

UROGRAPHY

CHANGING STRATEGIES

PIERRE VASSALLO

Urography is defined as the imaging of the urinary tract, so essentially any form of imaging done for the urinary system falls under this heading. There are two main reasons for imaging the urinary tract: renal colic and haematuria (particularly painless haematuria).

The first imaging studies to directly target the urinary tract were plain X-rays, which could detect the presence of a stone along the urinary tract and possibly just identify the renal outline. However, <80% of stones are visible on plain X-rays even with today's digital technology, whilst a renal mass would need to be at the edge of the kidney and be large enough to deform the renal outline in order to be detected on plain X-rays. The presence of gas and stool in the colon often obscures the urinary tract on plain X-rays severely limiting its value.

X-ray based intravenous urography (IVU) was later developed (Figure 1), which for several decades was the primary imaging modality for the urinary tract. This technique was first described in 1923, when Rowntree and co-workers injected 10% sodium iodide intravenously and noted that it enhanced the renal parenchyma. Sodium iodide is excreted through the urinary tract and this was visible on X-ray imaging. This was later combined with conventional tomography in an attempt to visualise the renal parenchyma in more detail and to detect small filling defects in the collecting system. However, even with the inclusion of conventional tomograms, IVU was virtually useless for imaging renal masses <3cm in diameter. In addition IVU requires relatively good renal function as it depends on renal excretion of intravenously injected contrast material to depict the urinary tract. Also, since IVU fails to provide any information to help characterise a renal mass, one must resort to cross-section imaging modalities such as ultrasound (US), computed tomography (CT) or magnetic resonance imaging

(MRI) to help reach a diagnosis.

US is an excellent tool for evaluating the urinary system and improving technologies have come to provide detailed morphological depiction of kidneys and bladder (Figure 2). However, due to their retroperitoneal location, the ureters are not visible on ultrasound. Until recently, US did not provide any information on renal function, but with the recent introduction of contrast-enhanced US, this is likely to change. Notwithstanding the fact that US is an excellent first imaging modality when investigating painless haematuria, in case of painful haematuria or suspicion of renal colic, a CT urogram is more appropriate as the first imaging exam.

CT urography is the cross-sectional equivalent of the X-ray IVU, but has the major advantage of having a much higher soft tissue resolution and has no interference from gas and stool within the bowel. CT detects urinary tract stones with much greater accuracy than any other technique, including MRI, with detection rates reaching 100% even for stones as small as 1mm in diameter (Figure 3). The only known exceptions are stones related to treatment with antiretroviral agents used in the treatment of AIDS; these medications have a tendency to crystallize within the urinary tract and are non-radiopaque making them invisible on CT. The presence of such stones may be diagnosed through knowledge of the clinical history and indirectly through the presence of obstruction caused by the stone. No intravenous contrast material is required to detect stones on CT urography, which is particularly advantageous in those patients with impaired renal function.

Intravenous contrast injection is required in cases of painless haematuria and in those individuals with either abnormal findings on the non-contrast scan or where there is clinical suspicion of a renal mass. The contrast-enhanced



CT urogram shows the exact size of the renal mass (Figure 4), whether there is extension of the lesion through Gerota's fascia or there is the presence or otherwise of hilar and intravascular extension (Figure 5). All these criteria help characterise the lesion, but more importantly assist with surgical planning. This information is required to decide whether either a partial or a total nephrectomy should be performed. Other important information that is visualised by CT urography is the presence of a synchronous lesion in the opposite kidney, as well as lymph node or distant (e.g. liver, lung or bone) metastasis. Delayed imaging after intravenous contrast material injection results in filling of the collecting systems and ureter as well as the bladder. Small urothelial tumors are best seen in these delayed scans (Figure 6).

MR urography is a more recent imaging modality that has potential benefits but also has its limitations. MR urography is insensitive to calculi. Examinations times are longer, spatial image resolution is lower than CT or IVU, it is more susceptible to motion artefacts and it is more expensive than other

urographic modalities. However, it utilises no ionising radiation and is therefore more suitable for the paediatric population and during pregnancy. Tissue contrast resolution is also higher in MR urography than in CT urography or US, making it more useful in patients with impaired renal function in whom intravenous contrast material administration is not indicated. The MR urography protocol is divided into two parts: (a) the static fluid imaging part, in which heavily T2 (water)-weighted images are obtained to depict the collecting system, ureters and bladder in both 2D and 3D modes, and (b) the dynamic contrast enhanced imaging part, which uses T1 (fat)-weighted images and intravenous contrast material injection similar to the early phases of an IVU but depicts cross-sectional anatomy and can therefore more accurately display pathology.

Static-fluid MR urography obtains images of the free fluid within the ureters and if serial images are obtained and played in a cine loop, temporary ureteric narrowing due to peristalsis can be distinguished from fixed stenosis that may be caused by inflammatory disease or a neoplasm. Static-fluid MR urography is best suited to imaging dilated collecting systems and ureters as occurs in the presence of obstruction (Figure 7). It is particularly useful to evaluate paediatric patients with congenital causes of urinary tract obstruction and in ureteric obstruction occurring during pregnancy.



