

MAGNETIC RESONANCE UROGRAPHY (MRU) AT 3 TESLA, TECHNIQUE, CLINICAL APPLICATIONS

Urorresonancia en 3 Tesla, técnica, aplicaciones clínicas

Juana María Vallejo¹ / Catalina De Valencia² / Diana Rodríguez² / Catalina Barragán³



Key words (MeSH)

Urography
Magnetic resonance
imaging
Urinary tract

Palabras clave (DeCS)

Urografía
Imagen por resonancia
magnética
Sistema urinario

Summary

Introduction: The absence of ionizing radiation and iodinated contrast media are the biggest advantages of magnetic resonance urography (UroRM) against urography scans (UroCT). **Objective:** Inform the utility of UroRM, its advantages and limitations through different cases and imaging characteristics typical of this study in the 3 Tesla magneto (3T). **Methods:** A collection of cases of UroRM was started from August 2013 to July 2014, conducted in 3T resonator. **Conclusions:** 3T UroRM provides an excellent definition of the urinary system and allows for the etiologies of obstructive disease and other renal lesions.

Resumen

Introducción: La ausencia de radiación ionizante y de medios de contraste yodados son las ventajas más grandes de la urografía por resonancia magnética (uroRM) frente a la urografía por escanografía (uroTAC). **Objetivo:** Informar la utilidad de la uroRM, sus ventajas y limitaciones mediante diferentes casos, así como las características imaginológicas propias de este estudio en el magneto de 3 Tesla (3T). **Métodos:** Se inició una recolección de los casos de uroRM desde agosto de 2013 hasta julio de 2014, realizados en resonador de 3T. **Conclusiones:** La uroRM en 3T proporciona una excelente definición del sistema urinario y permite establecer las etiologías de patología obstructiva y otras lesiones renales.

Introduction

Like UroCT, MRU has the utility of evaluating the renal parenchyma, the collector systems, ureters and bladder.

A better signal-noise signal in the 3 Tesla (T) resonator, the excellent contrast resolution and the absence of ionizing radiation make the MRU a promising study for the non-invasive evaluation of the urinary tract (1). However, it does not surpass UroCT in spatial resolution. New sequences and improvements in resolution have made interest in this technique to grow, as it competes with images obtained with other techniques, surpassing some of its limitations (2).

It is important to familiarize with the images obtained, know its limitations and artefacts, as well as to continue with studies in this technique that is considered in evolution.

Urography by MR is a study with important uses that allows the evaluation of the urinary tract, its anatomy and anomalies, as well as also offering big advantages to be employed in children and pregnant patients.

Two techniques of urography by resonance have been described: static and dynamic. In this study we will describe these techniques, the imaging protocol of

important applications of uro-resonance, using cases of our daily practice (3,4).

Technique of urography through resonance

Static Urography

Also called uro-resonance in T2 or hydrography. It is performed based on strongly pondered T2 sequences, which take advantage of the long relaxation times of urine, with

which it is possible to visualize high intensity signal and allows to view the urinary tract as a static column of liquid (5,6), ureters and bladder. These sequences can be repeated to observe the ureters in their totality and to characterize

useful in patients with poor renal excretion or reduction, as well as in pregnant patients (3,4,6-8).

The evaluation of the urinary tract with this technique does not require the use of contrast medium and thus does not depend on excretory renal function, but instead only on the presence of urine in the collecting system and ureters (9).

Hydration, the use of diuretics and compression can improve the quality of the images in patients with non-dilated collecting systems (3). Intravenous hydration is preferred to

of the urinary tract will interfere with imaging. In case that they do, it is possible to acquire additional sequences or to realize some post-processing to eliminate these elements from the image (3,7).

Sequences

- shot (1-2 secs).
- 3D, are useful to obtain information of thin sections or MIP projections of the whole urinary system.
- Heavy T2, is used to identify the site of stenosis (though additional sequences may be required).

• sense of stenosis; 10 to 15 sequences must be taken with time intervals of 5 to 10 secs between each to prevent the saturation of radiofrequency in the tissues, which would provoke the progressive loss of the signal intensity in the images.



¹Radiologist, radiology professor, University Hospital San Ignacio. Bogotá, Colombia.

²Radiologist, Pontificia Universidad Javeriana. Bogotá, Colombia.

³Fourth year radiology resident, Pontificia Universidad Javeriana. Bogotá, Colombia.

- T1 in phase and out of phase, is used to detect incidental suprarenal masses, clear cell kidney carcinomas and to characterize angiomyolipomas.

Dynamic urography

Is also called excretory uro-resonance or resonance in T1. Different from static urography, the dynamic technique is acquired after the administration of endovenous contrast medium, and depends of the renal function of the patient. This is done in order to obtain information about the complete urinary system, meaning, evaluating the renal parenchyma, the urothelium, the ureters and bladder. As such, the patient must have sufficient renal function to allow the excretion and uniform distribution of the contrast medium (3,5,8,10).

To evaluate the renal parenchyma and vasculature, pre-contrast images are taken, in early arterial phase and nephrographic phase. The sequences used in this technique are echo gradient in 3D with fat suppression. Immediately after, images through the bladder are performed to document the enhancement of the walls and the presence of possible urothelial lesions, while the urine remains in low signal (5).

Likewise to conventional excretory urography or scanography, images are performed during the excretory phase, after the administration of intravenous contrast medium. The presence of paramagnetic contrast medium in urine shortens the relaxation time of it in the pondered T1 sequences, which allows viewing it as a high signal. Posteriorly, an echo gradient in 3D sequence is performed in the coronal plane during apnea. This sequence must be acquired with fat suppression, since it increases visibility of the ureters. In patients that cannot suspend respi-

recommended dose of endovenous gadolinium is of 0.1 mmol/kg (3,5).

