Journal Homepage: - www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
Article DOI: 10.21474/IJAR01/4847
DOI URL: http://dx.doi.org/10.21474/IJAR01/4847
ISSN NO. 2320-5407

RESEARCH ARTICLE

ROLE OF DIFFUSION-WEIGHTED MAGNETIC RESONANCE IMAGING IN DETECTION OF NON-PALPABLE UNDESCENDED TESTES.

Manar M. Nasr MD[1], Wael Abdulghaffar MD[1] and Ahmad Yassin, MRCS[2].

1. Department of Diagnostic and Interventional radiology, Mansoura University Hospital, 3511212 El-Gomhoreya street, Mansoura, Egypt.
2. Pediatric surgery Department, Maternity and Children Hospital. Mozdalifa road, 6521. Holy Makah, Saudi Arabia.

Manuscript Info

Manuscript History

Received: 14 May 2017
Final Accepted: 16 June 2017
Published: July 2017

Key words:-
MRI, diffusion MRI, non-palpable testes, undescended testes

Abstract

Objective: To evaluate the role of diffusion weighted MRI in the detection of non-palpable undescended testes.

Materials and methods: Twenty nine boys with undescended testes underwent abdominal and pelvic MRI to identify the location of the testes. MRI was performed using the following sequences: T2-weighted half-Fourier single-shot turbo spin-echo (HASTE), 3-D gradient-echo T1-weighted, 2-D gradient-echo T1 in-phase and out-of-phase, respiratory-triggered, turbo spin-echo T2-weighted sequence with fat saturation and free-breathing diffusion-weighted imaging (DWI) with b values of 50, 400, and 800 s/mm2.

Results: In our study, we had 38 non-palpable undescended testicles detected in 29 patients. 17 testes were intracanalicular and 21 testes were intra-abdominal. All 17 intracanalicular testicles and 18 intra-abdominal testicles were identified by preoperative conventional MRI and DWI. The sensitivity and specificity values for the MRI with addition of DWI versus laparoscopic findings were 94.6%, and 100% respectively. The overall prediction accuracy was 94.7%.

Conclusion: DWI is easy to obtain and easy to evaluate in short time. DWI yields information that complements conventional MRI findings, improving identification and location of nonpalpable undescended testes. We recommend the use of DWI in addition to conventional MRI to increase the preoperative sensitivity and accuracy of identifying and locating nonpalpable testes.

Introduction:-

Undescended testes is detected in about 1% of newly born boys, from which 80% are palpable clinically (1) and 20% non-palpable testes which cannot be detected by physical examination; being absent, atrophic or intra-abdominal (2). About 18% of non palpable testes could be detected by physical examination under anesthesia, and 12.6% of viable testes could be discovered on exploration. They are usually detected distal to the inguinal canal and missed during physical examination (3).

Corresponding Author:- Manar M. Nasr MD.
Address:- Department of Diagnostic and Interventional radiology, Mansoura University Hospital, 3511212 El-Gomhoreya street, Mansoura, Egypt.

Diagnosis and management of non palpable testes is a very difficult dilemma and it is mandatory to be achieved to reach the best chance of proper testicular function; including normal hormonal secretions for normal future fertility. On the other hand, accurate diagnosis is very crucial to avoid malignant transformation (4,5).

Ultrasonography (US) is simple method of diagnosis of non-palpable testes in children and for surgical planning preoperatively. Many studies concluded that the accuracy of US was not satisfactory (6). Different radiological diagnostic procedures before laparoscopic intervention for non-palpable testis are still controversial regarding the cost benefit ratio. All imaging procedure for the assessment of non-palpable testis are needed to identify their location accurately and assess the viability before surgical interference.

MRI sequences including Fat suppressed T2 and diffusion weighted imaging (DWI); which depend on the Brownian motion of water molecules to provide tissue contrast could be helpful (7). DWI can be performed with MRI sequences at the same setting and it can provide more accurate additional information for non-palpable testes in comparison with conventional MRI alone (7).

