Efficiency of combined diffusion weighted imaging and conventional MRI in detection of clinically nonpalpable undescended testes

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Abstract

Purpose: The goal of the study was to highlight the added value of combined DWI and conventional MRI in detecting clinically nonpalpable undescended testes.

Patients and methods: Prospective study included 60 males referred for MRI evaluation of clinically diagnosed 66 nonpalpable undescended testes. MRI studies were performed using 1.5-T MRI machine and included axial and coronal spin-echo T1WIs, axial T2WIs, axial and coronal fat suppressed spin-echo T2WIs, and axial DWIs using three sets of b value (50, 400, and 800 s/mm²). All images were transferred to an independent workstation and evaluated by two radiologists for the presence or absence and location of the undescended testes. The findings were compared to laparoscopy results, and then, sensitivity, specificity, and accuracy were calculated for both conventional and combined (DWI and conventional) MRI.

Results: According to laparoscopic findings, sensitivity, specificity and accuracy of conventional MRI were 73.91%, 100%, and 80% and 69.57%, 100%, and 76.67% for radiologists 1 and 2 respectively, and of combined MRI were 86.9%, 100%, and 90% and 82.61%, 100%, and 86.67% for radiologists 1 and 2 respectively.

Conclusion: Adding DWIs to conventional MRI improves the sensitivity and accuracy of detecting clinically nonpalpable undescended testes.

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1. Introduction

Cryptorchidism or undescended testis (UDT) is the most common genital disorder identified at birth. The main reasons for treatment of cryptorchidism include increased risks of impairment of fertility potential, testicular malignancy, torsion and/or associated inguinal hernia [1]. Approximately 1% of males have undescended testes, 80% of them are clinically palpable and 20% are non-palpable. The term 'nonpalpable testes' implies that they cannot be detected on physical examination; they are intra-abdominal, absent, vanishing or atrophic [2]. Preoperative detection and localization of testes can determine the optimal type of procedure and allow for appropriate future planning. In the case of vanishing or absent testes, imaging findings could obviate the need for surgical exploration [3]. Different imaging tools have been suggested for identifying and locating non-palpable testes preoperatively with some limitations. Imaging modalities include US (Ultrasonography), CT (computed tomography), routine MRI, MRA...
sequences in proper localization of non-palpable testes

Diffusion-weighted imaging and conventional MRI

This study was to assess the added value of combined MRI examination.

needed for children less than 5 years for sedation during ral hydrate syrup at a dose of 1 ml/kg body weight was used for anatomic localization of elliptic hyperintense (DW and conventional) MR images, conventional MRI depicts abnormalities on the basis of tumor vascularity and cellularity. Therefore, DWI facilitates characterization of tissue at the microscopic level in a mechanism different from T1 and T2 relaxation. Intraabdominal testes are considerably more cellular than the adjacent tissues and organs, and thus, can be easily detected on DWIs owing to their increased signal intensity. Therefore, adding DWI to routine MRI improves identification of non-palpable undescended testes. The goal of this study was to assess the added value of combined Diffusion-weighted imaging and conventional MRI sequences in proper localization of non-palpable testes before unneeded laparoscopy.

2. Patients and methods

2.1. Patients

The study is prospective over the period from May 2014 to March 2016, and included 60 males (ranging in age from 15 months to 15 years with mean age 6.4 ± 3.9) referred for MRI evaluation of clinically diagnosed 66 nonpalpable undescended testes with non-conclusive ultrasonography findings. 54 cases were diagnosed of unilateral UDT (24 on the right side and 30 on the left side) with 6 cases clinically diagnosed of bilateral UDT. Patients with ambiguous genitalia or disorders of sexual development were excluded.

2.2. MR imaging

All MRI studies were performed with a 1.5-T MRI system (Achieva; Philips Medical Systems, Best, the Netherlands) using body coil (a phased-array coil). T1WIs, T2WIs and fat suppressed T2WIs as well as DWIs were performed during the same MRI examination for all patients. Images will be acquired with the patient is in supine position with head pointing to the magnet (head first supine; HFS). The body coil was securely tightened using straps to prevent respiratory artifacts. At the center the laser beam localizer will be placed over symphysis pubis. Chloral hydrate syrup at a dose of 1 ml/kg body weight was needed for children less than 5 years for sedation during MRI examination.

