INTRODUCTION

Cryptorchidism is the absence of one or both testes in the scrotum and is generally synonymous with undescended testis.\[^{1}\]

Most of undescended testis will be corrected spontaneously by the age of 1 year, but 0.8% of boys continue to have undescended testis.\[^{2}\] The incidence of undescended testis varies from 21% in preterm infants to 1.8-4.0% in term boys.\[^{3}\] 80% of undescended testes clinically palpable and 20% are non-palpable.\[^{4}\] The term non-palpable testis implies that the testis cannot be detected on physical examination.\[^{5}\]

The literature reports that nearly half of viable non-palpable testes (NPT) are in an abdominal position and 5% are in the inguinal canal. The remaining 45% are atrophic.
or absent, mostly as a result of in utero spermatic cord torsion and are located abdominally, inguinally or scrotally.[6,7] Accurate diagnosis and appropriate treatment lead to the highest chance of proper testicular function in an endocrine capacity, that is, with regard to fertility; in addition, accurate diagnosis can facilitate early detection of malignant tumors.[8, 9]

Preoperative location of the testis aids in a planned surgical approach, reducing the extent of exploration and anesthesia time. Imaging techniques for locating undescended testes therefore are important.[1]

Different diagnostic modalities have been used for detection and localization of non-palpable testis including ultrasonography, computed tomography (CT) and magnetic resonance imaging (imaging techniques) and laparoscopy (visualization).[10]

Ultrasound proved to be useful in localizing the testes within the inguinal canal but it shows difficulty in differentiating enlarged inguinal lymph node and testis. It usually fails to visualize intra-abdominal testes.[11]

Also, difficulties arise in fatty and uncooperative young patients; furthermore, the accuracy of ultrasound depends on the skill of the operator.[12]

With CT the non-palpable testis is more easily identified and can be distinguished from the contents of the cord and enlarged lymph nodes.[13]

However, CT has never been reported to have enabled identification of high abdominal testis, its main disadvantage is the associated radiation hazard to the testes.[14]

MRI is noninvasive, does not involve ionizing radiation, does not entail intravenous contrast and has the potential for tissue characteristic and yields multi-planar images.[15] Laparoscopy has been established as the most reliable diagnostic technique for the identification of nonpalpable testes However, it is invasive.[1, 16-17]

MR images of both normal and undescended testes show ovoid appearance which is hypo intense to fat on T1-weighted images while on T2-weighted images typically they are hyper intense or iso-intense to fat with surrounding black out-line. The mediastinum testis is visualized as a low-signal-intensity band within the testis which improves the specificity in diagnosis. The atrophic testis is diagnosed by its small size and the low signal intensity on both T1 and T2-weighted images. On coronal views, an inguinal testis is located along the course of a linear low-signal-intensity structure which extends to the scrotum.[18]

With DWI technique, information is extracted on the diffusion of water molecules, which reflects the degree of cellularity of tissue. A different image is produced than with conventional MRI sequences. Use of DWI therefore facilitates characterization of tissue at the microscopic level in a mechanism different from T1 and T2 relaxation.[19]

DWI is a non-invasive method to visualize changes in the translational (Brownian) motion of water molecules, and can provide tissue contrast, thus differing from conventional MRI.[20] In the testes, edematous tissue rich in intracellular water or highly cellular tissue composed of Sertoli and Leydig cells can show altered patterns of water diffusion.[21]

The degree of restriction of water diffusion in biologic tissue is inversely related to tissue cellularity and the integrity of cell membranes. The motion of water molecules is more restricted in tissues with the high cellularity.[22]

Atrophic testes show low signal intensity on the T2 – weighted images, the signal intensity of the testes was low because of its smaller size and remarkable atrophy in the seminiferous tubules, on diffusion, however, the signal intensity was low owing to the hypocellularity of the atrophic testes, so it can be speculated that testes with low signal intensity on DW are no longer viable.[23]