The accuracy of detection of the location of a nonpalpable testis with MRI and ultrasound are similar about (85% and 84% respectively) (6,8). Many recent studies have noted that combining DWI with routine MRI sequences improves the diagnostic accuracy of the procedure (9–17). At DWI, the testes show high signal intensity due to their high cellular density. DWI in addition to routine MRI sequences can improve the sensitivity and specificity of the technique in detecting non palpable testes located intra-abdominally (7).

Objective:-

The aim of our study was to assess the benefit of adding DWI to conventional MRI in the detection of nonpalpable undescended testes.

Materials and Methods:-

Patient Populations:-

Between April 2014 and May 2017, Forty one male patients (age range, 6 months–16 years; mean age, 9 years) with undescended testes were included in our study. Patients were imaged using conventional MRI, and DWI. Written informed consent was obtained from all patients' parents before MRI.

MRI Techniques:-

Magnetic resonance imaging was performed using a 1.5- T unit (Magnetom Espree; Siemens Medical Solutions, Erlangen, Germany), equipped with high-performance gradients and a six-element phased-array body coil. Before diffusion-weighted imaging the following sequences were done; Coronal T2-weighted half-Fourier single-shot turbo spin-echo (HASTE) using repetition time (TR) = 1200 ms, echo time (TE) = 95 ms, flip angle (FA) = 150, matrix = 256X 154, slice thickness = 5 mm, interslice gap = 30%, field of view (FOV) = 40 cm, and averages = 1. Axial 3-D gradient-echo T1-weighted (volumetric interpolated breath-hold examination = VIBE) using TR = 4.96 ms, TE = 2.38 ms, FA = 10, matrix = 256 x 166, slice thickness = 3.0 mm, interslice gap = 20%, FOV = 40 cm, and averages = 1. 2-D gradient-echo T1 in-phase and out-of-phase using TR = 124 ms, in-phase TE = 4.77 ms, out-of-phase TE = 2.38 ms, FA = 70, matrix = 256 x 168, slice thickness = 5 mm, interslice gap = 30%, FOV = 40 cm, and averages = 1. Axial and coronal respiratory-triggered, turbo spin-echo T2-weighted sequence with fat saturation using TR = 3800 ms, TE = 85 ms, FA = 150, matrix = 320 X 320, slice thickness = 5 mm, interslice gap = 30%, FOV = 40 cm, and averages = 1.

Diffusion-weighted MR imaging was performed using a single-shot spin-echo echo planar imaging (EPI) sequence with the b factors of 50, 400, and 800 s/mm^2 along the three orthogonal planes. In order to improve signal-to-noise ratio and for easier patient compliance, DWI under free-breathing was performed; using the following technical parameters TR = 6200 ms, TE = 95 ms, matrix = 125 x 192, slices thickness = 5 mm with inter-slice gap = 20%, FOV = 40 cm, and the average = 4. Acquisition time for the three different b factors was about 3.0 minute. The parallel imaging algorithms (GRAPPA), with an acceleration factor of 2, were added to reduce the acquisition time. Spectral fat saturation was employed systematically to suppress the chemical-shift artifacts.

Results:-

In our study, we had 38 non-palpable undescended testicles detected in 29 patients. Nine patients had bilateral undescended testicles (Fig.1). seventeen testes were intracanalicular (Fig.1 and Fig.2) and twenty one testes were intra-abdominal (Fig.3 and Fig.4).

All the seventeen intracanalicular testes and the eighteen intra-abdominal testes were identified by preoperative combined assessment involving conventional MRI (T1- and T2-weighted imaging, fat-suppressed T2-weighted imaging) and DWI (table 1).

On conventional MR images, testes were detected as elliptic areas of hypointense SI on T1-weighted images and hyperintense on T2-weighted images in their anatomical locations. On DWI, the testes have high signal intensity, therefore at DWI, the pelvi-abdominal region was scanned for focal areas of hyperintensity. Elliptic areas of hyperintensity were considered as testes and recorded. Their locations were classified into two anatomic regions: intracanalicular (Testes close to and below the internal inguinal ring) and intraabdominal (Testes above the internal ring).