The use of diuretics is a complement that can improve the excretion of contrast medium and allows obtaining a higher dilution of it. Additionally, it increases the time available to take the images post-contrast (10). It must be used in non-dilated collecting systems, as it can exacerbate the obstructive symptoms. Contraindications for its use include anuria, hyper sensibility to the medicament, electrolytic imbalance or hypotension and one must be cautious in patients allergic to sulphonamides. The recommended standard dose in literature is of 0.1 mg/kg, (5-10 mg for adults) (11).

This technique can be done in conjunction with conventional MR for the integral evaluation of the urinary tract. Its use is not recommended in patients with gravely compromised renal function and requires the acquisition of late images in patients with obstruction (3).

Sequences

- renal arteries; after taking two images post-contrast, images of the bladder are taken to observe the enhancement of the wall and to evaluate vesicle tumours (5).
- Images in the excretory phase can be taken 5 minutes after the injection of contrast medium, in non-obstructed patients, with normal or slightly affected renal function, in axial and coronal planes.
- Uro-resonance takes approximately 30 minutes to complete (12).

1. Simple Images

- Coronal and axial potentiated in T2, with and without fat suppression (single shot sequences).
- In phase and out of phase in axial in kidneys.
- Radial sequence (in parallel), in coronal and sagittal (with the orientation of each ureter).

2. Images with contrast medium

- Axial, T1 potentiated, simple and with contrast medium in arterial phase.

- Coronal, potentiated in T1, simple and with contrast medium in elimination phase.
- 3D reconstruction.

Patient preparation

The preparation of the patient is crucial to obtain a successful examination. The patient must be informed regarding the objective and procedure of the examination (12).

To initiate, the bladder must completely empty so as to not interrupt the examination due to miccional urgency and to increase comfort (8,13);

injection at the start of the acquisition, so long as there are no contraindications. Posteriorly, the patient is laid down in supine position, with the arms behind the head to avoid involving artefacts (12). In some patients it might be possible to administer intravenous furosemide.

Advantages of uro-resonance in 3T

the majority being done in 1.5T machines (13).

The advantages that the 3T offers are a better signal to noise ratio that, theoretically, improves spatiotemporal resolution and the acquisition of images of the whole urinary tract without having to change the coil

Additionally, it is observed that in the evaluated urinary systems it can be seen, approximately, 75% of the anatomy in an adequate way (13) and to perform an evaluation of each kidney (12, 14); this increases the possibility that this technique replaces renal gammagraphy in the evaluation of urinary tract disorders in children in the near future (14).

One must keep in mind that potentially all studies could present artefacts, the most common being of susceptibility, movement of the patient (not related to 3T), lack of signal homogeneity, peristalsis and accentuation in the chemical displacement. They are most frequent in the bladder (15%), where that of susceptibility prevails; followed by the collecting system (5%), were the most common is the lack of homogeneity, and is more pronounced in obese patients; in third place, in the ureters (3%). It is known that accentuation in the chemical displacement has no impact on diagnosis (8,13).

resonance performed in 3T machines when compared to 1.5T (5), but it is known that there are possible limitation of the imaging of the abdomen

intensity, due to the lengthening of the relaxation period of the T1. This fact could have a negative impact in the contrast of the images and in the possibility of observing lesions, as well as in the accentuation in the sus-

absorption rhythm, which are called "exacerbated 3T artefacts" (3,13).

The stationary wave and the artefacts of conduction can also be observed in 3T, in common sequences of uro-resonance (fast-spin echo).

with gadolinium magnetic uro-resonance.

Indications of uro-resonance

Magnetic uro-resonance is useful in the detection and follow-up of urothelial carcinoma, urinary obstruction, obstructive gallstones, kidney transplant evaluation and to characterize congenital anomalies (5,6,15).

Gallstones

CT is still the ideal exam for the diagnosis of ureter-gallstones, given

Blood clots are differentiated by having zones of high T1 signal, they do not enhance with paramagnetic contrast medium and disappear within weeks, while the neoplasias enhance with the contrast medium and can

The typical signs of uro-gallstones are renal and perirenal oedema (which differentiates them from chronic obstruction), ureteral dilation

with T2 information or in the excretory uro-resonance, all of these added with T2 information have a higher sensitivity, 96-100%, for the diagnosis of oedema in sequences with T2 information (3,19). It is typical that calcification, the ureter-vesicle junction, and the site where the ureter crosses

In comparison to radiography and simple scanography, urography by resonance is more sensitive to secondary changes of the obstruction

(perirenal oedema and ureteral dilation), but, even if combined with radio-though it is superior to this in the diagnosis of ureteral stenosis and neoplastic obstructions. In general, it allows diagnosing more ureter-gallstones than IV urography (3,8,10,11).

Other causes of obstruction

Uro-resonance has proven a high precision in the evaluation of the morphology of obstructions of the superior urinary tract, being the obstructions (12).

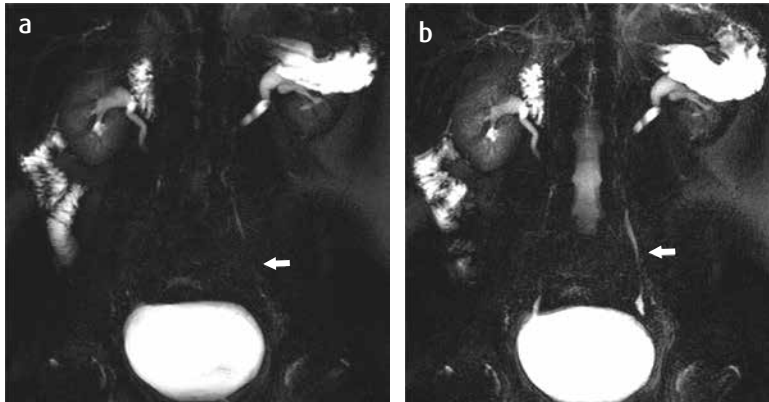


Figure 1. a) Normal peristalsis. Reconstruction in 3D of a 3T MR urography; b) Same patient 5 minutes after. There is an apparent absence of filling the medial third and distal left ureter (arrow in a), secondary to the normal ureteral peristalsis, as is confirmed in the control image with adequate filling of this portion of the ureter (arrow in b).



