Magnetic Resonance Lymphography at 3T: A Promising Noninvasive Approach to Characterize Inguinal Lymphatic Vessel Leakage

Q. Lu¹, J. Xu¹, N. Liu², and X. Zhao³

¹Department of Radiology, Renji hospital Shanghai Jiao tong University School of Medicine, Shanghai, China, People's Republic of; ²Plastic & Reconstructive Surgery, Shanghai 9th People's Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai; ³Center for BioMedical Imaging Research (CBIR), Tsinghua University School of Medicine, Beijing, China, People's Republic of

Introduction: Inguinal lymphatic vessel leakage (LVL) is a severe complication due to injury of lymphatic vessels after surgery, lymph node biopsy, or blunt trauma. The occurrence of LVL will subsequently lead to lymphedema at inguinal region or extending in the lower extremities. The lymphangiography using traditional contrast-enhanced imaging modalities, such as X-ray, ultrasound, and single photon emission computed tomography (SPECT), has been utilized to assess inguinal LVL. However, the radiation exposure and invasive procedure in X-ray, lower spatial resolution and unavoidable inter-operator variability in ultrasound, and lower sensitivity and poor anatomical visualization in SPECT limit the clinical application of lymphangiography in diagnosis of LVL. Recently, magnetic resonance (MR) lymphangiography has been successfully used to image the lymphatic vessels in human subjects. In this study, we sought to characterize the inguinal LVL in patients with suspected lymphatic vessel injury using 3.0T MR scanner.

Methods: Sixteen patients (6 males; mean age, 34.5 ± 24.5 years old) with suspected injury of lymphatic vessels were recruited in this study. The approval of Institutional Review Board and written consent forms were obtained for all the subjects prior to the initiation of this study. All the patients underwent lymphangiography using a 3.0T MR scanner (Philips Medical Systems, Best, Netherlands) and a six-channel, phased-array, and sensitivity-encoding reception coil.

MR imaging: The turbo spin echo (TSE) 2w images were acquired cross-sectionally and coronally in inguinal region prior to lymphangiography using the following parameters: TR/TE 3600/80 ms; field of view (FOV) 37 × 28 cm²; acquisition matrix 348 × 280. For MR lymphangiography, a 3D THRIVE sequence (T1 High Resolution Isotropic Volume Excitation) was performed pre- and post- contrast agent injection using the following parameters: TR/TE 23/2.1 ms; Flip angle 30°; FOV 37 × 3600/80 ms; acquisition matrix 348 × 280. For MR lymphangiography, a 3D THRIVE sequence (T1 High Resolution Isotropic Volume Excitation) was performed pre- and post- contrast agent injection using the following parameters: TR/TE 23/2.1 ms; Flip angle 30°; FOV 37 × 28 cm²; and matrix size 720 × 560. MR contrast agent gadobenate dimeglumine (Gd-BOPTA, MultiHance, Bracco, Milan, Italy) mixed with 1% lidocaine (Gd-BOPTA:Lidocaine = 10:1) was injected subcutaneously into the interdigital webs of the dorsum of foot. Eight dynamic scans were performed on the lower leg section to monitor the enhancement of lymphatic vessels. One dynamic scan was conducted at the knee plane and five dynamic scans were performed in the inguinal region to evaluate the morphologic changes of the lymph vessels and the enhancement of contrast agent at the leakage site.

Image processing: The 3D THRIVE images were reconstructed using maximum intensity projection (MIP) approach.

Data analysis: MR lymphangiography images were interpreted by two experienced radiologists with consensus. The presence or absence of lymphedema, lymphocele, and lymphatic fistula was identified. The number of lymphatic vessels in both lower and upper legs were determined and their maximum diameters were measured. The number and diameter of the lymphatic vessels of the legs were compared bilaterally for all the subjects.

Results: Of 16 patients, 12 had lymphedema in the unilateral leg. 3 had lymphedema in both legs, and one had no leg lymphedema on T2W images. After contrast agent injection (mean delay time, 13 minutes), the enhanced lymphatic vessel was found in all the legs. All the lymphatic leakage sites can be determined based on MR lymphangiography images. The enhanced lymphatic vessels appeared as beaded patterns (Fig. 1). The effusion of lymphoceles (Fig. 2) or lymphatic fistulas (Fig. 3) appeared as elliptical or irregular cystic masses with a highly dense inguinofemoral region on T2W images. Lymphocele was observed in 13 patients (81.2%), and lymphatic fistula was identified. The number and maximum diameter of lymphatic vessels were compared bilaterally for all the subjects.

Table 1. Comparison of enhanced lymphatic vessels.

<table>
<thead>
<tr>
<th>Lymphatic vessels</th>
<th>Comparison of enhanced lymphatic vessels between legs with lymphatic leakage</th>
<th>without lymphatic leakage</th>
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<tbody>
<tr>
<td>Number</td>
<td>5.8 ± 4.0</td>
<td>2.9 ± 1.7</td>
</tr>
<tr>
<td>Maximum diameter, mm</td>
<td>3.04 ± 1.4</td>
<td>1.66 ± 0.53</td>
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</table>

Discussion and conclusions: MR lymphangiography is a promising noninvasive approach to characterize the lymphatic vessel leakage in the inguinal region. When combined with the traditional MR sequence (T2w), MR lymphangiography enables accurately identifying the critical features of lymphatic vessel leakage, such as lymphedema, lymphocele, and lymphatic fistula. However, the procedure of injecting contrast agent into the interdigital webs of the dorsum of foot is a little complicated. Therefore, developing a new MR contrast agent which is able to specifically enhance the lymphatic vessels and lymph nodes is the future direction.

Reference: