Intravenous urography, a useful technique still alive

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Learning objectives

To review the possible findings in intravenous urography, making special emphasis on diseases with possible definitive diagnosis without need of additional techniques.
Background

Intravenous urography (IVU) is one of the classical techniques of conventional radiology consisting in excretory system analysis through concentration and elimination of iodinated contrast introduced into the circulatory system. In recent years, this technique has been displaced by new technologies that allow an assessment more "global" of possible pathologies of a patient. This is given both by radiologists, who prefer the more detailed and objective interpretation of CT and MRI, as specialists in other areas, because of its anatomical and vision in tune with defensive medicine which partly shields in the medical image.

However, U.I.V. has certain undeniable advantages from the point of view of diagnosis (for its assessment of the excretory system dynamics) and administrative (given its low cost, simplicity and low technical requirement). It is therefore important not to forget this test within the existing arsenal of radiologist, mainly in the education of new specialists. We review detectable alterations in intravenous urography based on observed cases in our hospital, mainly focused on diseases where a direct diagnosis can be reached by this technique without additional tests.

CONGENITAL ANOMALIES

Renal agenesis and hypoplasia

Agenesis is the absence of formation of kidney, so monorenal patients will be detected (bilateral agenesis is incompatible with life). In urography we can observe the absence of enhancement in the nephrographic phase at the theoretical kidney location and obviously no excretion.

Hypoplasia corresponds to changes in differentiation during embryonic kidney development, with variable gravity. It manifest as foci of deformity and absence of enhancement at nephrographic phase, but would require the differential diagnosis with renal infarction areas.

Abnormalities of Position and Shape

Renal ectopia
Position of the kidney outside the usual location, usually lower or even pelvic region. Intrathoracic kidneys can also be seen.

Fusion
Have multiple variants (disk, L) being the best known the "horseshoe kidney" with fusion of the lower poles ahead of the aorta which provides vascularisation Fig. 1 on page 9 Fig. 2 on page 9 Fig. 3 on page 10. They usually show poorly drained supernumerary calyces due to its position which can lead to complications related to poor drainage.

**Malrotation**
Abnormalities of the position due to incomplete rotation of the kidney on its axis during embryonic development. The renal pelvis will position anteriorly at different angle depending on the degree of defect of the rotation, so an asymmetry in the arrangement of the cups will be seen in pyelographic phase Fig. 4 on page 11 Fig. 5 on page 12. Oblique views may be useful for evaluation.

**Lobulations and humps**
Remains of embryonic development that poses differential diagnosis with supernumerary pyramids and renal tumours.

**Sponge kidney (Cacchi-Ricci disease)**
Ectasia and dilatation of the collecting ducts of the renal pyramids, with a characteristic image UIV of linear striations (brush look) adjacent to calyces, corresponding to cysts and dilatation of the collecting ducts of Bellini next to calyceal fornix Fig. 6 on page 13 Fig. 7 on page 14. There may be multiple calcium microlithiasis (apatite) due to hypercalciuria associated to stasis, that often detach the calyx producing repeated renal colics.

**Ureteropelvic junction stenosis**
It is a relatively common malformation that can remain asymptomatic or low symptomatic and appears at any age. Has a slight predominance in men and left kidney (5-20% bilateral). Cause may be intrinsic, extrinsic or functional. Ureteropelvic obstruction determines a hyperpressure and difficulty pyelic emptying, which develops more or less dilated calyces and pelvis with variable renal parenchymal atrophy and poor filling of the ureter (the "balloon and rope" sign) Fig. 8 on page 15 Fig. 9 on page 16 Fig. 10 on page 17. The U.I.V. is the test of choice, which in many cases must be complemented with retrograde ureteropyelography to detail ureter in its entirety, as it may be associated with pathology of the ureter and ureterovesical junction.

**Ureteral Malformations**

**Incomplete ureteral duplication or Y-shape**
Present in 0.4% of autopsies. There is a single kidney from which two ureters origin; the upper one drains on upper calyx without a proper pelvis, and lower drains to pelvis to which converge the middle and lower calyces Fig. 11 on page 18 Fig. 12 on page...
19. The terminal ureter is generally normal, but may have the same abnormalities that any ureter. It can be seen sometimes forking or duplication only at the level of renal pelvis, with single ureter Fig. 13 on page 20 Fig. 14 on page 21.