Figure 2. Dynamic uro-resonance with normal paramagnetic contrast medium. Patient of 31 years in caesarean post-surgery, with suspicion of ureteral lesion. Coronal sections over the renal parenchyma in phases a) early arterial, b) late arterial, c) cortical, d) medullar, e) early excretory and f) late excretory, where the normal contrast medium elimination can be observed. g and h) Three-dimensional reconstructions in excretory phase with information sequences in T1, where a physiological tightening of the ureter can be observed at the crossing of the iliac vessels (arrow). i) Three-dimensional reconstruction of the arterial phase where the unique bilateral renal arteries (arrows) and other vessels are identified.

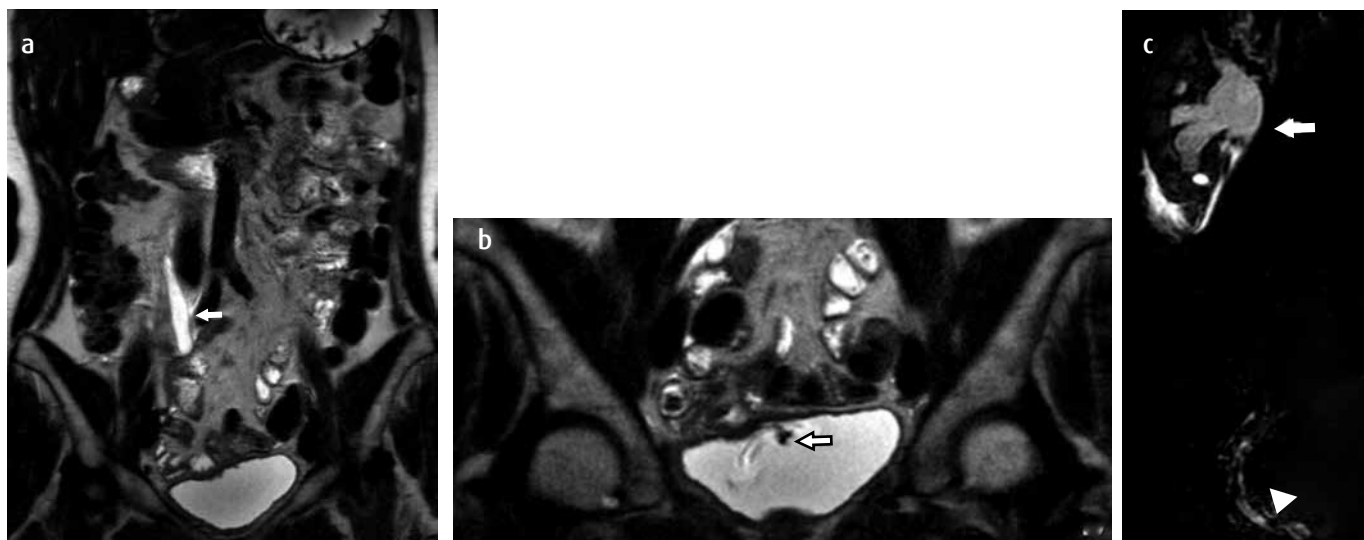


Figure 3. Distal gallstones in a woman with pain in the right iliac pit and suspicion of appendicitis. MR urography in coronal sections potentiated in T2, a) abdomen and pelvis; b) bladder. There is dilation of the right ureter with loss of the physiological stenosis in the crossing of the iliac vessels (arrow in a). Protrusion of the ureteral mucosae is observed in the right lateral bladder wall, secondary to the obstruction of the calcification (arrow in b). c) 3D reconstruction, of the same patient, which shows right hydronephrosis (arrow), with perirenal liquid secondary to the obstructive nephropathy and a defect of filling in the distal third of the ureter, corresponding to a calcification (arrow head).

Neoplastic obstructions can be benign or malignant (20,21). A benign pathology is represented by fibro epithelial polyps (3), while a malignant pathology is given by urothelial carcinomas, metastasis, tumoural lymphatic ganglia and direct infiltration (3,5). Other causes of obstruction can be intra or extra-ureteral. Intra-ureteral are represented by blood clots, loose buds (within the context of necrosis), infections, post-surgical changes (figure 4) and endometriosis. The extrinsic causes are retroperitoneal fibrosis, compression or invasion due to adjacent malignity (figure 5) or inflammatory diseases (4,9,18,22,23).

The urothelial carcinoma is one of the most frequent neoplasias found in urography (24). This can be uni or multifocal and is observed in the uro-resonance as a defect of sessile filling or of polypoid filling (25). It can also present, uniquely, as a focal thickening of the wall, or as a tumour/urine interface in the shape of a meniscus, or there can be an abrupt change in the ureteral calibre. One must be especially careful when there is a concentric thickening of the urothelium with enhancement, as it can be difficult to differentiate from inflammatory or infectious processes (11).

Uro-resonance is more sensitive than the CT in the characterization of obstructions not related with gallstones (23,26,27). Benign stenoses typically have smooth borders (3) and are not associated to soft tissue masses, while the malign can have irregular borders and

to quantify the gravity of the stenosis. If this is partial, in the movie uro-resonance there will be intermittent distension and collapse of the ureter below the narrowing, and in the excretory, there will be enhancement of the distal ureter to it. The high-grade obstruction will show delay in the contrast medium excretion of the affected side (3).

which are generally partial and are identified as a smooth narrowing. The most frequent causes of extrinsic obstructions are uterine fibromas, liquid collection, retroperitoneal fibrosis and some vascular anomalies (3).

The role of uro-resonance in patients with urothelial cancer risk has not yet been determined. The cancers of the bladder, cervix and prostate are frequent causes of malign obstruction. In the study of the transitional cell carcinomas, it is important the evaluation of the whole urinary tract as it is frequent to find multifocal affection (3).

Hematuria

The presence of hematuria without urinary infection association may require also of the highlighting of a routine uro-resonance to discard parenchymatous and renal vascular lesions (12). This does not have the same spatial resolution as a CT, but can be useful in the detection, characterization and staging of the neoplastic processes (28). The sensitivity for the diagnosis of small sized tumours has not yet been determined (3,8).