On our combined conventional MR images and DW images, conventional sequences were referred to for anatomic location of the hyperintense elliptic areas on the DW images. On DW images, testes were considered the focal areas of hyperintensity that did not represent T2 shine through from fluid-containing structures, on the other hand, hyperintensity due to susceptibility artifacts around bowel loops containing air were dismissed and not considered testes (18).

In our study, all testes were intra-abdominal. Three could not be identified, out of them, 2 were intra-abdominal atrophic testis and one ended blindly at the cord structure intra-abdominally (vanishing testis) as confirmed by surgical findings (fig 5). The following table summarizes the identification of nonpalpable undescended testes in our study in comparison with laparoscopic findings (Table 2).

The sensitivity and specificity values for conventional MRI versus laparoscopic findings were 89.1 and 100% respectively. The overall prediction accuracy was 89.4% while the sensitivity and specificity values for the conventional MRI with addition of DWI versus laparoscopic findings were 94.6%, and 100% respectively. The overall prediction accuracy was 94.7%.

Table 1:- Location of Nonpalpable Undescended Testes in our study

	Conventional MRI (n=33)	Conventional MRI and DWI (n=35)	Laparoscopy (n=38)
Intracanalicular (n=17)	17	17	17
Intra-abdominal (n=21)	16	18	21
Total (n=38)	33	35	38

Table 2:- Identification of Nonpalpable Undescended Testes According to Laparoscopic Findings.

	Conventional MRI	**Conventional MRI and DWI**
True-Positive (No.)	33	35
False-Negative (No.)	4	2
True-Negative (No.)	1	1
False-Positive (No.)	0	0
Sensitivity	89.1%	94.6%
Specificity	100%	100%
Accuracy	89.4%	94.7%