**Complete ureteral duplication**
In 0.2% of autopsies. Similar to the incomplete but with independent ureteral bladder mouths Fig. 15 on page 22 Fig. 16 on page 23. 50% has associate reflux of the lower system and 13% ureterocele. The ureter draining the upper system often ends in the bladder trigone in a lower position.

**Ectopic Ureter**
The ureter may show an ectopical end in 7% of cases in the bladder neck, posterior urethra, seminal vesicle and vas deferens in men and the urethra, vagina, cervix and uterus in women.

**Ureterocele**
It consist on a saccular cystic dilatation of the intramural segment of terminal ureter, secondary to congenital obstruction of the ureteral orifice, which is blocked by default in the reabsorption of membranes. It is more common in women, 10% are bilateral and present association with ureteral duplication of up to 80%. In childhood forms can lead to secondary megaureter and hydronephrosis; in adult forms may be present without dilatation of the ureter.
It can produce a bladder filling defect caused by intraparietal dilatation. Characteristically in U.I.V. shows the "sign of the cobra head" with a radiolucent halo, peripheral to intramural ureter Fig. 17 on page 24 Fig. 18 on page 25. Irregularities or loss of edge definition in the halo may indicate the presence of pseudoureterocele, secondary to oedema related to a recent lithiasis / impacted or a tumour in the ureteral orifice.

**Megaureter**
Partial or complete dilation of the ureter due to malfunction of its terminal segment: there is a defect in the development of longitudinal orientation muscle fibres from the terminal ureter, so that there is an area that does not relax and prevents the normal flow of urine into the bladder.
Ureterectasia can be observed above the affected area showing elongation, kinking and dolicomegaureter Fig. 19 on page 26 Fig. 20 on page 27. It can be bilateral (25-30%).

**ACQUIRES PATHOLOGIES**

**Renal mass**
A mass effect caused by a renal process generally will be observed as calyceal deformity, displacement or elongation at excretory phases in the UIV Fig. 21 on page 28 Fig. 22 on page 29. Sometimes it is possible to view cortical associated deformities or altered enhancement zones in the nephrographic phase. The most common causes are kidney cysts, but additional testing is needed facing this finding to exclude malignant processes.

**Papillary Necrosis**

Typically associated with ischemic injury of the renal medullary portion, often caused by consumption of NSAIDs, sickle cell anaemia, infections (Tuberculosis) and diabetes. In IVU or retrograde urography can show different forms: calcifications associated with devitalized papilla forming a filling defect ring image Fig. 23 on page 30, central or lateral calyceal fornices excavation filled by the contrast Fig. 24 on page 31.

**Calyceal diverticulum and bladder**

Diverticular dilatations of the urinary tract and in continuity with it, so it can be seen on IVU gradual filling of these structures by contrast with later elimination. Often depend on the bladder wall (relative to neurogenic or struggle bladder, usually) Fig. 25 on page 32 Fig. 26 on page 33 and less frequently on calyceal walls (due to the obliteration of a renal fornix) Fig. 27 on page 34 Fig. 28 on page 35 Fig. 29 on page 36. In the latter it is possible to observe calcium lithiasis or calcic slurry deposited on occasions.

**Hydronephrosis**

Dilation of the urinary tract caused by increased back pressure secondary to block the flow by a mechanical or functional obstructive cause of intrinsic or extrinsic origin Fig. 30 on page 37. In U.I.V. prone plaques can help to rule out the non-obstructive hydronephrosis.

Its importance is determined by the pathophysiological changes that originate in the renal parenchyma with loss of renal function; a limit of 60-70 days is, for some authors, the maximum time to functional posterior recovery before evolving into renal atrophy. Dilation is variable and dependent on time of evolution. With moderate or severe degrees we can appreciate a distorted nephrogram by dilated pelvicalyceal system.