Conventional MRI examination included axial and coronal spin-echo T1-weighted sequence, axial T2-weighted sequence, axial and coronal fat suppressed spin-echo T2-weighted sequence, and axial DWI, slice thickness, 4 mm; interslice gap, 1 mm; field of view, 50 cm². DWIs were performed using three sets of b value (50, 400, and 800 s/mm²). All MRI images including diffusion-weighted image sequences were transferred to an independent workstation.

2.3. Image analysis

Two radiologists with different experiences (9 and 14 years respectively) in MR abdominal imaging independently reviewed the MR images and were aware of the patient’s clinical data. They recorded the presence or absence and the location of UDT.

First, the DWIs (with b values of 50, 400, and 800 s/mm²) were reviewed alone, then the conventional MR images, and finally the combined (DWI and conventional) MR images. At DWIs, the abdomen was imaged for focal elliptic areas of hyperintensity, that did not represent T2 shine through from fluid-containing structures, recorded as testes, and their anatomic location was classified into intracanalicular, low intraabdominal, and high intraabdominal.

On conventional MR images, testes appeared as elliptic areas hypointense on T1WIs and iso- or hyperintense on T2WIs, in the aforementioned locations. On the combined (DW and conventional) MR images, conventional MRI was used for anatomic localization of elliptic hyperintense areas on the DWIs.

2.4. Laparoscopy and histopathologic examination

All the patients underwent laparoscopic exploration under general anesthesia within 2 weeks of the MR imaging to determine the location of all nonpalpable testes. Intraabdominal atrophic testes were treated with laparoscopic orchiectomy. Orchiectomy samples were taken for histopathologic examination.

2.5. Statistical analysis

DWIs, conventional MRI, and combined (DWIs and conventional) MRI findings were compared with laparoscopy results. For each observer, sensitivity, specificity, and accuracy of location of the testes were calculated for DWIs, conventional MRI, and combined (DWIs and conventional) MRI. Data were statistically described in terms of mean ± standard deviation (±SD), and range, or frequencies (number of cases) and percentages when appropriate. Comparison of sensitivity and overall accuracy between the different techniques was done using Chi squared test (McNemar test). Accuracy was represented using the terms such as sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy. All statistical calculations were done using computer program.
3. Results

According to the laparoscopic findings, 48 undescended testes were diagnosed in 60 patients, and located as follows: 4 high intraabdominal, 24 low intraabdominal (Fig. 1), and 20 intracanalicular (Figs. 2–4), whereas, 18 testes were absent (testicular agenesis) as shown in Table 1.

The combination of DWI and conventional MRI was the most accurate and sensitive technique, facilitating the localization of 40 testes by radiologist 1 and 38 testes by radiologist 2, with accuracy of 90% and 86.67%, compared to 80% and 76.67% for conventional MRI, respectively. Sensitivity of 86.96% and 82.61% by combined MRI compared to 73.91% and 69.57% by conventional MRI, was found for radiologists 1 and 2, respectively. However, both combined and conventional MR imaging had a specificity of 100% (Table 2).

In 14 patients (23.33%), laparoscopy revealed testicular agenesis, compared to 20 patients (33.33%) reported using MRI combined imaging. By conventional MRI, UDTs were detected in 34 (56.66%) and 32 (53.33%) patients by radiologists 1 and 2, respectively, while by combined MRI, they detected UDTs in 40 (66.66%) and 38 (63.33%) patients, respectively, compared to 46 patients (76.66%) diagnosed with UDTs on laparoscopy. Radiologist 2 could not identify two cases of left high intraabdominal testes identified by radiologist 1 and confirmed by laparoscopy. Both radiologists could not identify two left UDTs on conventional and combined MRI that was left lower abdominal UDT by laparoscopy. Two right UDTs were not identified on both conventional and combined MRI by both radiologists and reported by laparoscopy as right low intraabdominal UDT. On two laparoscopic examinations, bilateral low intraabdominal atrophic UDT was detected and was overlooked on both conventional and combined MRI by both radiologists (Table 3).

4. Discussion

The incidence of UDTs varies from 21% in preterm infants to 1.8–4.0% in term boys [11]. 80% of UDTs are clinically palpable and 20% of them are nonpalpable [12]. Non-palpable testis implies that the testis cannot be detected on clinical examination [13]. Accurate diagnosis and appropriate surgical treatment are important for proper testicular function and can facilitate early detection of malignancy [14,15]. Preoperative localization of the testes aids in planning surgical approach, reducing extent of exploration and anesthesia time [16].

Laparoscopy is the most reliable diagnostic technique for the detection of nonpalpable UDTs; however, it is invasive [17–19]. Thus, different diagnostic imaging modalities have been used for detection and localization of nonpalpable UDTs including ultrasonography, computed tomography (CT) and magnetic resonance imaging (MRI) [20].