Figure 4. Bilateral ureteral stenosis posterior to treatment with radiotherapy for a rectum carcinoma in a man of 62 years of age. 3D 3T magnetic resonance urography reconstructions, a) right side, and b) bilateral, where it is evident the narrowing of both distal ureters (arrows), with bilateral hydronephrosis and proximal tortuosity of both ureters.

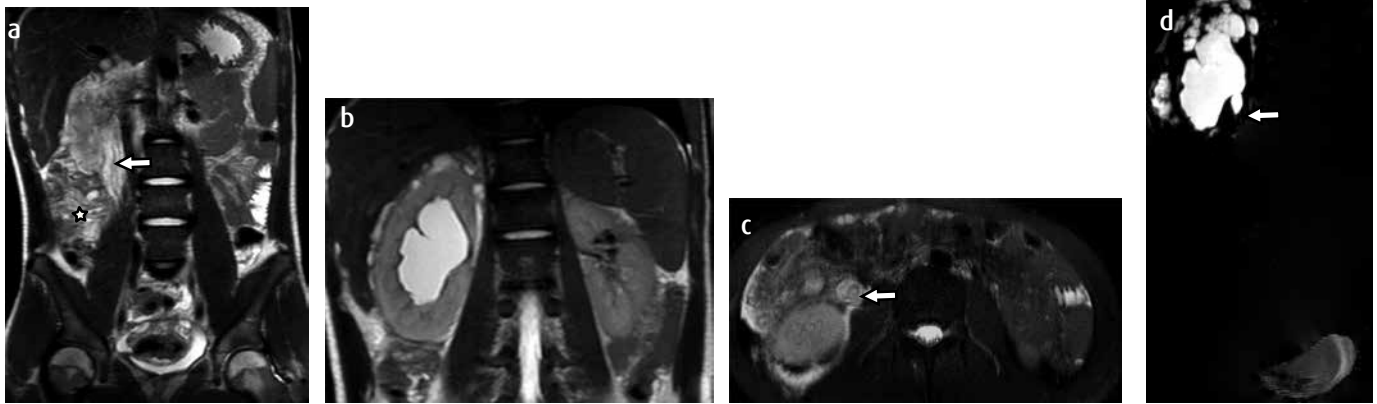


Figure 5. Peritoneal metastasis with infiltration to the right ureter in a 17 year old patient with familial colon carcinoma. Urography by 3T MR. a) Coronal section of the abdomen potentiated in T2, that demonstrates direct infiltration of the right ureter (arrow) and increase in the signal intensity of the mesenteries by metastatic compromise (asterisk). b) Sequence potentiated in T2 of the superior hemi-abdomen in coronal section, with right hydronephrosis secondary to ureteral obstruction by tumoural invasion. c) Axial section in STIR where it is evident the increase in size and in signal intensity of the right ureter (arrow). d) 3D reconstruction, with right hydronephrosis secondary to the ureteral compromise in the pielo-ureteral union (arrow)

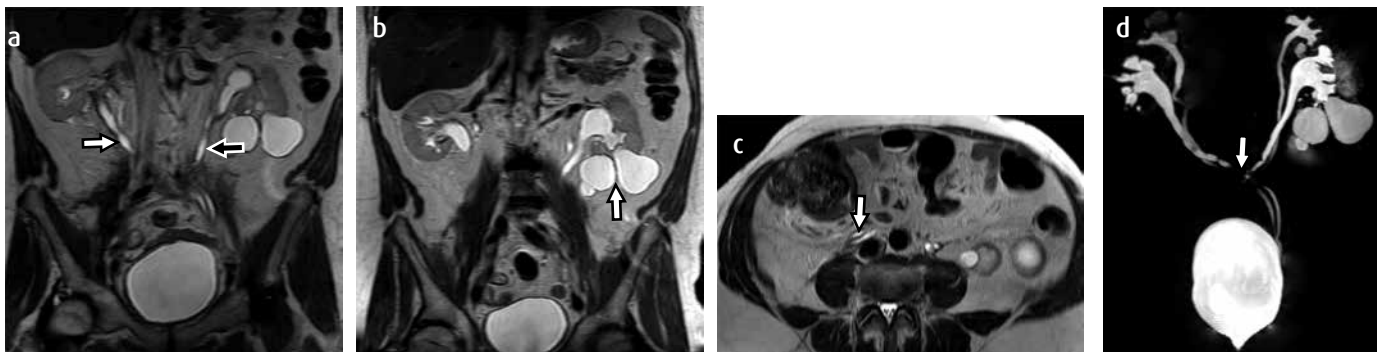


Figure 6. Patient with bilateral double collecting system history, with inadvertent lesion of one of the right ureters during an amplified pelvic lymphadenectomy for the treatment of a prostate adenocarcinoma. The patient required trans-ureterosotomy of the right ureters to the left due to impossibility of an uretero-vesicle reimplant. 3T magnetic resonance urography. a and b) Coronal sections potentiated in T2, where a slight dilation of the collecting systems and ureters of both sides are identified (arrows), as well as multiple simple cortical cysts in the inferior pole of the left kidney (arrow). c) Axial section with potentiated T2, where the horizontal orientation of the right ureters before the anastomosis with the contralateral can be observed (arrow). d) 3D reconstruction, that shows the bilateral double collection system, with the collecting systems and inferior ureters with a high grade of dilation and the right ureters anastomosed to the right ureters in the medial line (arrow).