Hydronephrosis is classified into 4 grades depending on the findings displayed in IVU Fig. 31 on page 38:

- **Grade I** - slightly dilated renal pelvis without calyceal ectasia.
- **Grade II** - moderate pelvic and calyceal dilatation (distal calyces with concave or flattened morphology).
- **Grade III** - great pelvic and calyceal dilatation (chalices show inversion of their distal surface, convex shape) and normal renal parenchyma.
• Grade IV - Very large renal pelvis with very dilated calyces and thinning of the renal parenchyma.

Acute obstruction shows a persistent nephrogram with delayed contrast elimination (sometimes hours) determined by the degree of blockage, the rate of urine which passes through the tubules and the size / type of pelvis Fig. 32 on page 39. Chronic obstruction is one of the most common causes of complete loss of function ("dumb kidney"), but usually persists minimal concentration capacity sometimes observing slight contrast excretion at 48-72 h.

Lithiasis
Calculations formed in the interior of the urinary tract, usually related to increase in the presence of certain salts in urine or favoured stasis circumstances. Most are composed of calcium, the rest is composed of various substances such as uric acid, cystine and struvite. The calcium and struvite are radiopaque therefore visible on plain radiographs Fig. 33 on page 40 Fig. 34 on page 41; the other can be seen as contrast filling defects in the excretory phase of the IVU. They are the most common cause of obstruction of the urinary tract and IVU request for assessment Fig. 30 on page 37.

Processes and bladder pyeloureteral neoformativos
They appear as contrast filling defects inside the light, generally with smooth or lobed well-defined edges, non-motile to changes in patient position (prone / supine) Fig. 35 on page 42 Fig. 36 on page 43 Fig. 37 on page 44. Oblique views may be useful in these cases. Masses can appear as single or multiple, especially in the case of transitional cell carcinoma Fig. 38 on page 45, so that facing a mass is necessary a proper display of the entire excretory system.
A possible false positive are clots that may occur in association with higher haematuria or neoplastic pathology (with elongated morphology "in spaghetti" as ureteral molds) Fig. 39 on page 46. Sometimes have poorly defined edges and mobility, but this is not always reliable.

Fistulas
Pathological communications developed between two structures secondary to adjacent inflammatory changes of varying origin. For assessment it will be especially useful IVU and retrograde urography in the upper system, and cystography or urethrography in the lower one.
Within the excretory system multiple fistulas are possible, being the most common the vesico-rectal (usually caused by diverticulitis, inflammatory bowel disease or neoplastic processes) Fig. 40 on page 47 and vesico-vaginal (gynaecological or obstetric processes) Fig. 41 on page 48.
**Imprinting and struggle bladder**

It is not uncommon to observe imprints on the bladder wall caused by adjacent structures, mainly associated with prostatic hypertrophy, characteristically appearing on its underside related to middle lobe prominence Fig. 42 on page 48. The latter usually associate difficulty in removing urine, a fact that long-term produces an effort or "struggle" bladder visible in UIV as overall wall thickening (a radiolucent halo contrast adjacent the bladder) and irregularities of the inner edge of the wall resulting from herniation of the mucosa, typically as wide as they are high Fig. 43 on page 48.

**Cystocele**

Bladder prolapse through the anterior vaginal wall, associated with weakness of the muscular wall of postsurgical or postmenopausal causes. In U.I.V. bladder lower displacement can be seen (lower to suprapubic line in a plate with good technique) and less frequently deformity of the lower face bladder, sometimes with tapering Fig. 44 on page 49 Fig. 45 on page 50.
Fig. 1: Horseshoe kidney

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Fig. 2: Horseshoe kidney, excretory phase

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**Fig. 3:** Axial abdominal CT section from the same patient. Note the junction zone of the lower renal poles before aorta.

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Fig. 4: Bilateral renal malrotation: the renal pelvis are located before, partially obscuring calyces

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Fig. 5: Right renal malrotation.

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**Fig. 6:** Striation adjacent to the renal calyces (brush look) relative to tubular ectasia associated to sponge kidney

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Fig. 7: Striation adjacent to the renal calyces (brush look) relative to tubular ectasia associated to sponge kidney

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Fig. 8: Ureteropelvic junction stenosis associated with significant hydronephrosis.