**Fig. 1.** 3 years old boy presented with right sided clinically nonpalpable testis. MRI imaging revealed a right low intraabdominal testis close to internal ring, showing intermediate signal intensity on axial T2WI (a), and marked hyperintensity on axial DWI (b) obtained with b value of 800 s/mm².

**Fig. 2.** 15 months old boy presented with right sided clinically nonpalpable testis. MRI imaging revealed a right intracanalicular testis (arrowed), showing intermediate signal intensity (surrounded by mild vaginal hydrocele) on axial fat suppressed T2WI (a), and marked hyperintensity on axial DWI (b) obtained with b value of 800 s/mm².
MRI is a noninvasive diagnostic imaging technique and does not entail ionizing radiation. A study done by Kane-moto et al. found that MRI has an accuracy, sensitivity and specificity of 85%, 86% and 79%, respectively, for the diagnosis of nonpalpable UDTs [21]. Another study conducted by Sarihan et al. found that MRI had sensitivity and specificity of 78.6% and 100%, respectively, in the detection of nonpalpable UDTs [22]. Both studies used conventional MRI techniques.

In the current study, the performance of two radiologists with different levels of experience in interpreting the MRI findings of 60 patients, referred with clinically nonpalpable UDTs, was compared. Using MRI alone, the sensitivity was 73.91% and 69.57%, while accuracy was 80% and 76.67% for radiologists 1 and 2, respectively. However, when DWI was added to conventional MRI, both sensitivity and accuracy were increased for radiologists 1 and 2 (sensitivity 86.96% and 82.61%; accuracy 90% and 86.67%). So, with combined DWI and conventional MRI, both radiologists performed better in detection and localization of UDTs and our results confirm that DWI findings complement that obtained with conventional MRI on identifying and locating undescended testes.

Kato et al. reported that sensitivity, specificity, positive and negative predictive values for combined DWI and conventional MRI versus the operative findings were 100%, 100%, 100%, and 100%, respectively.

Table 1
Location based distribution of 66 clinically nonpalpable UDTs in 60 patients according to laparoscopy findings.

<table>
<thead>
<tr>
<th>Location</th>
<th>Absent</th>
<th>Intra-canicular</th>
<th>Low intra-abdominal</th>
<th>High intra-abdominal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right testis</td>
<td>6</td>
<td>14</td>
<td>10</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>Left testis</td>
<td>12</td>
<td>6</td>
<td>14</td>
<td>4</td>
<td>36</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>20</td>
<td>24</td>
<td>4</td>
<td>66</td>
</tr>
</tbody>
</table>

Fig. 3. 5 years old boy presented with right sided clinically nonpalpable testis. MRI imaging revealed a right intracanalicular testis (arrowed), surrounded by mild vaginal hydrocele and showing intermediate signal intensity on axial T1WI (a), axial and coronal T2WIs (b and c), and marked hyperintensity on axial DWI (d) obtained with b value of 800 s/mm².

Fig. 4. 17 months old boy presented with left sided clinically nonpalpable testis. Conventional MRI imaging failed to detect the undescended testis on axial T2WIs (a), while on axial DWI obtained with b value of 800 s/mm² (b), a markedly hyperintense small left intracanalicular testis (arrowed), was detected and confirmed by subsequent laparoscopy.
97.3%, 96.3% and 100%. The overall prediction accuracy was 98.4% [7]. Our results also agreed with those of a study conducted by Kantarci et al. who investigated the diagnostic performance of DWI and MRI in localizing nonpalpable UDTs, reported higher sensitivity and accuracy of combined MRI. It also compared the performance of two radiologists of different experiences in MRI interpretation. With MRI alone, the sensitivity was 85% for both radiologists, while accuracy was 86% for radiologist 1 and 84% for radiologist 2. However, when DWI was added to conventional MRI, both the sensitivity and accuracy were improved for both radiologists (sensitivity 91% and 88%; accuracy 92% and 86%) [10]. Another recent study by Emad-Eldin et al. revealed that conventional MRI alone had an accuracy of 91.5% in detecting nonpalpable undescended testes, while the combination of DWI and MRI increased accuracy to 95.7%, with a sensitivity of 93.5% and 100% specificity [23].

5. Conclusion

Adding DWIs to conventional MRI increased its sensitivity and accuracy of preoperative detection and localization of clinically nonpalpable testes.

Conflict of interest

The authors declare that there are no conflict of interests.

References


