Feasibility of MR urography in patients with urinary diversion

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Purpose

Several imaging techniques including excretory urography, fluoroscopic retrograde contrast injection, computed tomography (CT) loopography and urography have been used to evaluate urinary diversions (1-7). Magnetic resonance (MR) urography is a non-invasive imaging technique that does not require ionizing radiation or iodinated contrast medium, and therefore has become the technique of choice in patients with frequent follow-up requirement or poor renal function (8-10). T2-weighted MR urograms can be obtained as single thick slab or maximum-intensity-projection (MIP) views generated from multiple thin slice three-dimensional (3D) T2-weighted images. T1-weighted MR urography technique uses the fast gradient echo T1 weighted sequences. With the administration of intravenous contrast medium, it becomes possible to obtain i.v. urography like images by employing MIP method.

The aim of this presentation was to determine the feasibility and diagnostic value of magnetic resonance urography in the visualization of the normal postoperative anatomy and the detection of complication affecting patients with urinary diversion.
Methods and Materials

Fourteen patients (13 male and 1 female, 8-77 years old, mean age 54.2) with urinary diversion who underwent MR urography for the evaluation of suspected complications and tumor recurrence were included. The study consisted of evaluation of thirty-eight collecting systems in the nineteen MR urograms. MR urography examinations had been performed because of abnormal clinical or laboratory findings suggesting diversion malfunction or tumor recurrence, or routine follow-up. Estimated glomerular filtration rate (eGFR) values of all patients were calculated before the MR urography study using the Modification of diet in renal disease (MDRD) study group equation (11). Of the patients, blood creatinin values ranged from 0.76 to 1.71 mg/dL and eGFR values ranged from 42 to 107 mL/min/1.73 m$^2$. Only T2-weighted MR urography was performed in two patients with low eGFR values (42 and 45 mL/min/1.73 m$^2$). One patient had three and three patients had two examinations.

MR urography examinations were performed with two different 1.5 T MR Scanners (Symphony, Siemens, Erlangen, Germany, and Intera Nova, Philips Medical Systems, Best, the Netherlands) by using phased-array body coils. MR urography protocol began with localizing sequences and continued with conventional axial and coronal T1 and T2-weighted MR imaging sequences to assess the renal parenchyma and peri urinary area. Then MR urography protocol continued with single and multislice T2-weighted MR urography sequences. Subsequently, i.v. 20 mg furosemide (Lasix; Aventis Pharmaceuticals, NJ, USA) was administered to dilate the collecting system by increasing glomerular filtration rate and to reduce the T2* effect of intravenously administered contrast agent. Five minutes after the diuretic injection, 0.1 mmol/kg of gadobenate dimeglumine (MultiHance; Bracco Imaging, Milan, Italy) was given intravenously. Patients were examined in the coronal plane during the nephrographic phase (at 15 seconds, 1, 3, 5, 10 minutes) using coronal 3D T1-weighted sequences. To be able to depict the entire urinary collecting system, additional delayed excretory phase images were obtained as deemed necessary. Upon the completion of the above mentioned examinations, multislice heavily T2-weighted and 3D T1-weighted images were converted by a MIP technique to generate i.v. urogram-like images.

The urinary systems were evaluated for the presence of focal renal lesions on the conventional T1 and T2-weighted MR images and the findings were noted. Extrinsic mass lesions affecting the kidneys or ureters, presence of dilation, contours of neobladder and extraurinary abnormalities were also recorded. The urinary collecting system was divided into 5 segments; right and left intrarenal collecting system and proximal ureter (the renal calicies, pelvis and the proximal 1/3 of the ureter); right and left mid-distal ureter (mid and distal 1/3 of the ureter including ureterocutaneostomy or uretero ileostomy sites); urinary conduit or reservoir (including ileo cutaneostomy site). According to this segmentation model, while each patient with ureterocutaneostomy has 4 segments, each patient with ileal conduit-ileo cutaneostomy or ileal neobladder has 5 segments (Fig. 1).
Fig.: Fig. 1: Schematic diagrams show cutaneous ureterostomy (a), ileal conduit/uretero-ileo-cutaneostomy (b), and ileal neobladder (c) urinary diversions, and our segmentation model.

References: Gulhane Military Medical School - Ankara/TR

We separately evaluated the T2 and T1-weighted MR urographies for the assessment of the urinary collecting system. The locations of non-visualized segments on MR urography images and the locations of abnormalities affecting the urinary diversion such as dilation, ureteral strictures, intrinsic or extrinsic masses were also recorded. The clinical, laboratory data and follow-up imaging findings were regarded as standard. For the visualization of the urinary system, the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), as well as the accuracy of MR urography techniques were calculated according to standard formulae.
Fig. 0: Schematic diagrams show cutaneous ureterostomy (a), ileal conduit/uretero-ileo-cutaneostomy (b), and ileal neobladder (c) urinary diversions, and our segmentation model.

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Results

According to our segmentation model, 91 segments were evaluated with T2-weighted MR urography protocol and 81 segments were evaluated with T1-weighted MR urography protocol. Eighty one (89.01%) of all 91 collecting system segments in patients with urinary diversion could be demonstrated with T2-weighted MR urography alone, 71 (87.65%) of all 81 segments with T1-weighted MR urography alone, and 76 (93.83%) of all 81 segments with combined technique MR urography (Fig. 2, 3).