Fat-suppressed T2- weighted imaging was considered suitable for distinguishing between the testes and lymph nodes, as the lymph node has lower signal intensity than the testes.[24]

Non-malignant lymph nodes have homogeneous high signal intensity on images obtained at a b value of 0 s/mm², whereas they have low signal intensity at a b value of 1,000 s/mm².[25]

Diffusion-weighted MRI (DWI) of the abdomen and pelvis, which has been widely used for diagnostic purposes, entails a contrast mechanism for evaluating pathologic changes in solid abdominal and pelvic organs.[26] On images with low b value, fluid-containing structures such as the bowel contents, urinary bladder, and gallbladder have high signal intensity, and the testes have mild to low signal intensity. On images with a high b value of 800-1000 s/mm2, the bowel contents are suppressed, and the testes have high signal intensity, therefore, we can
easily visualize undescended testes using DWI with a high b value.\[23\]

Studies have shown that adding DWI to a routine MRI examination increases diagnostic accuracy of undescended testes.\[27, 28\] Our aim is to evaluate the role of diffusion-weighted MRI in the evaluation of non-palpable undescended testes.

**PATIENTS AND METHODS**

This prospective study was conducted in the department of radiology MRI unit of Al-Yarmouk teaching hospital from November 2012 to the end of February 2013. Twenty boys with age range between 4-13 years, mean age 7 year were suspected having undescended testes by clinical and ultrasound examination. All those patients were referred from pediatric surgery department in pediatric hospital center, surgical department in Al-Yarmouk teaching hospital & all patients-parents provided informed verbal consent.

All MRI examinations were performed with a 1.5-T MRI system (Achieva Philips) with high performance gradient the patients underwent MRI with a free breathing axial turbo spin-echo T1-weighted sequence (TR/TE, 498 /10), axial T2 and coronal fat-suppressed turbo spin echo T2-weighted sequence (1073 /80), and an axial DWI image, slice thickness =3-5 mm; gap =2 mm including the images with b value of 300, and 600 s/mm\(^2\), were reviewed DW image alone, then the conventional MR, and finally the combined DW and conventional MR image.

- Two observer groups reviewed images. Each group was composed of two specialist radiologists. Three sets of images were reviewed by each observer group for each of the 13 cases included in the study (MRI only, DWI only, MRI + DWI). The image sets for each case was separately presented to observer groups, and in a random fashion, with the observer groups blinded to case identity. Decision on each set of images was reached by consensus within each observer group.

- Statistically: McNemar test was used to compare different MR protocols for both observer-groups. Inter-observer agreement was tested with Kappa statistics. Differences with a p-value of less than 0.05 were considered statistically significant.

**RESULTS**

This is a prospective study of 20 healthy-boys with unilateral non-palpable undescended testes their age ranges of (4-13 years) and mean age was 7 years ,all the boys underwent MRI image for identification of the non-palpable testes and the result were compared with surgical findings. Two observer groups reviewed the images. About 7 cases were negative on all MRI protocols while 13 cases were with positive findings; three sets of images were reviewed by each observer group for each of the 13 cases included in our study (MRI only, DWI only, MRI + DWI). The two observers detected 12 /13 tests with (MRI +DWI). With DWI alone, observer 1 located 11/13 testes, and observer 2, located 12/13 testes, while by using conventional MRI alone, both observers located 10/13 testes.

The two observer-groups show that the combination of DWI and conventional MRI was the most sensitive technique ,facilitating visualization and location of 12 testes by two observer 92.3 %,using diffusion alone, observer 1 and 2 visualized and located 11 and 12 testes with sensitivity 84.6 % and 92.3% respectively ,both observer-groups visualize and located 10 with conventional MRI the sensitivity 76.9%. [table1]