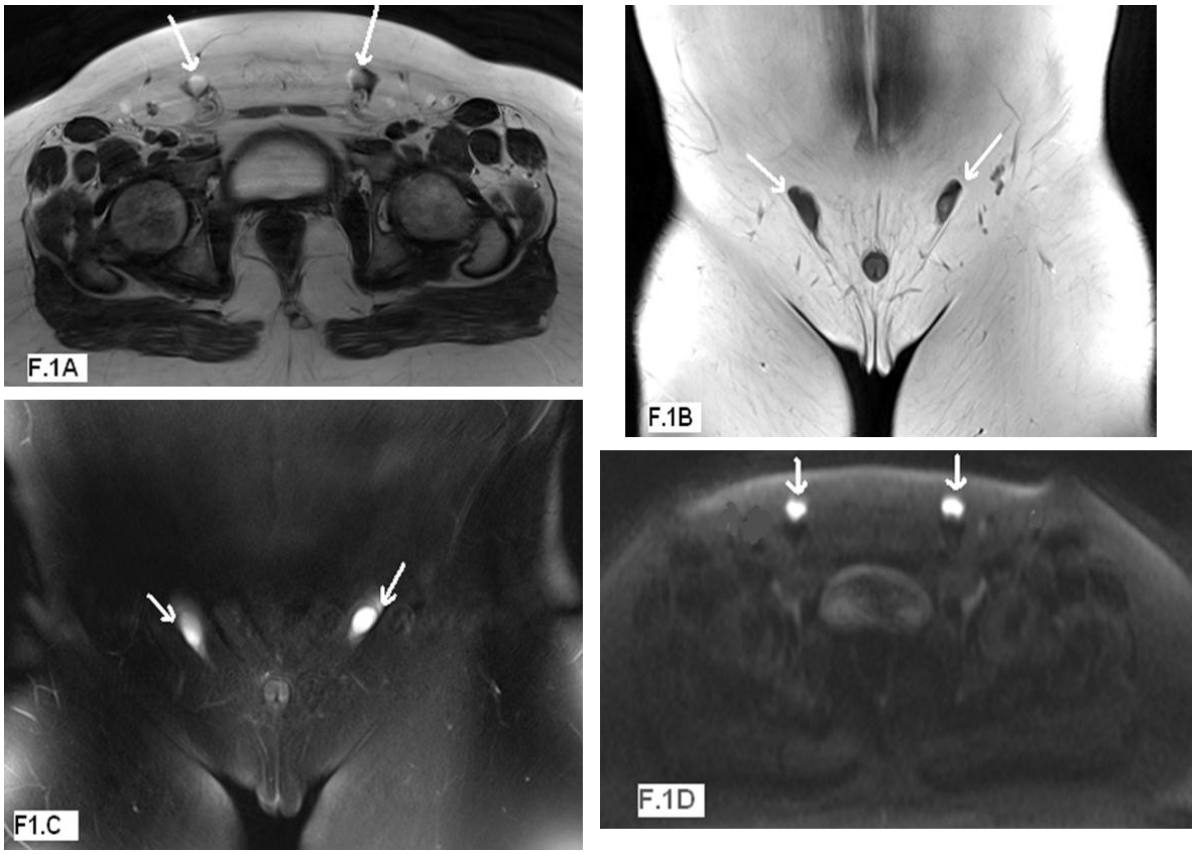

Figure 1:- Bilateral intracanalicular testes appear hyperintense on Axial T2 (a) Coronal fat suppressed T2WI (c) and axial DW MRI obtained at *a b* value of 800 (b) and appear hypointense on T1WI (b).

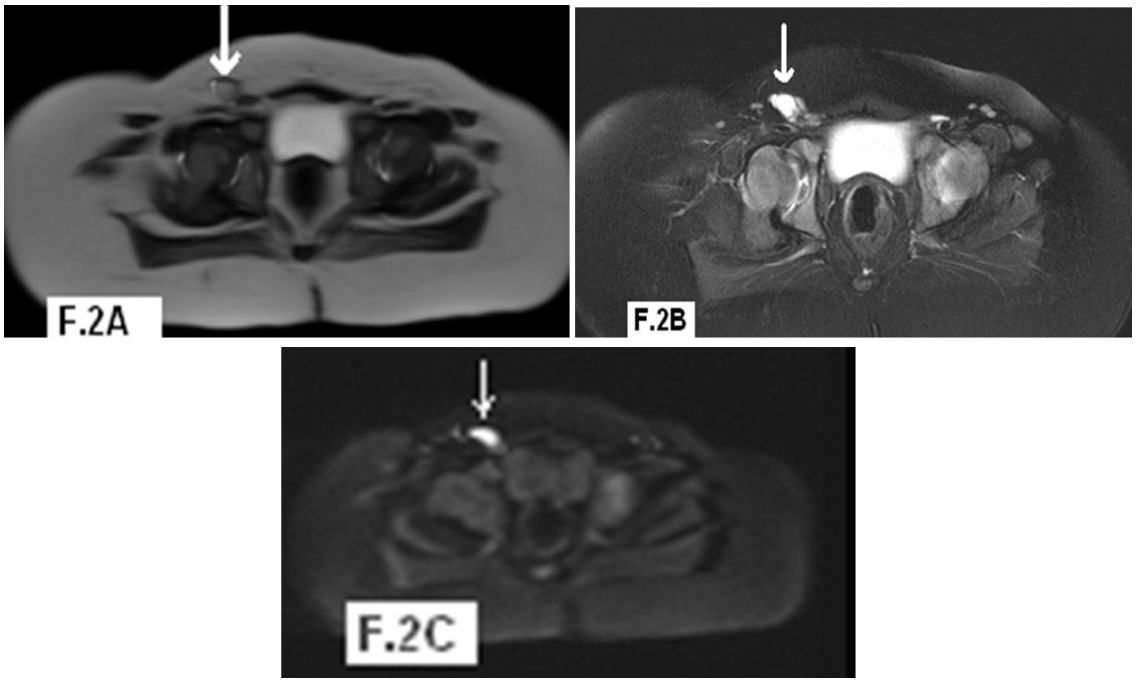

Figure 2:- right intracanalicular testis appears hyperintense on Axial T2 (a) and of higher SI on axial fat suppressed T2WI (b) and axial DW MRI obtained at *a b* value of 800 (c).