Fig.: Fig. 2: A 54-year-old male patient with cutaneous ureterostomy. Coronal maximum-intensity-projection (MIP) magnetic resonance (MR) urography images obtained from three-dimensional (3D) T2 turbo spin echo (TSE) (a), and excretory phase 3D T1-weighted (b) sequences show bilateral intrarenal collecting systems and entire courses of ureters with cutaneous anastomoses.

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Fig.: Fig. 3: A 72-year-old male patient with ileal conduit/uretero-ileo-cutaneostomy. 
Coronal MIP MR urography images obtained from T2-weighted 3D TSE (a), and excretory phase 3D T1-weighted (b) sequences show right distal ureteral and uretero-ileal anastomotic stenoses (arrow) causing loss of the visualization. Ectatic right pelvicaliceal system, and proximal and mid ureteral segments can be seen on T2-weighted MR urography image (a), but cannot be demonstrated on T1-weighted MR urography image in patient with non-functioning right kidney (loss of the contrast excretion) (b).

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T2-weighted MR urography could not visualize 5 segments due to ureteral stenoses, 1 segment due to tumor invasion, and 4 segments due to thin caliber of the segments. T1-weighted MR urography could not visualize 4 segments due to non-functioning kidney, 2 segments due to ureteral stenoses, 2 segments due to both ureteral stenoses and non-functioning kidney, 1 segment due to ureteral contraction, and 1 due to tumor invasion. Same five segments (due to ureteral or uretero-ileo anastomosis stenoses or due to tumor invasion) in three patients could be visualized by none of T1-, T2-weighted MR urography and combined technique.

For the visualization of the urinary segments, sensitivity, specificity, PPV, NPV and accuracy were 95.29%, 100%, 100%, 60% and 95.6% in T2-weighted MR urography, 93.42%, 100%, 100%, 50% and 93.82% in T1-weighted MR urography, respectively. All parameters were 100% in combined technique.

MR urography studies showed various urinary abnormalities including collecting system dilation, renal parenchymal thinning, simple cyst, cortical scar, ureteral stenosis, renal atrophy, non-functioning kidney, uretero-ileo anastomosis stenosis, pyelonephritis,

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tumor invasion of the ureter, bladder cancer recurrence, partial duplex collecting system, horseshoe kidney and reservoir calculus (Fig. 4).

Fig.: Fig. 4: Tumor invasion of the left ureter in 47-year-old male patient with uretero-ureterostomy. (a) Coronal MIP MR urography image obtained from excretory phase 3D T1-weighted sequence shows left atrophic kidney (arrowheads), loss of the visualization of left collecting system and minimal retrograde enhancement of the left distal ureteral segment (*). More delayed excretory phase T1-weighted axial MR images (b and c) show tumoral invasion of the left ureter (arrow) by recurrent colon cancer.

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Images for this section:

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Conclusion

Various early and late complications may be seen following urinary diversion procedures. Because of these potential complications, patients with urinary diversion require a strict radiologic follow-up. CT urography is a relatively new technique using multidetector CT (MDCT) to obtain rapidly acquired, multiphase scans for almost isotropic-multiplanar 3D images of the genitourinary system (6, 12, 13). CT may not be diagnostic in case of compromised renal function, and in case of ureteral obstruction in which contrast excretion may be too low to allow visualization of the collecting system. In addition, radiation exposure is a major disadvantage, especially in multiphasic scans and follow-up studies. Moreover, the necessity of administration of potentially nephrotoxic iodinated contrast agents in this patient group with the high incidence of the poor renal function is an important restriction for CT urography.

In our study, both T1, and T2-weighted MR urography techniques had high sensitivity, specificity and accuracy values. Moreover, the sensitivity, specificity and accuracy percentages were almost 100% when these two techniques were combined. The causes of the high success rates of the MR urography can be attributed to; (i) T1 and T2-weighted MR urography series can be safely repeated until obtaining optimal visualization, (ii) static T2 weighted MR urography technique can provide perfect visualization in patients, who have poor functioning or non-functioning kidneys.

In our study, the non-dilated urinary segments could not be viewed by T2-weighted sequences. However, these segments could be demonstrated on contrast-enhanced T1-weighted sequences. Similarly, some segments could not be depicted by T1-weighted sequences due to poor renal function and/or dilution of the contrast media in dilated collecting systems. In contrast, T2-weighted sequences could clearly show these segments. The urinary systems of all the patients could be entirely visualized by combined T1- and T2-weighted MR urography technique, but three patients. Two of these patients had distal ureteral and uretero-ileal stenoses and the other one had ureteral invasion by recurrent colon cancer. In these three patients, MR urography could not demonstrate some segments, but could reveal the pathologies causing loss of visualization.

In general, T1 and T2-weighted MR urography techniques have been shown to be complementary to each other. But, T2-weighted MR urography sequences alone may adequately depict the entire urinary collecting system especially in patients with poor renal function. In view of the fact that, malfunctioning urinary diversion and denervation of the ureters both cause dilation of the urinary collecting system, we suggest that T2-weighted MR urography technique alone may adequately depict the entire urinary collecting system in a short time, especially in patients with poor renal function.

In conclusion, the combination of T2 and T1-weighted MR urography techniques can accurately and safely detect and discriminate various urinary and extra-urinary
abnormalities. MR urography also provides useful information about functional status of the kidneys and allows imaging of the collecting systems of poor or nonfunctioning kidneys in a short time by using T2-weighted MR urography technique.
References

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