# Intravenous urogram interpretation

## Introduction

Renal colic is a common acute clinical presentation. Although computed tomography is recommended as the first-line investigation (Royal College of Radiologists, 2007), this is not always readily available especially out of hours, and in these instances an intravenous urogram (IVU) is often performed. IVUs are frequently requested in the emergency setting by accident and emergency doctors and they are also involved in the procedure (giving the contrast injection) and initial interpretation of the subsequent films. Additionally IVUs involve several radiographs with a typical radiation dose of 2.4 mSv (by comparison the UK background radiation dose is 2.2 mSv per year). It is therefore important to have a working knowledge of basic interpretation.

## Patient preparation

Take a careful history; ask specifically about a personal history of asthma, allergies, drug history and sensitivities including previous contrast reactions. The risk of a serious adverse reaction to contrast is about 1 in 40 000. Asthmatics have a six-fold increased risk of a severe contrast reaction. If the patient has required hospital admission within the last 2 years because of his/her asthma or the asthma is poorly controlled then consultation with a radiologist is advised as an alternative test may be preferable (e.g. ultrasound or computed tomography).

If the patient has multiple allergies then a full allergy history should be taken. Premedication with steroids does not reduce the risk of a severe reaction (Morcos and Thomsen, 2001; Morcos et al, 2001).

If the patient has a history of renal impairment, then measurement of pre-procedure serum creatinine is required. A creatinine level of 130 µmol/litre or above is used to identify patients at risk of nephrotoxicity. If the creatinine level is above 130 µmol/litre then consultation with a renal physician is required, as it may be necessary to pre-hydrate the patient or pre-medicate him/her with N-acetylcystine before the procedure.

If the patient is a diabetic on metformin this drug must be omitted for 2 days before the procedure if the serum creatinine is raised. If the creatinine was initially raised metformin should only be restarted 48 hours after the procedure provided the serum creatinine has returned to the pre-procedure level.

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## The procedure

### Control film

The KUB (kidneys ureters and bladder) is an initial radiograph before contrast is injected. It covers the abdomen and pelvis to the level of the pubic symphysis (*Figure 1*). The KUB should be scrutinized for signs of renal tract calcification, over 90% of renal calculi are opaque. Start off by identifying the renal outlines (normally at the level of L2–3). These are difficult to identify as they are soft tissue structures. If the renal outlines cannot be identified accurately this does not matter as they will be demonstrated later after contrast injection. Any areas of high density may represent stones and should be documented. Then follow the line of the ureters. These can be traced by following the tips of the transverse processes from L3–L5. At this point the ureters deviate laterally and cross the sacro-iliac joints, before curving inwards over the ischial tubercles and entering the bladder.

***Figure 1. Kidneys ureters and bladder (KUB) radiograph with a left-sided stent (JJ stent) in-situ. The stent has its upper end in the collecting system of the left kidney and the lower end in the bladder. It depicts the course of the left ureter.***

### Contrast injection

A 19G butterfly needle should be sited in a peripheral vein. The contrast can then be injected. This is normally drawn up by the radiographer for the doctor to inject. A number of propriety brands are available. At the authors' institution 100 ml Omnipaque 350 is used (other brands include Niopam and Urograffin). After the contrast has been injected the radiographer will take a sequence of radiographs to demonstrate different parts of the renal system.

#### Immediate film

A film taken immediately after injection of contrast should demonstrate increased density of the kidneys because of uptake within the nephrons. The following should be assessed:

**Kidney position:** The left kidney lies in a slightly higher position than the right. If either kidney is not seen, then a full abdominal film may be needed to look for an ectopic kidney.

**Kidney size:** Kidney length should be roughly equivalent to 3–3.5 lumbar vertebrae.

Look for symmetry: the left may be larger than the right, but a discrepancy of >1.5 cm in length is abnormal.

**Kidney shape and outline:** Look for irregularities in outline of the kidney (*Figure 2*). There are sometimes depressions in the cortex; this can be congenital (fetal lobulation) or the result of parenchymal scarring. Renal masses may also cause an abnormal outline.

#### Five-minute film

This outlines the pelvicalyceal system. Normal calyces are cup-shaped (*Figure 3*). If the collecting systems are under-filled then a compression band is placed around the patient's abdomen. This has the effect

**Figure 2. A nephrogram. The normal smooth outline of the kidneys can be appreciated (compare this with Figure 1).**

of preventing drainage of contrast into the ureters and allowing the collecting systems to fill. Compression should not be used if the IVU is being performed for the investigation of obstruction, if there has been recent abdominal surgery or if the patient has an abdominal aneurysm.

