
MAJOR PAPER

Moderately T2-weighted Images Obtained with the Single-Shot Fast Spin-Echo Technique: Differentiating between Malignant and Benign Urinary Obstructions

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The purpose of this study was to determine whether a distinction could be made between benign and malignant urinary obstructions in moderately T2-weighted images obtained with the single-shot fast spin-echo technique. Forty-four lesions in 39 patients with urinary obstruction were evaluated with the single-shot fast spin-echo (SSFSE) technique with an effective TE of 90–100 ms and without fat saturation. Benign and malignant lesions were compared for the presence of ureteral wall thickening and a signal intensity relative to the proximal ureteral wall.

Statistically significant differences were found between benign and malignant lesions in both morphologic change (P<0.0001) and signal intensity of the lesions at the obstruction position (P<0.0001). The combination of wall thickening and increased signal intensity as a predictor of malignant disease yielded a sensitivity of 88% and a specificity of 100%. Neither increased signal intensity nor wall thickening as a predictor of benign disease yielded a sensitivity of 89% and a specificity of 88%. The moderately T2-weighted SSFSE technique without fat saturation can accurately distinguish between benign and malignant urinary obstructions.

Keywords: magnetic resonance imaging, urinary tract, urinary tract obstruction, urinary tract disease

Introduction

Heavily T2-weighted imaging employing the rapid acquisition with relaxation enhancement (RARE) technique is suitable for visualization of both dilated and undilated urinary tracts.1–3 Recent studies have reported the usefulness of breath-hold magnetic resonance (MR) urography with ultra-fast T2-weighted sequences, such as the half-Fourier acquisition single-shot turbo spin echo (HASTE) technique and single shot fast spin-echo (SSFSE) technique for identifying urinary disorders.4–7 Although such ultra-fast T2-weighted sequences accurately show the level and degree of ureteral obstruction, they rarely reveal the cause of urinary tract dilatation. Because fat saturation pulse and long effective echo time sequences are applied for complete signal suppression of surrounding soft tissues in these techniques, they cannot distinguish the ureteral wall from surrounding soft tissues.

On the other hand, T2-weighted images with medium TE, such as 80–120 ms, provide us with more detailed soft tissue contrast. We defined T2-weighted images with medium TE as moderately T2-weighted images. Soft tissue contrast is more prominent in moderately T2-weighted images than in heavily T2-weighted images. Therefore, the moderately T2-weighted images should distinguish the ureteral wall from ureteral fluid and from periureteral fat. In this study, we used moderately T2-weighted images without fat saturation with ultra-fast T2-weighted sequences to evaluate the morphologic change and signal intensity of the le-
sion at the obstruction location. We then examined whether MR urography could be used to distinguish between benign and malignant ureteral obstructions.

Materials and Methods

Patients

Thirty-nine patients with urinary tract dilatation diagnosed by ultrasound or excretory urography were examined by means of breath-hold SSFSE MR imaging. The study group comprised 12 women and 27 men aged 16–83 years (mean, 55.8 years). Thirty-four patients had unilaterally dilated ureters and 5 had bilaterally dilated ureters. Diseases included urothelial carcinomas in 8 patients, bladder carcinomas in 5 (2 had bilaterally dilated ureters), metastatic ureteral infiltration in 2, urinary stones in 7, renal sinus lipoma in 1, intraluminal hematoma in 1 and nonmalignant uretero-pelvic junction (UPJ) stricture in 16 (2 had stricture bilaterally). One patient had bilaterally dilated ureters due to different causes, bladder carcinoma of the right ureter and UPJ stricture of the left.

The diagnoses of urothelial carcinomas, bladder carcinomas, and metastatic ureteral infiltration were confirmed by surgical findings. Diagnosis of urinary stones was based on a history of stones and plain radiographs showing calculi in 3 patients, and on excretory urograms, retrograde pyelography, or computed tomography in 4 patients. The diagnosis of renal sinus lipoma was confirmed by CT and MR findings. The diagnosis of intraluminal hematoma was confirmed by MR imaging and clinical course. UPJ stricture was diagnosed when urine cytology indicated class 1 or 2, negative tumor marker, and no clinical change over 3 months.

The cases involving dilated ureters were classified into two groups: a malignant group in which ureteral obstruction was caused by a malignant disease including urothelial carcinoma, bladder carcinoma, and metastatic ureteral infiltration; and a benign group in which ureteral obstruction was caused by a benign disease that included urinary stones, renal sinus lipoma, intraluminal hematoma, and UPJ stricture.