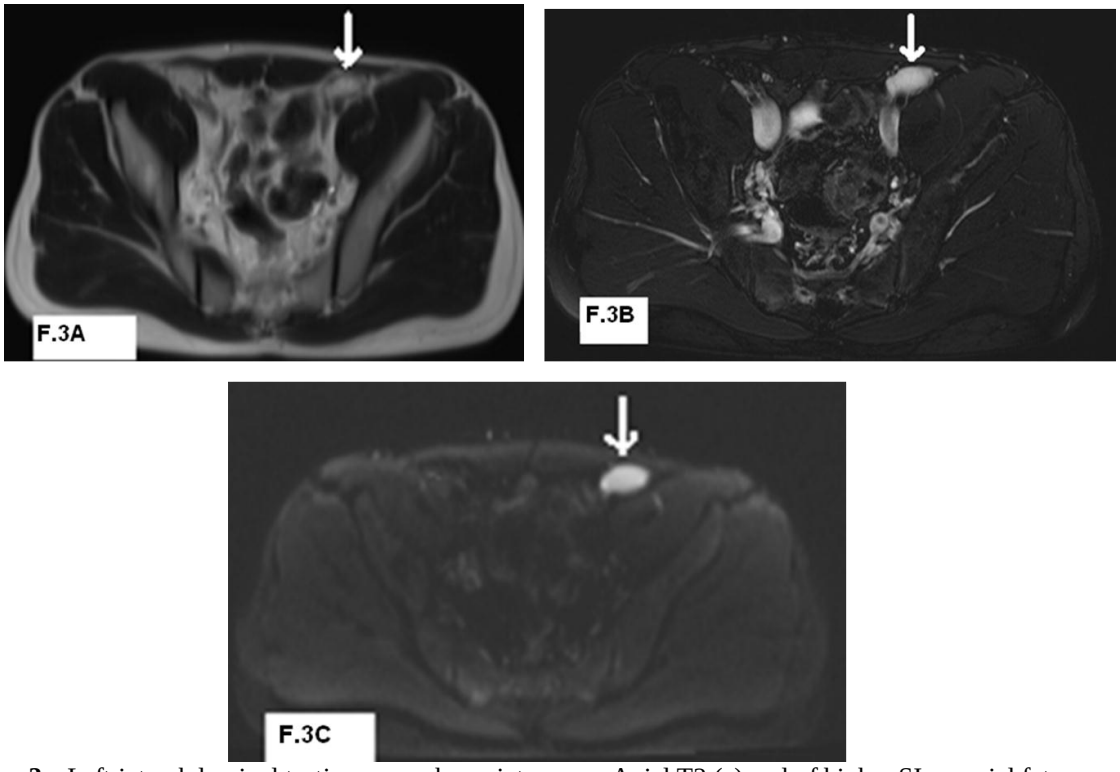

Figure 3:- Left intraabdominal testis appears hyperintense on Axial T2 (a) and of higher SI on axial fat suppressed T2WI (b) and axial DW MRI obtained at *a b* value of 800 (c).