Dilated or clubbed calyces may reflect obstruction or destruction of the papilla.

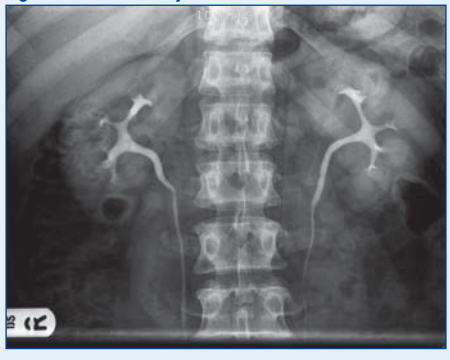
If there appears to be two separate groups of calyces within one kidney this could represent a duplex system.

If there is a prominent bowel gas pattern or faecal loading, it may be difficult to see the detail of the collecting system. In these circumstances tomograms can be obtained, where a slice of a certain thickness (determined by the angle of swing of the X-ray tube) is seen in focus, and the tissues outside this slice are seen out of focus.

### Ten-minute film

The ureters can now be identified as they contain contrast. They should be followed from the kidneys to the bladder. Often the ureters are not seen along their entire length. If this is the case then the patient can be turned over and a prone film taken. This has the effect of making the posteriorly placed kidneys superior to the ureters when the patient is prone, and contrast therefore drains under the effect of gravity down the ureters.

**Figure 3. Normal calyces.**



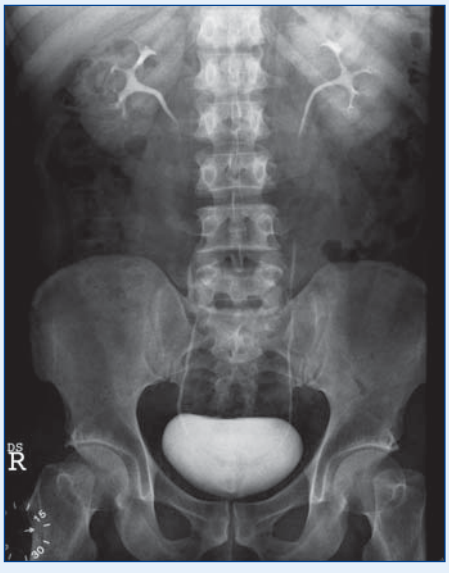
The bladder can also be assessed on the 10-minute film (*Figure 4*). It should have a smooth outline and the contrast should be evenly distributed through it. It is difficult to assess the size and shape of the bladder objectively, and there is a large degree of normal variation. However, an enlarged bladder will be seen to bulge upwards from the pelvis. An enlarged bladder can be caused by an enlarged prostate (in males), a urethral stricture or a neurogenic bladder.

An irregular outline may be the result of trabeculation of the muscular wall of the bladder, a sign of chronic outflow obstruction. Filling defects within the bladder may be seen when it is filled with contrast. This could represent an intravesical tumour that needs further investigation. Gas within the bladder may be caused by a fistula with the bowel, e.g. in Crohn's disease, or may be the result of bladder catheterization.

### Post-micturition

After the 10-minute film the patient micturates, and the bladder should empty of contrast (*Figure 5*).

**Figure 4. Intravesical contrast at 10 minutes.**



## Common pathology

### Calculi

Most renal calculi are composed of calcium, this means up to 90% are radio-opaque. Seventy five per cent are composed of either calcium oxalate or calcium phosphate.

Staghorn calculi (*Figure 6*) tend to occur in alkaline infected urine. They are associated with urea-splitting bacteria such as proteus.

### Obstruction

This is the most common reason for requesting an emergency IVU, and is usually secondary to a renal stone (*Figure 7*). A stone may lodge at any point in the ureter from the kidney to the bladder but impaction is most likely at the three points of anatomical narrowing of the ureter:

- Pelviureteric junction
- Pelvic brim
- Vesicoureteric junction.

The patient presents with loin pain colic.

The IVU may demonstrate opacification of the collecting systems. The calyces of the right kidney are dilated and are said to be clubbed (*Figure 8*).

**Figure 5. Post micturition.**


**Figure 6. Staghorn calculus seen on kidneys ureters and bladder (KUB) film within the collecting system of the right kidney.**

*Figure 7. Radiograph depicting an area of density inferior to the right sacro-iliac joint (arrow).*

Below (*Figure 9*) after micturition very little contrast is seen in the left collecting system. On the right side there is still contrast distending the collecting system and this extends down to the level of the obstruction, this is known as a standing column of contrast within the right ureter.