Figure 1. IVU depicting normal collecting systems, ureters and a bladder: the darker region noted within the bladder is the result of the prostatic impression



Figure 2. US scan of a left kidney showing an 8.2cm mass (between cross-hairs) occupying almost all of the said kidney with a normal upper renal pole (arrow) and the spleen (S) located to the left in the image



Figure 3. A 3mm stone located in the distal left ureter (arrow) is seen on non-contrast enhanced CT urogram

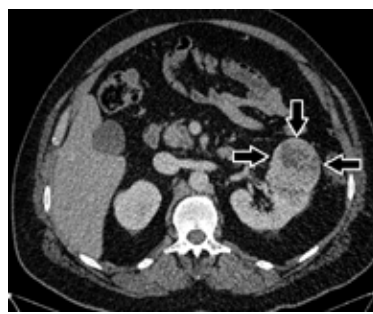


Figure 4. Incidental left renal mass noted during an abdominal ultrasound in a patient undergoing a routine medical check-up. CT shows size, location and margins of the left renal mass (arrows) along with the absence of renal hilar and vascular infiltration



Figure 5. Post-IV contrast CT scan shows right kidney completely replaced by tumor (T) and extension of tumor into the inferior vena cava (arrow)

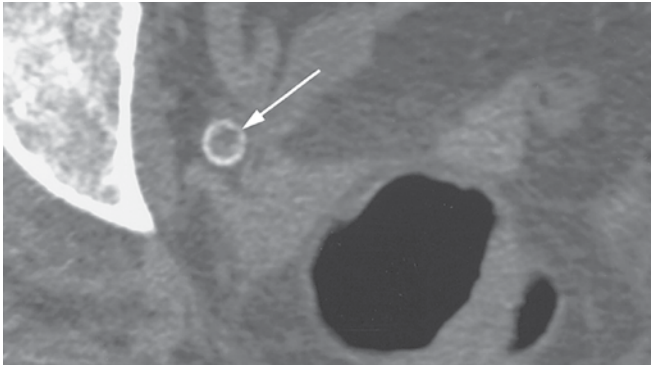


Figure 6. Filling defect in the distal right ureter surrounded by a rim of contrast material (arrow). The absence of calcification with the filling defect raised the suspicion of an urothelial tumor. This was confirmed to be a transitional cell carcinoma by retrograde ureteroscopy

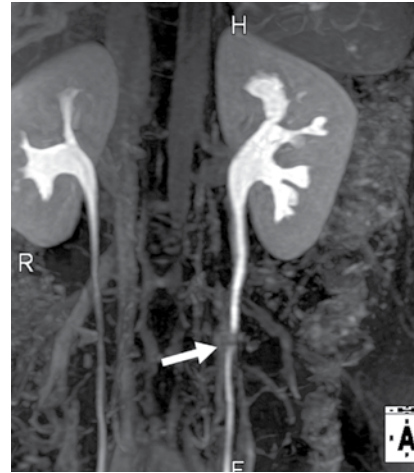


Figure 8. MR dynamic urogram showing partial obstruction of the left ureter by a stone (arrow). Note that the stone gives no signal and hence appears as a filling defect

Dynamic MR urography involves a process similar to that of dynamic CT urography and IVU. IV injected contrast material is excreted through the kidneys and is concentrated in the collecting systems and ureters. The problem with MR contrast material is that in high concentration it results in signal loss (susceptibility effects) and can actually obscure a lesion in the collecting system. To counter this phenomenon, various protocols have advocated use of smaller doses of IV contrast material, parallel use of diuretics and different levels of intravenous hydration prior to the exam. The image quality and accuracy of dynamic MR urography using these enhancements is now close to that of CT urography, but the technique is more time consuming (Figure 8).

Urography has seen significant development over the decades since its first use almost 100 years ago. The diagnostic accuracy with which we can evaluate urologic symptoms has been key to our detailed planning of treatment particularly with stone disease and urologic tumors. Selection of the best imaging algorithm will lead to rapid and accurate diagnosis and will improve the outcome of treatment. ❄️

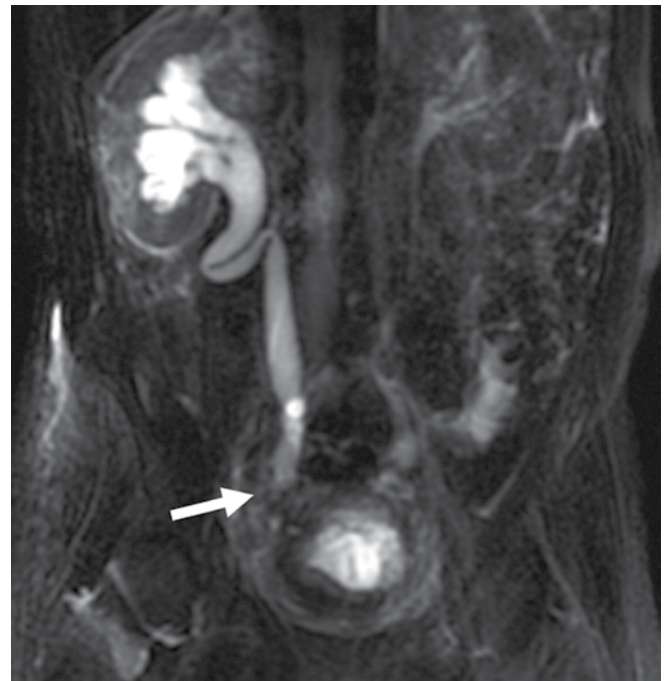


Figure 7. MR static urogram showing a dilated right renal collecting system and ureter extending down to the level of the pelvic brim (arrow). The obstruction at this level was due to an enlarged lymph node containing metastasis from a prostate cancer