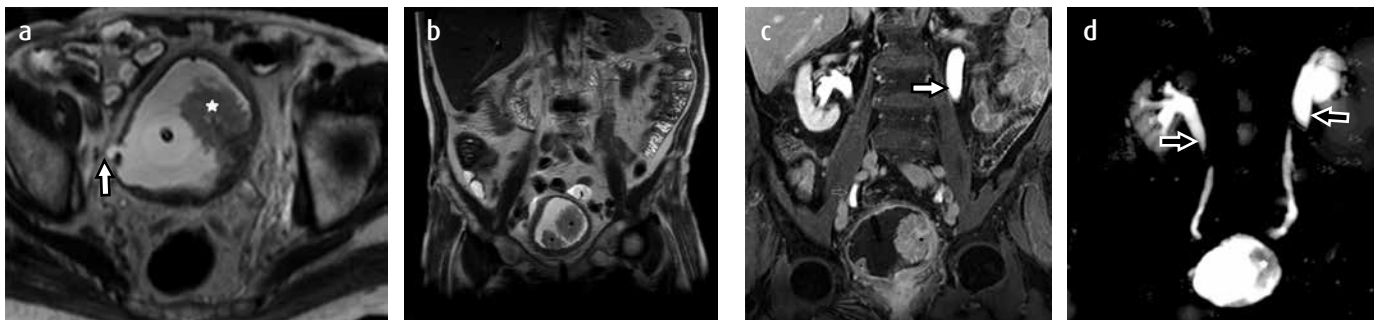


Figure 7. Patient with multifocal urothelial carcinoma of the bladder. 3T magnetic resonance urography. Sequences potentiated in T2 in axial section a) and coronal b) that show an thickening of the bladder walls with a polypoid mass of intermediate signal intensity in the left lateral wall of the bladder (asterisk). Also observed, a diverticulum in the postero-lateral wall of the bladder (arrow). In the interior of the bladder a vesicle probe can be observed. c) Coronal section potentiated in T1 with fat suppression and contrast medium that show intense enhancement of the larger sized mass, as well as of another polypoid lesion (asterisk) and slight dilation of the right collection system and both ureters (arrows). d) 3D reconstruction, with a filling defect of the bladder due to the carcinoma that originates in the left lateral wall of the bladder (asterisk) with dilation of both collecting systems (arrows).

Pre and post-surgery evaluation

Uro-resonance has been proven to be a useful tool in the post-surgical evaluation of procedures such as uretero-iliostomy, uretero-sigmoidostomy, ureterostomy to skin, orthotopic neobladder reconstruction and kidney trans-

complications such as stenosis of the anastomosis, ureteral compressions by taken into account that in the post-surgical, false positives can present due to blood clots, air bubbles or metallic surgical material (18,29).

Angiography and uro-resonance can be combined for pre-surgical evaluation of vascular anatomy, of the collecting system and of the renal parenchyma in potential kidney donors (30). Likewise, in patients receiving the transplant, these studies complement the ultrasound, which remains the

authors guarantee that the use of urography by resonance is superior when compared to ultrasound, for the full evaluation of the inserts, whether vascular or of the collecting system, especially to evaluate pathologies of the renal parenchyma that may contribute to the diagnosis of rejection (31). It may be useful to perform the static and dynamic technique in these patients (3,32).

Vesicle lesions

clots, air bubbles, neoplasias, ureteroceles, enlarging of the prostate or foreign bodies. In the uro-resonance neoplasias, characteristically, are adhered to the wall or, simply, can be observed as a focal thickening of intermediate signal intensity in the bladder all in sequences with T1 information and

Blood clots are frequent in patients in hematuria study, characteristically they are high signal intensity in sequences with T1 information and do not enhance with contrast medium (18).

Kidney lesions

Uro-resonance can detect intrarenal urothelial carcinomas. It is important to clarify that the detection of small sized lesions with this methods is still unknown. It allows performing an initial scan of other lesions of the urinary system. In the cases in which the lesion is surrounded by urine, it can be

information, where as those not surrounded by urine will be less evident and can only be observed using an endovenous injection of intravenous contrast medium (16,23).

Congenital anomalies

Uro-resonance is useful in the evaluation of congenital anomalies such as kidney agenesis, kidney mis-rotation, displasias, ectopic ureters, tetrocavous ureters, primary megaureters, duplications and pieloureteral junction obstruction (the two most frequent indications) (3,4,9,12,22,33-37).

Ureteral duplication is one of most frequent congenital anomalies of the urinary tract (3,5,36,37). It can be partial, when the ureters are joined before arriving to the bladder; or complete, when they are inserted separately. Complete duplication is more frequent in women and uro-resonance offers

in these cases the ureter of the superior pole is inserted more inferior and medial than the ureter of the inferior pole (5). This is more susceptible to obstruction, as it can form a ureterocele or lead outside of the bladder. The

diagnosis (38-40). Additionally, it allows for the evaluation of complications associated to the double collecting system (3,36).

The pielo-ureteral junction is the most frequent site of obstruction of the collecting system in children. The uro-resonance allows the anatomical evaluation and in many cases, functional, if associated with the software used in functional URs. This type of uro-resonance allows quantifying independently the function of each kidney without the use of ionizing radiation (41-43).

The theories of the aetiology of peliocalicial stenosis include an abnor-

scars. In patients with worsening of kidney function, surgical correction is indicated and, in 50% of patients, the cause is vascular. This diagnosis changes the surgical approach and for this reason it is recommended that the arterial phase of uro-resonance with contrast medium be done with an angiographic sequence (3,43,44).