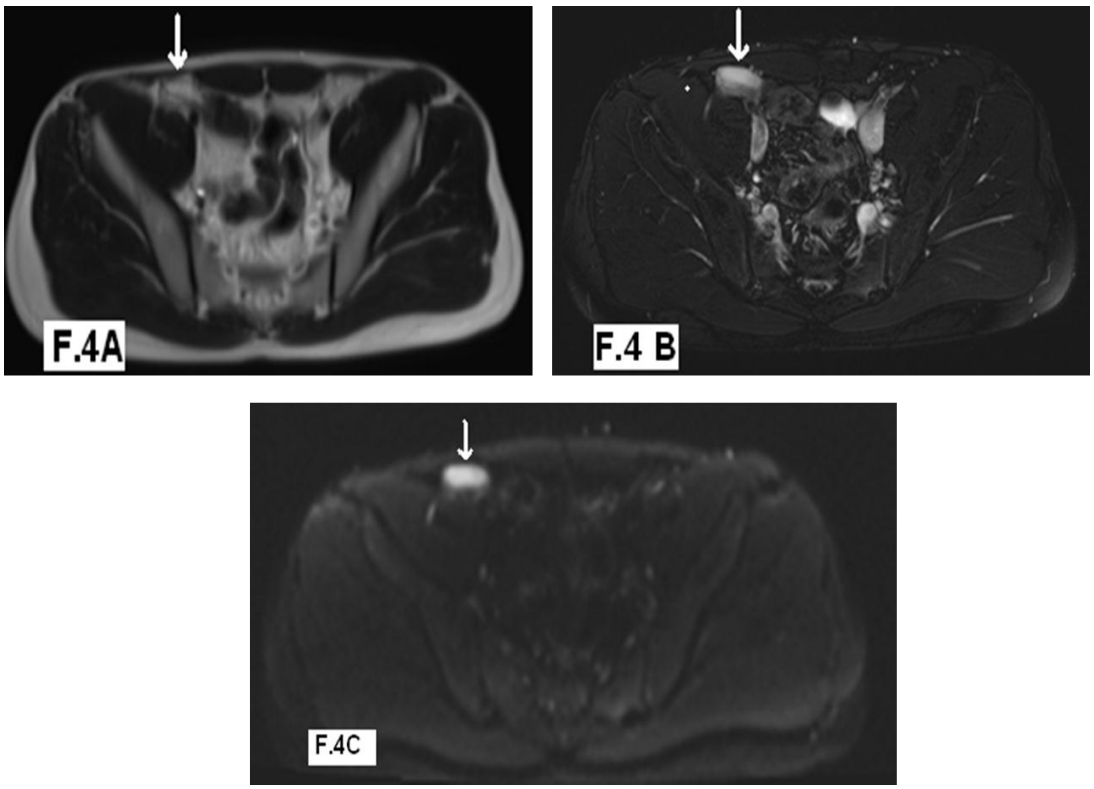

Figure 4:- Right intraabdominal testis appears hyperintense on Axial T2 (a) and of higher SI on axial fat suppressed T2WI (b) and axial DW MRI obtained at *a b* value of 800 (c).