**Table 1: Sensitivity of protocols in the two observer groups.**

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Sensitivity</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Observer Group 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRI</td>
<td>76.9%</td>
<td>(46.0% - 93.8%)</td>
</tr>
<tr>
<td>DWI</td>
<td>84.6%</td>
<td>(53.7% - 97.3%)</td>
</tr>
<tr>
<td>MRI + DW</td>
<td>92.3%</td>
<td>(71.7% - 95.3%)</td>
</tr>
<tr>
<td><strong>Observer Group 2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRI</td>
<td>76.9%</td>
<td>(46.0% - 93.8%)</td>
</tr>
<tr>
<td>DWI</td>
<td>92.3%</td>
<td>(62.1% - 99.6%)</td>
</tr>
<tr>
<td>MRI + DW</td>
<td>92.3%</td>
<td>(71.7% - 95.3%)</td>
</tr>
</tbody>
</table>

Using McNemar test, we found statistically non-significant differences in sensitivity between different protocols: DWI and MRI (p = 1.00 for observer group 1, p = 0.62 for observer group 2), MRI + DW and MRI (p = 0.25 for observer group 1, p = 0.25 for observer group 2), MRI + DW and DWI (p = 0.48 for observer group 1, p = 1.00 for observer group 2). [Table 2]
Table 2: Comparison of protocol sensitivity in the two observer groups.

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Sensitivity</th>
<th>McNemar Test p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observer Group 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DWI vs. MRI</td>
<td>DWI &gt; MRI</td>
<td>1.00</td>
</tr>
<tr>
<td>MRI + DW vs. MRI</td>
<td>MRI + DW &gt; MRI</td>
<td>0.25</td>
</tr>
<tr>
<td>MRI + DW vs. DWI</td>
<td>MRI + DW &gt; DWI</td>
<td>0.48</td>
</tr>
<tr>
<td>Observer Group 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DWI vs. MRI</td>
<td>DWI &gt; MRI</td>
<td>0.62</td>
</tr>
<tr>
<td>MRI + DW vs. MRI</td>
<td>MRI + DW &gt; MRI</td>
<td>0.25</td>
</tr>
<tr>
<td>MRI + DW vs. DWI</td>
<td>MRI + DW &gt; DWI</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Kappa Analysis

The two observers agreed on 38 of 39 assessments (97.4%) (κ = 0.88). Using the DW images, the two observers agreed on 13 of 13 assessments (100%) (κ = 1.00) compared with 37 of the conventional MR images (97%) (κ = 0.89) and 36 of the combined conventional MR and DW images (94%) (κ = 0.95)

Table 3: Kappa test for inter-observer agreement between the two observer groups.

<table>
<thead>
<tr>
<th>Agreement</th>
<th>Percent Agreement</th>
<th>Kappa</th>
<th>Strength of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRI</td>
<td>100% (13 of 13)</td>
<td>1.00</td>
<td>Perfect</td>
</tr>
<tr>
<td>DWI</td>
<td>92.3% (12 of 13)</td>
<td>0.63</td>
<td>Good</td>
</tr>
<tr>
<td>MRI + DW</td>
<td>100% (13 of 13)</td>
<td>1.00</td>
<td>Perfect</td>
</tr>
<tr>
<td>Total</td>
<td>97.4% (38 of 39)</td>
<td>0.88</td>
<td>Very good</td>
</tr>
</tbody>
</table>

At surgical finding, testes were identified in intra-canalicular location in 9 (69.2%) as seen in (fig. 1),

Fig. 1. 6-years boy with intra-canalaric non-palpable Undescending testes (left testis) A. axial T2 weighted MR image B. coronal T2 weighted MR image C. axial T1 weighted MR image (show hypo intense on T1 and Iso to hyper intense in T2) D. diffusion-weighted MR image with b value of 600 s/mm show markedly hyper intense testis.

Lower intra-abdominal location 3 cases (23.1 %) as seen in figure (fig. 2),

Fig 2. 11-years boy with low intra-abdominal non-palpable undesceded testis (left testis) Axial T1 weighted MR image B. coronal T2 weighted MR image C. fat suppression T2 weighted MR image (testis show hypo-intense in T1, hyper intense on T2, testis just proximal to left internal ring) D. diffusion-weighted MR image with b value of 600 s/mm show markedly hyper intense testis.