This study is also useful in the evaluation of ectopic ureters in the vagina

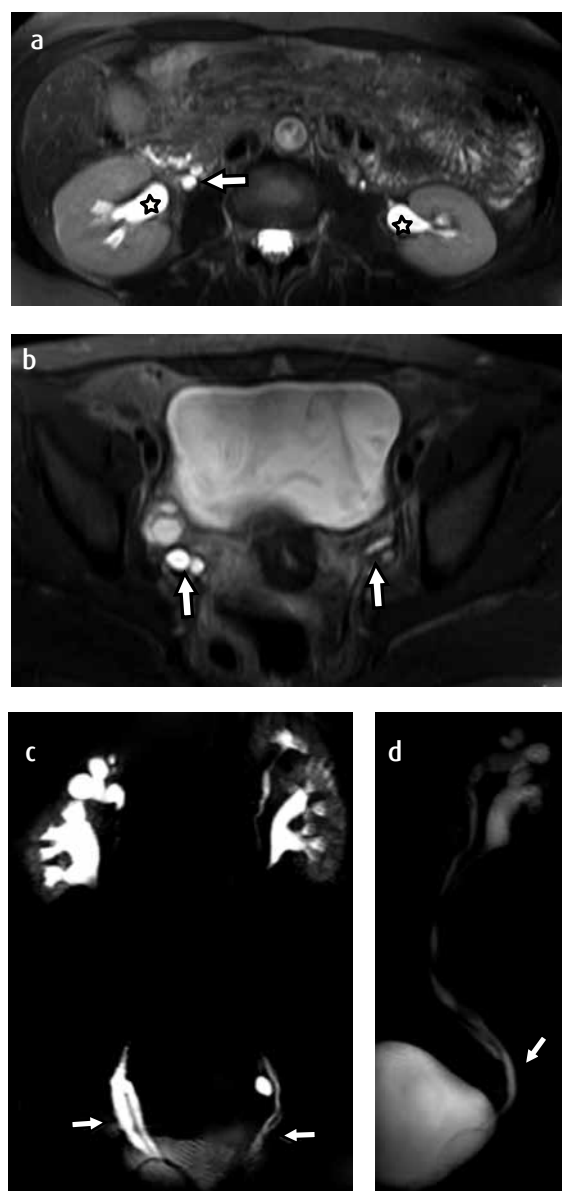


Figure 8. Patient with double bilateral collecting system, in whom the law of Weidert-Myer is applied (the ureter of the superior collecting system drains in a more caudal and medial position, while the inferior drains in a more cranial and lateral portion). 3T MR urography. a) Axial section potentiated in T2 with fat suppression that demonstrates the dilation of both superior collecting systems (asterisks) and the two ureters of the right side (arrow). b) The same sequence in a section through the bladder with two ureters on each side. c) 3D bilateral reconstruction and d) of the right side, where dilation of both collecting systems on each side can be observed (arrow). There exists a diverticulum in the inferior third of one of the left ureters.

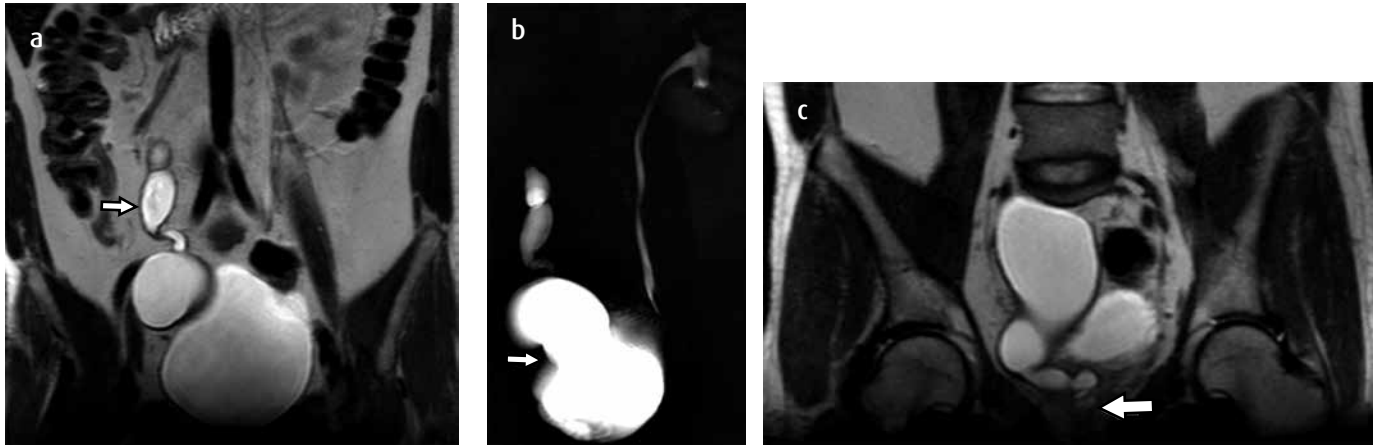


Figure 9. Ectopic ureter that drains in a prostatic utricle: man of 35 years of age, with urinary tract infection to repetition. Initial ultrasound showed a tubular structure in the pelvis communicated with a cystic lesion in the prostate. 3T MR urography. a) Coronal section potentiated in T2 with dilation and tortuosity of the middle third and distal from the right ureter (arrow), without evident renal parenchyma on this side. b) 3D coronal reconstruction, with normal left collecting system and a right dilated ureter without apparent kidney (arrow). c) Coronal section potentiated in T2 of pelvis that shows a dilated ectopic ureter draining into a prostatic utricle (arrow).

Foetus and pregnant women

Only static urography in T2 and movie uro-resonance is performed. The importance in these patients is to differentiate the ureteral physiological dilation from the pathological (45-47).

It must be taken into account that physiological dilation occurs in the third trimester of gestation, secondary to ureter compression between the psoas and the gravid uterus. It is considered physiological dilation of the urinary system if there is compression of half the ureter with gradual decrea-

urine between the site of physiological compression and the uretero-vesicle

reported about teratogenic effects in animals, in high and repetitive doses (50,51). To the moment no real indications for the use of MR with contrast medium for foetal urological evaluation, but in occasions it has been indicated for evaluation of some maternal pathology (51).

remains chelated, there is a higher probability that there is a potentially toxic dissociation of the ion of the chelated molecule (51).

restrict exposition (52).

An increase in body temperature above 1.5 C and higher than 40 minutes are the values above which it has been estimated that adverse effects for embryonic or foetal development can occur (52,53). Maintaining foetal temperature below 38 C and an increase below 0.5 C in maternal temperature are suggested factors that can avoid teratogenic effects (54).

Up to date there has been no reproducible detrimental effects in mothers course, many have reported as well that it is uncertain the risk for damage due to MR to mothers and fetuses and thus, it is still necessary more evidence t elaborate solid conclusions (52,55).

