

# MR urography (MRU) of non-dilated ureter with diuretic administration: Static fluid 2D FSE T2-weighted versus 3D gadolinium T1-weighted GE excretory MR

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Received 30 May 2014; received in revised form 4 August 2014; accepted 6 August 2014

Available online 6 September 2014

## Abstract

**Objective:** The goal of this prospective study was to compare the efficiency of two types of MRU after diuretic administration to identify the non-dilated ureter.

**Methods:** MR pelvic examinations were performed in 126 patients after receiving furosemide. Each patient underwent in addition to their protocol for context, two types of MRU: 2D T2-weighted FSE (T2w-MRU) and 3D Gd T1-weighted GE (CE-MRU). Four segments were checked for each ureter.

For the first part of the analysis, readers evaluated the whole image quality using a four points subjective scale and for the second part, they were asked to score separately each ureteral segment as present or absent.

**Results:** 1008 ureteral segments were checked. For the image quality, readers did not find any significant difference ( $3.8 \pm 0.5$  vs  $3.6 \pm 0.7$ ,  $p$  value: 0.13) between MRU methods. The interobserver agreement was excellent with a  $\kappa$  correlation coefficient as high as 0.89 for T2w-MRU and 0.92 for CE-MRU, respectively.

For the detection of the segments and considering the 9 rotations for the T2W MRU, there were no statistically significant differences between the two groups.

**Conclusion:** T2-weighted MRU with multiple orientations and diuretic is sufficient to identify the non-dilated ureter. It offers information on ureteral peristalsis. It can be suggested that this sequence is able to detect an initial obstruction before hydronephrosis occurs.

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**Keywords:** Magnetic resonance imaging; Urography; Ureter; Technology; Diuretics

## 1. Introduction

MR urography (MRU) can be performed with two different imaging strategies: unenhanced MR urography (T2w-MRU), based on heavily T2-weighted FSE sequences and contrast-enhanced excretory MR urography (CE-MRU), which is performed with a 3D GE T1-weighted sequences following intravenous gadolinium administration.

A heavily T2-weighted sequence, utilizing the single-shot fast spin-echo (SSFSE) sequence, provides static “hydrographic” images of fluid inside the urinary tract. It is known to be mainly useful for only evaluating dilated systems [1–3] because of its inability to visualize entirely non-dilated ureters [4]. So

**Abbreviations:** MRU, magnetic resonance imaging; MIP, maximum intensity projection; 3D, three dimensional; 2D, two dimensional; Gd, gadolinium; FSE, fast spin echo; GE, gradient echo.

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<http://dx.doi.org/10.1016/j.ejro.2014.08.001>

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that, in routine practice, excretory CE-MRU is the technique most commonly used to evaluate the non-dilated collecting system. This later also provides rough renal functional information [5,6]. Low-dose (5–20 mg) intravenous furosemide administration has been recommended for excretory CE-MRU to improve the visualization of the non-dilated upper urinary tract [7,8].

To the best of our knowledge, no recent paper has explored the potential of the repetition of this simple breath hold T2w-MRU sequence. Our hypothesis was that by using low-dose of furosemide and additional multiple rotations around the ureter may improve the detection of the whole non-dilated ureter as well as MRU with intravenous administration of contrast medium and provides a pertinent information.

The purpose of this prospective study was to compare those two types of MRU in terms of ureteral visualization in patients with non-dilated ureters, using diuretic administration by means of a direct confrontation of each technique in the same patient. To the best of our knowledge, there is no paper in the literature concerning this evaluation.

## 2. Materials and methods

### 2.1. Patient population

This prospective, single-institution study received approval by our local ethical committee and no written informed consent was necessary. However all patients were orally informed just before the examination of this additional exploration of their urinary tract regarding to the use of a supplementary drug. During a period of 12 months from April 2012 through April 2013, among a cohort of 155 patients referred to our MR department for a pelvic with retroperitoneal MR exploration, we have selected 126 patients (extensive endometriosis: 38 patients, various pelvic carcinoma staging: 54 patients, suspicion for retroperitoneal fibrosis: 15 patients, lymph nodes or retroperitoneal masses recurrency: 19 patients) with bilateral non-dilated ureter who underwent both a 2D T2w-MRU immediately followed by an excretory 3D CE-MRU. Serum creatinine level was normal for all cases. We have excluded from the study the patients with urinary tract dilatation ( $n=6$ ) or urinary symptoms ( $n=2$ ), moderate renal deficiency or known allergic reaction to medication ( $n=6$ ) and those who had undergone a previous pelvic surgery ( $n=15$ ) (Fig. 4).

### 2.2. MR imaging

MR examinations were performed on a 3.0T MR unit (Achieva, Philips Medical Systems, Best, the Netherlands) by using the phased array dedicated coil for pelvic and lower abdomen exploration. The field of view was large enough to cover entirely the retroperitoneum with the exploration of the whole ureter from the uretero pelvic junction to the bladder neck.

Each patient was explored in addition to our routine protocol for the clinical context with two breath-hold MRU sequences in coronal orientation. Patients were asked to void their bladder before MR examination and received an intravenous antispasmodic medication as glucagon at the dose of 1 mg (Glucagon®

Table 1  
Parameters for the two types of MRU.

	CE-MRU 3D GE T1-weighted excretory phase	T2w-MRU 2D single shot turbo spin-echo T2-weighted
TR/TE (ms)	3.6/1.6	5750/744
Flip angle	25°	90°
Matrix size (mm)	231 × 480 interpolated to 512	384 × 229 interpolated to 512
Orientation	Coronal/MIP	Coronal/rotations
Fat suppression	Yes	–
Parallel imaging acceleration factor	1	2
FOV (mm)	400/450	425/297
ETL	1	254
EPI	1	1
Excitation(s)	2	1
Slice number	80	12
Slice thickness/gap (mm)	2/1	40
Acquisition time	18 s	5 s

Lab Novo Nordisk Pharmaceuticals SA) at the beginning of the exploration. If no urinary dilatation was observed on the first non-injected routine sequences, the patient received an intravenous injection of furosemide at the dose of 20 mg (Lasilix® Lab Sanofi-Aventis) (Fig. 4). Patients were orally informed of potential side effects such as increased urination at the end of the exploration. Technologists completed a standardized adverse events form for each patient.

Five minutes later a 2D coronal single shot turbo fast SE T2-weighted static fluid MRU (T2w-MRU) was performed localized on the right and the left urinary tract with an acquisition time of 5 s. Each sequence was repeated nine times with coronal rotations and cine loop registration on each urinary tract.

At the end of this first MRU sequence, an intravenous injection of 0.2 ml/kg body weight gadolinium-based contrast medium, (Dotarem, Guerbet, Roissy CdG, France) followed by a 15 mL saline flush was performed. Five minutes later, coronal excretory phase MR urogram was obtained by means of a 3D breath-hold T1-weighted GE sequence with an acquisition time from 15 to 18 s (Table 1). Maximum-intensity-projection (MIP) images were processed from the original source images of this excretory MRU.

MRU sequences were followed by post-injected morphologic sequences if needed.

### 2.3. Image interpretation

The two types of MRU, including original source images and MIP reformations available from the workstation, were retrospectively reviewed. Each sequence was evaluated separately and independently by two radiologists (PhH, GA) with five and three years of experience in abdominal MR imaging, respectively. Disagreements were checked by consensus with a third radiologist (CR) with twenty years experienced in that field to find a consensus. The readings were done in several sessions

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