Image Analysis

All MR images were obtained with a 1.0T superconductive unit (Signa; General Electric Medical Systems, Milwaukee, WI, U.S.A.) at a standard gradient field strength and with commercially available pulse sequences and a torso phased-array coil.

Before moderately T2-weighted MR urography, T1-weighted fast spoiled grass sequences (150 [TR/TE], flip angle, 90°, matrix size, 256×128) were performed to localize the kidney, ureter, and urinary bladder in the axial and coronal planes. Next, a heavily T2-weighted sequence with SSFSE was performed to localize the obstruction in the coronal plane. In SSFSE sequence acquisition, all radio-frequency refocused echoes are sequentially phase-encoded after a single excitation. The heavily T2-weighted sequence we used involves a single-slice acquisition with a slice thickness of 50–70 mm, an effective TE of 1,160–1,170 ms, a 256×256 matrix, and fat saturation.

Moderately T2-weighted MR imaging was done with an SSFSE sequence acquired both on the coronal and axial planes of the obstruction site revealed by the heavily T2-weighted sequence. Multislice acquisition was obtained with a slice thickness of 4 mm, an effective TE of 92 ms, a 256×160 matrix, and a receive bandwidth of 62.5 KHz and without fat suppression. The field of view varied between 30 and 35 cm providing pixel dimensions in the range of 1.9–2.2 mm. Ten to 15 sequential, 4 mm thick sections were acquired at an acquisition time of 20 to 30 s. All images were obtained during breath-holding, and no post-processing was performed.

No drugs were given and no external ureteral compression was applied. The patients were not hydrated orally prior to the MR examination.

Results

In all 44 lesions, both morphologic changes and signal intensity of the lesion at the obstruction could be evaluated. Artifacts such as motion artifacts, chemical shift artifacts (CSA) and so on did not impede the interpretation.

When morphologic change at the level of ob-
Fig. 1. Coronal images of a 75-year-old man with urothelial carcinoma (a) Image obtained with heavily T2-weighted SSFSE with fat saturation (2047/1166), single slice acquisition, shows urinary dilatation and the level of obstruction (arrow). (b) Image obtained with moderately T2-weighted SSFSE without fat saturation (1714/93), multislice acquisition, shows a mass with inhomogeneously increased signal intensity (arrowheads) at the obstruction.

Table 1. Morphologic changes in obstructive lesions

<table>
<thead>
<tr>
<th></th>
<th>wall thickening</th>
<th>no change</th>
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<tbody>
<tr>
<td>Malignant group*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>bladder carcinoma</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>urothelial carcinoma</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>metastatic infiltration</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Benign group*</td>
<td>27</td>
<td>24</td>
</tr>
<tr>
<td>UPJ stricture</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>urolithiasis</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>renal sinus lipoma</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>intraluminal hematoma</td>
<td>1</td>
<td>0</td>
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<tr>
<td>Total</td>
<td>44</td>
<td>18</td>
</tr>
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</table>

*: statistically significant differences P < 0.0001

Moderately T2WI Using SSFSE

When the signal intensity of the obstructive lesions was examined (Table 2), 13 (30%) of the 44 ureters showed increased signal intensity (Figs. 1–3) and 31 (70%) showed iso-signal inten-
Coronal images of a 71-year-old woman with urothelial carcinoma

Moderately T2-weighted SSFSE without fat saturation image (1714/93), multislice acquisition, shows wall thickening with inhomogeneously increased signal intensity (arrowheads) at the obstruction.

Coronal images of a 67-year-old man with urothelial carcinoma

(a) Image obtained with heavily T2-weighted SSFSE with fat saturation (2047/1164), single slice acquisition, shows urinarily dilatation and the level of obstruction (arrow). The round lesion superimposed on the renal pelvis is a renal cyst.

(b) Image obtained with moderately T2-weighted SSFSE without fat saturation (1714/93), multislice acquisition, shows wall thickening with inhomogeneously increased signal intensity (arrowheads) at the obstruction.
Discussion

The image quality of ultra-fast $T_2$-weighted sequences such as HASTE and SSFSE are judged as interpretable for the diagnostic purpose of detecting urinary tract obstruction.4–7 In these methods, long effective TE and a frequency-selective fat saturation pulse or an inversion-recovery pulse are used. $T_2$-weighted sequences with a long effective TE make the fluid in the collecting system more prominent than those with a short effective TE and reduced soft tissue contrast. Fat saturation reduces high signal intensities from retroperitoneal fat. Consequently, these methods provide a strong contrast, which is characteristic of MR urography. However, these methods cannot distinguish the ureteral wall from surrounding soft tissues, and the lesions are represented as nonspecific filling defects.7 In MR urography, calculi were demonstrated as nonspecific intraluminal obstacles, but