## Horse-shoe kidney

Horse-shoe kidneys (*Figure 10*) are one of the commonest congenital renal anomalies. They are caused by (embryological) failure of separation of the metanephric ridge. Horse-shoe kidneys are formed by fusion of the lower poles of the kidneys across the midline via an isthmus of tissue lying anterior to the aorta and inferior vena cava.

*Figure 8. Hydronephrosis and clubbed calyces (right kidney).*

*Figure 9. A standing column of contrast (right).*

## Medullary sponge kidney

This is a congenital cystic disease of the renal medulla causing localized dilatations of the collecting ducts in the papillae. It is bilateral in 75% of cases. This condition is discovered in adulthood either incidentally or following secondary complications including haematuria, infection and urinary calculi. Renal function is usually preserved. Calcification may be seen in 80% of cases (*Figure 11*) and is classically described as having a 'bunch of grapes' appearance.

## Duplex system

Partial or complete duplication of the ureter can occur. This always affects the kidney end of the renal system, the ureters can then join at any point (*Figure 12*) or can enter into the bladder with two separate ureteric orifices. They are usually an incidental finding. However, they can present with recurrent renal tract infections.

*Figure 10. A horse-shoe kidney. Contrast is seen in both renal collecting systems. The kidneys are rotated with the lower poles more medially placed than normal. The kidneys have a pelvicalyceal system more inferior than normal.*

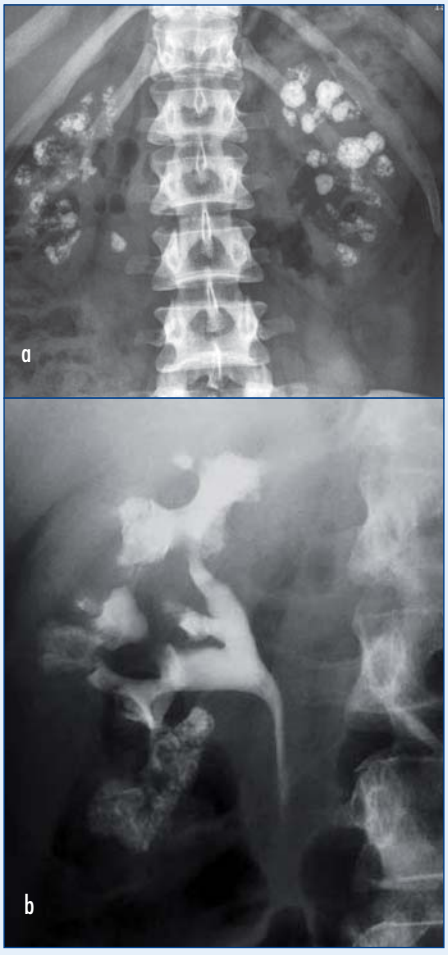
## Filling defects in the ureter

Radiographs may demonstrate filling defects within the ureter. The filling defects shown in *Figure 13* were subsequently shown to be transitional cell carcinoma.

## Filling defects in the bladder

Although evaluation of the bladder is rather insensitive on IVU, large lesions will show up as filling defects. An appearance such as *Figure 14* needs further investigation, usually by cystoscopy. Again the above lesion was subsequently proved to be a transitional cell carcinoma of the bladder.

*Figure 11. Medullary sponge kidney. a. The plain film may demonstrate enlarged kidneys. b. Post contrast view of a right medullary sponge kidney.*



## Conclusions

Although other modalities are being increasingly used in the investigation of acute renal tract symptoms, in particular computed tomography, the ease with which an IVU can be performed means that it is still a widely performed investigation in the acute setting. Although it is not possible in such a short article to fully explore all the different pathologies that are diagnosable on an IVU, this article provides the essential knowledge the clinician needs for its initial interpretation. BJHM

*Conflict of interest: none.*

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***Figure 12. A left-sided duplex system.***

***Figure 13. A large filling defect within the left ureter is identified with the arrow. Compare this with the normal right side.***

***Figure 14. Filling defect within the bladder.***

## KEY POINTS

- The junior doctor will often see the intravenous urogram films before the radiologist.
- A knowledge of how an intravenous urogram is performed will help in its initial interpretation.
- An appreciation of the common pathologies to affect the urinary tract will help correlate the intravenous urogram images to the diagnosis.