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**Fig. 9:** Ureteropelvic junction stenosis. There is a small post-stenotic dilatation

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Fig. 10: Bilateral ureteropelvic junction stenosis.

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Fig. 11: Right incomplete double system

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**Fig. 12:** Right incomplete double system with ectasia grade I.

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Fig. 13: Bifid pelvis

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Fig. 14: Pelvic duplication with grade II hydronephrosis associated, caused by a stone impacted at the ureteropelvic inferior junction (not visible in this image).

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Fig. 15: Left complete double system.

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**Fig. 16**: Bilateral complete double system.

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Fig. 17: Sign of the cobra head (arrows) in relation to bilateral ureterocele.

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**Fig. 18:** Left ureterocele with cobra head sign (arrow).

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Fig. 19: Megaureter (arrow).

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Fig. 20: Megauteter (detail of fig.19 with a late projection).

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**Fig. 21:** Calyceal displacement and deformity by mass effect (star). Additional proofs showed the existence of a large simple renal cyst.

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Fig. 22: Calyceal displacement and deformity by mass effect (star). Additional proofs showed the existence of a large simple renal cyst.

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Fig. 23: Papillary necrosis with rim sign (arrows) caused by detached papillary calcifications.

**Fig. 24:** Papillary Necrosis: central papillae excavation filled with contrast (arrows).

Fig. 25: Bladder diverticulum dependent of upper left side of the bladder

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**Fig. 26:** Multiple millimetric bladder diverticula.

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Fig. 27: Calyceal diverticulum (contrast filled) dependent from central chalices of right kidney.

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**Fig. 28:** Progressive repletion in different phases of calyceal diverticulum. A grouped stones can be seen at this location

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Fig. 29: Abdominal CT Axial section, case of Fig. 28: there is a communication of the diverticulum with the adjacent cup and multiple stones deposited in its decline area.

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**Fig. 30**: Hydronephrosis grade III with obstructive stone in the proximal third of the ureter (arrow).

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**Fig. 31:** Grading of hydrenephrosis in U.I.V.

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Fig. 32: Loss of function of left kidney with present nephrogram and delayed elimination. Ultrasound found the presence of a large underlying hydronephrosis.

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**Fig. 33:** Lithiasis in the distal third part of the right ureter (arrow).

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**Fig. 34:** Excretory phase of Fig. 33 case; there is an obstruction by a stone with moderate hydronephrosis.

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**Fig. 35:** Bladder filling defect in relation to neoplasm (arrow).

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Fig. 36: Bladder filling defect near the right ureterovesical junction in relation to neoplasia. Note the notches on the wall of the distal ureter (arrow) suggesting its infiltration.

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Fig. 37: Multifocal bladder neoplasm, anteroposterior and oblique view.

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Fig. 38: Multiple filling defects in left pelvis and ureter regarding multifocal transitional cell carcinoma.

Fig. 39: Bladder neoplasm (star). There are filling defects in its lower area with ill-defined borders that were checked during as mobile during exploration, in relation to clots.

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**Fig. 40:** Cystography. Vesicorrectal fistula with progressive rectal filling (star).

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![Image of cystography showing vesicorrectal fistula](image)

**Fig. 41:** Vesicovaginal fistula with passage of contrast to vagina (arrow) during cystography.

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![Image of cystography showing vesicovaginal fistula](image)

**Fig. 42:** Prostate imprint over bladder soil (star) with wall thickening related to effort or struggle bladder (arrows).

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![Image of cystography showing prostate imprint](image)
Fig. 43: Effort / struggle bladder: wall thickening with mucosal herniations (arrows).

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Fig. 44: Cystocele: note the caudal sharpening and descended bladder.

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**Fig. 45:** Cystocele.

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Conclusion

It is increasingly tempting to fall into the monotony of the tendency to use CT and MRI before any finding or unusual suspicion, since techniques are in vogue, with high definition and "easy" interpretation. However, we should not dismiss so joyfully classical techniques of proven effectiveness. Intravenous urography, a cheap and low-radiation technique, still has great utility as a dynamic test for detection of multiple pathologies if we know how to properly interpret their findings. At this time of imposed austerity measures, we must not forget the classics of our radiological arsenal.
References