Kidney transplant

cular), renal (disease of the parenchyma) and post-renal (obstruction). Uro-resonance allows to evaluate and determine what type of lesion the transplanted kidney is suffering, since the contrast medium allows to evaluate vascular structures (3) and to detect a possible stenosis of the renal artery or alterations of the renal parenchyma, using sequences with T2 information, among which, equally, one can visualize hydronephrosis, ureteral stenosis, lymphoceles and urinomas, and provides functional information of the insert, which decreases, potentially, the need for a biopsy (12).

Contraindications

- Patients with liquid restrictions (such as those with congestive cardiac
- Dynamic uro-resonance should not be performed in patients with

Disadvantages of uro-resonance

The low sensitivity to determine the histology or composition of renal limitations to magnetic uro-resonance.

Other limitation is the long time for the acquisition of the images (5,37) and he high sensitivity to movement (12). Uro-resonance presents a lower spatial resolution when compared to CT and intravenous urography (3,11).

Dynamic uro-resonance is contraindicated in patients with bad renal

Artefacts

Observed approximately in half of the patients and more frequent in sequences of single shot, since the liquid in movement will have a loss of appearance in consecutive sequences, besides not being visualized in the dynamic uro-resonance (3).

defects.

The susceptibility artefact, given by metallic elements, can limit the visualization of ureteral segments or create the appearance of ureteral stenosis. It is recommended always to compare with other type of studies (3,56).

Kidney breast cysts can simulate dilation of the collecting system and are differentiated from hydronephrosis in the post-contrast excretory phases (3).

with T1 information, but can be clearly differentiated in sequences with T2 information (3).

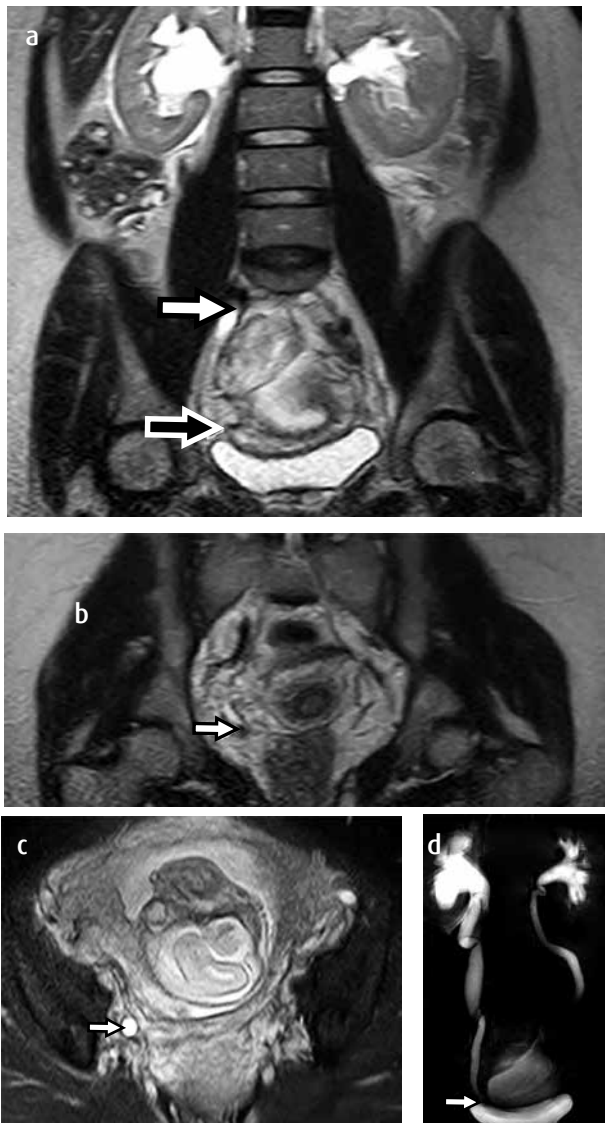


Figure 10. Patient of 31 years of age with pregnancy of 27 weeks. Consult to emergency services due to pain in the right iliac pit. A magnetic uro-resonance is performed for bilateral hydrophrenosis with right prevalence found in an extra-institutional ultrasound. a and b) Potentiated images in T2 without fat suppression, coronal section of the right pelvis and kidney, a) where right hydrophrenosis with dilation of the distal ureter is observed. b) At the level of the pelvis a calcification at the utero-vesical junction is identified of this side (rounded hypointense structure, arrow). c) Axial section in STIR of the bony pelvis shows the foetus, with the dilated right ureter at the crossing of the iliac vessels (arrow). d) 3D uro-resonance reconstruction, where the bilateral dilation of the collecting systems can be observed, predominantly on the right side. The distal ureter from this side presents an abrupt termination, with meniscus configuration due to the presence of calcification in this zone (arrow).

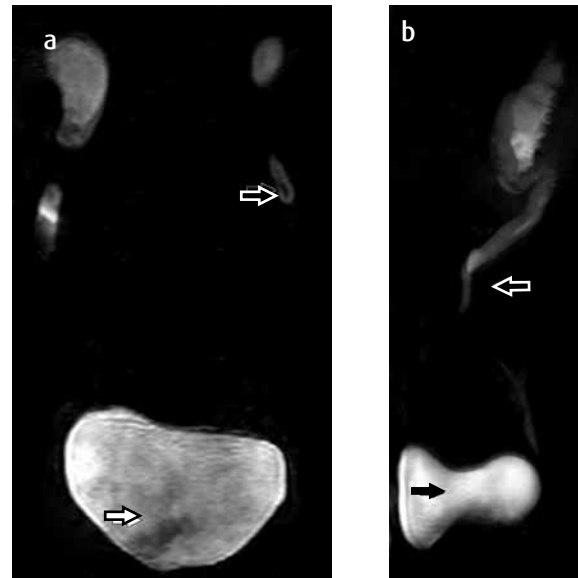


Figure 11. Three-dimensional reconstructions of dynamic magnetic resonance urography with gadolinium in the excretory phase. a) and b) Filling defects in the bladder (white and black arrows) and in the right ureter (hollow arrows), secondary to artifact by flow.

