true hydronephrosis should be anechoic and not show any bloodflow.
• It is almost impossible to pick up malrotation from the supine images. When scanning the child prone it will be much more obvious with the renal pelvis coming straight out towards the probe (figure 2).

Micturating cystogram (MCUG)
There are very limited indications for an MCUG in current imaging/management algorithms. MCUG is not universally indicated in UTI, or in the assessment of reflux. NICE gives guidance on this.1 However, an MCUG remains mandatory in a boy with a first presentation of bilateral hydronephrosis including a posterior urethral valve (PUV). Antibiotic cover must be given and this is also detailed on the NICE website. It is essential that coned views, of a decent image size and taken as full exposures in a steep oblique/lateral profile, are obtained of the male urethra during voiding; ideally both with the catheter still in place and with catheter then removed. This is because occasionally the catheter itself can flatten a syringocele or minor leaflet and it is only apparent when the tube is removed that there is a significant obstruction. The only exception to this is when the presence of a PUV has been clearly demonstrated on the tube-in view and there is nothing extra to be gained from a tube-out view, apart from the trauma (and associated complications) of having to re-catheterise the patient. In these instances the catheter should be left in (figure 3).

An MCUG might also be performed in a male or female
infant with a large ureterocele also demonstrated on ultrasound. In this instance it is crucial to obtain a true lateral view during voiding to establish whether the ureterocele is presenting an obstruction to voiding, or indeed, bridging the bladder neck and falling into the proximal urethra. Without the lateral view this will not be appreciated.

Two minor points of technique:

i. By far the easiest way to secure the catheter tube in a male infant is to place a single length of sticky tape vertically down the anterior abdominal wall from just below the umbilicus, along the length of the penis (but not around it), and along the first 5cm or so of the catheter tube, and then to pinch it together over the length tube. The tube is then totally secured with respect to the patient’s abdomen and cannot be peed out or dislodged, but can very easily and quickly be removed without any fiddling around when you need to do the voiding views.

ii. In baby girls it is essential to make sure there is slight separation of the thighs at the point of voiding otherwise contrast will reflux into the vagina rather than run away freely. While this doesn’t really matter in itself it will be impossible not to know that the patient doesn’t have a urethral-vaginal fistula or UG sinus.

CT and MRI

As described above, CT plays a minor role in paediatric renal imaging. If CT is performed, one should aim to only do a single phase scan if at all possible. For complex stone disease this would usually only be an unenhanced scan. If parenchymal, vascular, or ureteric information is also required in the context of stone disease it may be possible to do a single post-contrast scan at about 10 minutes’ delay post intravenous contrast. If needing contrast for both the arterial and venous phases then the biphasic Camp Bastion protocol is very useful. This is available at the British Society of Paediatric Radiology website at www.mybspr.org/contrastwheel.htm and includes protocols for children of varying weights with volumes of contrast and timings already calculated. While there may be anxiety about missing calculi obscured by the contrast, it is usually possible to review the images on bone windows which will beautifully delineate the still highly attenuating calculi against a background of “washed out” contrast (figure 4). CT is also used for complex vascular anatomy in the context of complicated horseshoe kidneys or in surgical planning for complex tumour surgery.

CT may be performed for the work-up assessment of tumours in centres that do not have ready access to MR but, whenever possible, it would be preferable that MR is performed in the tertiary centre that will then take on the child’s oncology care.

MRI is increasingly playing a role in the assessment of the renal tract in children. It is still subject to the constraints imposed by the need for a general anaesthetic in children between the ages of about six months and seven years. Babies can have a feed-and-wrap scan, and children older than seven years can usually tolerate a scan without any sedation. The main indications for MR in children are to delineate complex anatomy or to assess tumours. As above, sometimes MR is necessary in the depiction of a duplex kidney that hasn’t been resolved by ultrasound. This would particularly apply in the context of a tiny occult moiety at the upper pole of the kidney in a female patient complaining of ‘wetting’ and never having been ‘dry’. The history is critical, and if the underwear is always damp then MR can be very helpful in demonstrating a duplex that has previously been missed, and the ectopic insertion of the ureter at or below the bladder neck therefore making continence impossible.

Tumour imaging by MR is far superior to that obtained by CT, owing to the vastly improved tissue resolution (at the slight expense of spatial resolution). Routine tumour assessment would usually include STIRs in three planes, a T2 space, ADCs, T1 WE, and 3D VIBE (or equivalent) pre and post gadolinium. The ADC maps are especially useful in demonstrating the tissue characteristics of the tumour (figure 5), and any subsequent change following chemotherapy.

Going forward, MR will become increasing valuable in the assessment of differential renal function but currently most centres do not have the level of access to allow this to become a routine technique.

Reference


Figure 1

Differentiating between an MCDK and hydronephrosis. (A) An MCDK showing multiple cysts of slightly varying sizes and echogenic intervening parenchyma. (B) Hydronephrosis with multiple dilated calyces of a similar size with a normal intervening parenchyma. (C) The same kidney as in (B) showing the connection of the calyces to the dilated renal pelvis.
Figure 2
The use of prone imaging in a malrotated kidney
(A) The right (i) and left (ii) kidney imaged supine, both showing renal pelvic dilatation. (B) The same right (i) and left (ii) kidney imaged prone, showing that the right kidney is malrotated and the renal pelvis exists posteriorly towards the probe, unlike on the left side which has a normal orientation. (C) The right kidney following nephropexy (ie securing the kidney so it can freely drain) with the dilatation completely resolved. This was not a pelvi-uretetic junction obstruction as might have been thought from the supine imaging alone.
Figure 3
Normal MCUG and posterior urethral valves
(A) Normal appearance of the male urethra during voiding with the catheter out. The entire length of the urethra must be shown, in a steep lateral oblique projection, on a good quality ‘exposure’ image. (B) Classic appearances of a posterior urethral valve with dilation of the posterior (upper) urethra and an abrupt calibre change at the level of the valve leaflet. There is nothing extra to be gained by taking the catheter out at this point and a tube-out view should not be obtained.

Figure 4
Contrasted CT still showing small calculus in the right kidney when viewed on bone windows.

Figure 5
MRI in bilateral nephroblastomatosis.
(A) The STIR sequence demonstrates the extensive rind of mid/low signal nephroblastomatosis which is crushing the normal high signal renal parenchyma centrally. (B) The ADC map clearly demonstrates the low signal of the cell-dense nephroblastomatosis.