& lastly one case presented with high intra-abdominal location (7.7%). Of the 13 cases, 4 right sided (30.8%) and 9 left sided (69.2%) [Table 4]
Table 4: Location-based distribution of nonpalpable undescended testes according to surgical findings.

<table>
<thead>
<tr>
<th>Location</th>
<th>Intracanalicular</th>
<th>Lower intra-abdominal</th>
<th>High intra-abdominal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right sided</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4 (30.8)</td>
</tr>
<tr>
<td>Left sided</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>9 (69.2)</td>
</tr>
<tr>
<td>Total</td>
<td>9 (69.2)</td>
<td>3 (23.1)</td>
<td>1 (7.7)</td>
<td>13 (100)</td>
</tr>
</tbody>
</table>

Note: Values in parentheses are percentages.

**DISCUSSION**

Twenty boys with non-palpable undescended testes were included in our study. age ranges between (4-13 yrs.) ; 7 cases had negative finding (4 with bilateral testes and 3 of them unilateral).13 cases show positive finding ; for each patient, MRI were performed as a noninvasive diagnostic technique that hold great potential for abdominal imaging as well as it does not entail ionizing radiation or intravascular contrast media , T1- and T2 and fat-suppressed T2- weighted imaging , as well as DWI, axial and coronal view were performed during the same MRI examination, and the imaging results of positive finding were compared with surgical findings.

According to surgical finding about 9 cases identify intracanalicular location 69.2 % , and 3 just proximal to internal ring 23.1% and one of them intra-abdominal 7.7%, 69.2% left sided and 30.8% right sided; compared with other study done by Mecit Kantarci et al.[23] which identify 50% intracanalicular , 29% lower intra-abdominal, 10.5% high intra-abdominal , 55.3% right sided and 34.2% left sided .

We compared the performance of two observers with different levels of experience in interpreting the MRI findings. With MRI alone, the two observer detected 10/13 cases, the sensitivity was 76.9% for both observers; Kanemoto et al.[16] used MRI for the diagnosis of nonpalpable testis found that MRI can be expected to have sensitivity of 86%; Sarihan et al.[29] found that MRI had sensitivity of 78.6% ; Mecit Kantarci et al.[23] show that sensitivity of MRI 85 % ; Desireddi et al. [30] shows that the sensitivity of 74% in the detection of non-palpable undescended testis, only conventional MRI techniques were used in these studies ,and their results are consist with our study .

The sensitivity of detection of non-palpable testes increase with the use of DWI alone as observer 1 detected 11/13 and observer 2 detected 12/13 therefore the sensitivity was 84% and 92.4% for observer 1 &2 respectively and 92.3% after the use of combined DWI and MRI ,this result consistent with the study done by Mecit Kanarci et al.[23] ;as they found a sensitivity of 91%.

By comparing the sensitivity of three protocol in this study we found that the combined DWI+MRI more sensitive than using DWI alone and DWI more sensitive than MRI alone also by using McNemar test there was no statistically significant differences in sensitivity between MRI protocols this due to small sample size used in this study compared with other studies, and the inability to use the laparoscopy as a gold standard for diagnosing undescended testis.

In this study all patients had known non-palpable undescended testis and were otherwise completely healthy, therefore misdiagnosis of an infected lymph node with undescended testis in the inguinal region was unlikely, so there were no false positive cases detected, for these reasons we were unable to calculate specificity and accuracy.

In conclusion combining DWI with conventional MRI sequences improve the sensitivity for detection of nonpalpable undescended testis; however, in this study there were no significant differences in sensitivity among different protocols used (MRI only, DWI only, MRI with DWI), due to small sample size recruited for this study. We conclude that the information from DWI with high b value complements that from conventional MRI to improve visualization of undescended testis.

**References**


Mustansiriya Medical Journal Volume 12 Issue 2 December 2013 | 5