<table>
<thead>
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<th>Table 2. Signal intensity of obstructive lesions</th>
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<tr>
<td>iso or signal void</td>
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<tr>
<td>Malignant group*</td>
</tr>
<tr>
<td>bladder carcinoma</td>
</tr>
<tr>
<td>urothelial carcinoma</td>
</tr>
<tr>
<td>metastatic infiltration</td>
</tr>
<tr>
<td>Benign group*</td>
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<tr>
<td>UPJ stricture</td>
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<tr>
<td>urolithiasis</td>
</tr>
<tr>
<td>renal sinus lipoma</td>
</tr>
<tr>
<td>intraluminal hematoma</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

*: statistically significant differences $P<0.0001$

Fig. 4. Coronal images of a 43-year-old man with UPJ stricture
At the level of obstruction, an image obtained with moderately $T_2$-weighted SSFSE without fat saturation (1714/93), multislice acquisition, dose not show wall thickening (arrowheads). The signal intensity of the wall at the obstruction is the same as that of the proximal ureteral wall.

Fig. 5. Coronal images of a 62-year-old man with urolithiasis
Image obtained with moderately $T_2$-weighted SSFSE without fat saturation (1714/93), multislice acquisition, shows signal void calculi (arrow). The ureteral wall at the obstruction does not show morphologic change or signal intensity change (arrowheads).
Fig. 6. Coronal images of a 53-year-old man with urolithiasis. Image obtained with moderately T2-weighted SSFSE without fat saturation (1714/93), multislice acquisition, shows a round signal void mass lesion (arrowheads). The boundary between the ureteral wall and the lesion cannot be identified.

Fig. 8. Coronal images of a 56-year-old man with metastatic infiltration. Image obtained with moderately T2-weighted SSFSE without fat saturation (1714/93), multislice acquisition, shows a mass without increased signal intensity (arrowheads) at the obstruction.

this finding is not limited to calculi, and blood clots and small tumors may exhibit the same pattern. Distinguishing between intrinsic and extrinsic obstructions is also difficult in urinary tract disorders.

The method we used, that is, effective TE of 90–100 ms without fat saturation, provides soft tissue contrast that is more enhanced than with heavily T2-weighted images, and it can depict soft tissue structures such as the ureteral wall. Therefore, we believe this method is a major improvement for evaluation of a lesion at the site of an obstruction.

We were concerned that CSA would prevent us from making a correct interpretation; however, in our study, no interpretation was interrupted by CSA. Two reasons are considered for this: technical reasons and interpretation skills. CSA depends on the magnetic power of a machine and the receive bandwidth. The higher the power of a machine and the narrower the receive bandwidth, the more prominent is the CSA. Our machine is 1.0T system and we used a wider receive bandwidth (62.5 kHz), which explains why the CSA was not prominent in our cases. Because CSA has several characteristics such as appearing frequency encode direction, those familiar with CSA can easily distinguish true signal changes from CSA.

In our results, statistically significant differences were found between benign lesions and malignant lesions in both the morphologic change and signal intensity of the obstructive lesions. According to our results, if a lesion at the obstruction shows wall thickening with increased signal intensity, it should be diagnosed as a malignant process. If a lesion at the obstruction does not show morphologic change or signal intensity change, it should be diagnosed as a benign process.

Two cases of malignant lesion, urothelial carcinomas, did not show any morphologic change or signal intensity change (Fig. 7). Those 2 were class V in urine cytology. Therefore, MR urography alone cannot indicate the correct diagnosis in all cases. Because this study did not cover many other causes of ureteral obstructions, such as benign tumors and infections, further studies are needed to investigate the use of MR urography in these diseases.

In conclusion, with moderately T2-weighted MR urography without fat saturation, we can evaluate both the morphologic and signal intensity changes of a lesion at the level of obstruction. With this technique, we can distinguish benign and malignant urinary obstructions.
Fig. 7. Image of a 70-year-old woman with urothelial carcinoma
(a) Coronal image obtained with heavily $T_2$-weighted SSFSE with fat saturation (2047/1164), single slice acquisition, shows urinary dilatation and the level of obstruction (arrow). (b) Coronal and (c) axial images obtained with moderately $T_2$-weighted SSFSE without fat saturation (1714/93), multislice acquisition, do not show morphologic change or signal intensity change at the obstruction (arrowheads).

References