Key points in the interpretation of uro-resonance (56)

Haemorrhage in the collecting systems decreases the signal intensity of urine (3).

Peristaltism and ureteral spasms can annul the image of segments of the ureter in 3D echo-gradient sequences (3).

The vessels can generate impressions in the ureter simulating areas of stenosis (18).

Movement of the patient can generate images that are not real (13).

Lo vasos pueden generar impresiones en el uréter simulando áreas de estenosis (18).

Movement of the patient can generate images that are not real (13).

Conclusions

The two techniques of uro-resonance (static and dynamic) are complementary studies for the morphological and functional evaluation of the urinary system with some advantages over intravenous urography, the CT and ultrasound. These advantages are the absence of ionizing radiation and of iodinated contrast medium, for which it can be very useful in patients with transplanted kidneys, children and pregnant women. Additionally, it has the capacity to provide the same information as many studies done separately.

along with reconstruction and basic sequences, must be used for the global interpretation of this image modality.

References

2009;34: 527-40.

2003;56:1139-43.

applications. Radiographics. 2008;28:23-48.

1):42-7.

by gadolinium and diuretics: a comparison with conventional urography in diagnosing the cause of ureteric obstruction. BJU Int. 2000;86:960-5.

- 2004;52:320-7.
8. Colville JA, Killeen RP, Buckley O, et al. Does a full bladder aid upper tract visualization in magnetic resonance urography? *Australas Radiol.* 2007;51:362-4.
- obstruction. *Abdom Imag.* 1998;23:27-34.
- compared with urography. *AJR.* 2001;176:105-12.
- versus intravenous urography (IVU) in obstructive uropathy: a prospective study of 30 cases. *J Assoc Physicians India.* 2005;53:527-34.
- Urology.* 1998;52:602-8.
- with compromised renal function: the role of noninvasive imaging modalities. *J Urol.* 2004;171: 2303-6.
- cancer: evaluation of hydronephrosis using high resolution magnetic resonance urography. *J Urol.* 2005;174:478-82.
- role of magnetic resonance urography and noncontrast computed tomography. *Urology.* 2004; 63:225-9.
- nance urography in the evaluation of obstructive uropathy. *Urology.* 2013;81:623-7.
- computed tomography urography in the evaluation of patients with haematuria. *Radiol Med.* 2013;118:1184-98.
19. Cohnen M, Brause M, May P, et al. Contrast enhanced MR urography in the evaluation of renal transplants with urological complications. *Clin Nephrol.* 2002;58:111-7.
- uation with gadolinium- enhanced MR angiography and MR uography. *Radiology.* 1998;207:165-72.
- duplex sonography. *Abd Imaging.* 2006;31:461-82.
- tation--evaluation with functional magnetic resonance urography. *Transplant Proc.* 1997;29:132-5.
- cated duplex kidneys in children: preliminary report. *Pediatr Radiol.* 2001;31:215- 23.
25. Karaveli M, Katsanidis D, Kalaitzoglou I, et al. MR urography: anatomical and quantitative information on congenital malformations in children. *Niger Med J.* 2013;54:136-42.
- diagnosis of duplex renal system: Our initial experience at a tertiary care institute. *Indian J Urol.* 2009;25:52-5.
- Int.* 2008;24:979-86.
28. Kibar Y, Avci A, Akay O, et al. Dribbling of urine due to ectopic vaginal insertion of an upper pole ureter diagnosed by magnetic resonance urography. *Int Urol Nephrol.* 2005;37:695-7.
- phy in the evaluation of a horseshoe kidney with ureteropelvic junction obstruction. *Urology.* 1998;51:484-6.
- Opin Urol.* 2010;20:323-9.
- depiction of fetal and maternal hydronephrosis by magnetic resonance urography. *Urology.* 1999;53:825-7.
- magnetic resonance urography for the evaluation of suspected renal colic in pregnancy. *Urology.* 2012;79:1252.
- nancy: magnetic resonance urographic patterns in physiological dilatation versus calculous obstruction. *J Urol.* 2004;171:256-60.
- 2011;196:325-30.
- magnetic exposure during magnetic resonance imaging. *Phys Med Biol.* 2010;55:2411-26.
- thermia. 2003;19:295-324.
40. International Commission on Non Ionizing Radiation Protection (ICNIRP). Medical magnetic resonance (MR) procedures: protection of patients *Health Phys.* 2004;87:197-216.
- normal paediatric assessment at 9 months of age. *Br J Radiol.* 2000;73:190-4.
- contrastenhanced MR urography for measurement of split renal function. *Radiology.* 2014;273:801-12.
- of urinary obstruction in the pediatric population. *Magn Reson Imaging Clin N Am.* 2010;16:643-60.
45. Renjen P, Bellah R, Hellinger JC, et al. Advances in urologic imaging in children. *Radiol Clin N Am.* 2012;50:207-18.
46. Adeb M, Darge K, Dillman JR, et al. Magnetic resonance urography in evaluation of duplicated renal collecting systems. *Magn Reson Imaging Clin N Am.* 2013;21:717-30.
- MR Urography in children with hydronephrosis. *J Advanc Res.* 2015;6:145-53.
- urography at 3T: clinical feasibility. *J Comput Assist Tomogr.* 2013;37:29-36.
- and targeted helical CT in patients with renal colic: a new approach to reduce delivered dose. *J Magn Reson Imaging.* 2004;20:264-71.
- in children: evaluation of suspected ureteral ectopia in duplex systems. *J Urol.* 2001;166:2346-50.
- overview. *BJR.* 2006;79:614-26.
- of uret- erohydronephrosis. *J Comput Assist Tomogr.* 1994;18:601-8.
- preoperative diagnostic workup in children affected by hydronephrosis: should IVU

Corresponding Author

Catalina De Valencia

Carrera 7 # 40-62
catalina.devalencia@gmail.com

Received for evaluation: July 9, 2014

Accepted for publication: December 28, 2014