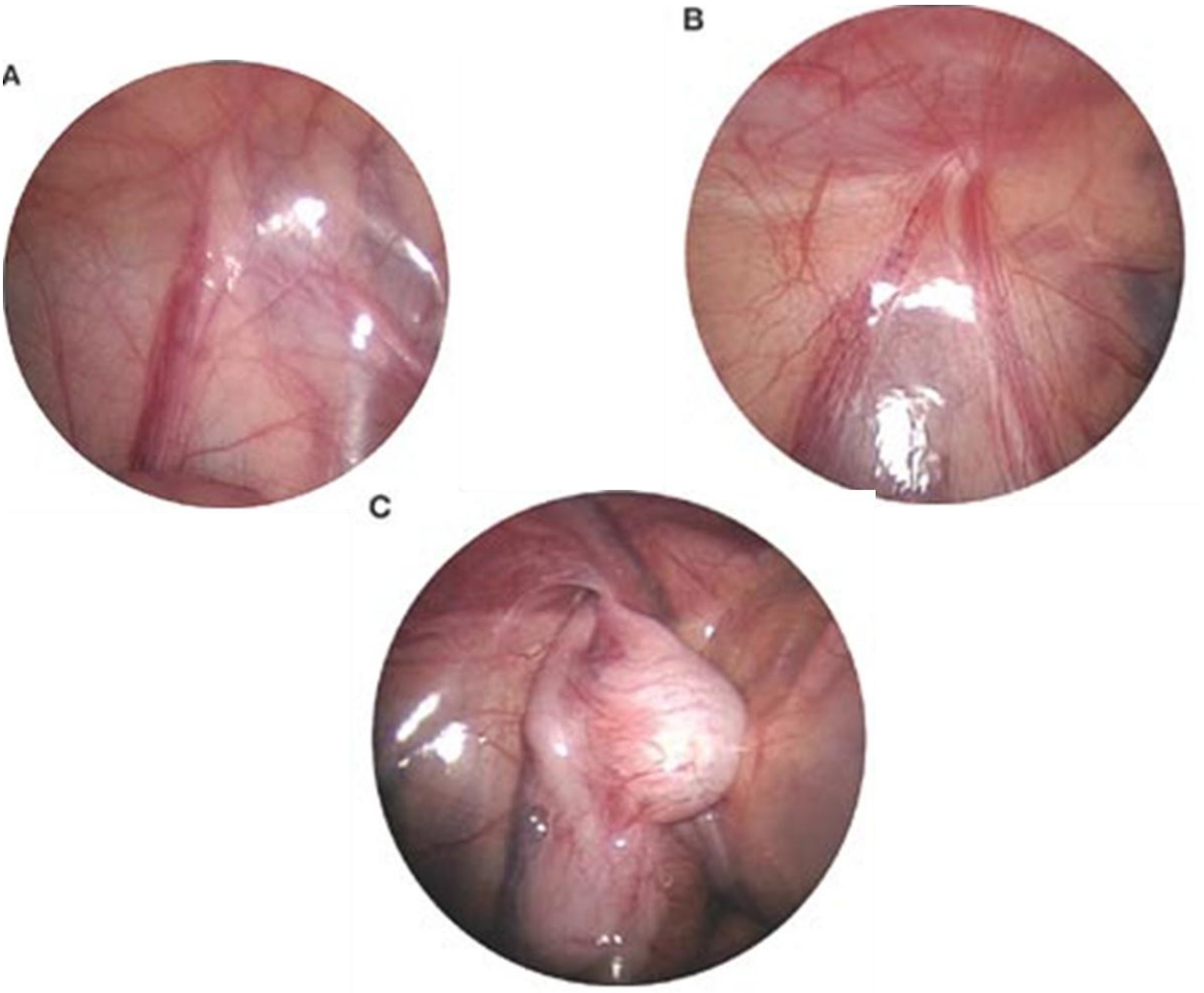

Figure 5:- Intra-operative images; (a) shows blind ended vas and vessels indicating absent testis. (b) shows the vas and vessels entering the internal inguinal ring so teticles must be extra-abdominal. (c) shows intra-abdominal testicles just at the internal inguinal ring.

Disscusion:-

Many diagnostic procedures to identify the nonpalpable testis; including sonography, CT, MRI, and laparoscopy have been used and many trials were done to assess their benifits. Laparoscopy has been considered the most reliable and accurate diagnostic procedure for the identification of nonpalpable testes however being an invasive procedure is the main disadvantage [6].

In contrary to CT, MRI is not an ionizing radiating technique therefore, it is more preferable imaging modality with much less side effects for pediatric patients. Undescended testes have the same magnetic resonance signal characteristics as scrotal testes. They are low signal intensity on T1-weighted images and high intensity of T2-weighted images. Kanemoto et al concluded that in spite of considering the high sensitivity and specificity of MRI in comparison with ultrasound in detection of undescended testes, the inability to detect a testis does not completely exclude its absence (19). They studied the role of MRI in detecting of nonpalpable testis and they noted that MRI have an accuracy of 85%, sensitivity of 86%, and specificity of 79% (6).

Desireddi*et al.* reported that, the accuracy of detecting a viable testis by conventional MRI, was 74% with positive predictive value 70%, and negative predictive value 44% (20).

In our study, the sensitivity and specificity values for conventional MRI versus laparoscopic findings were 89.1 and 100% respectively. The prediction accuracy was 89.4%. Our result of conventional MRI has a relatively high sensitivity and specificity as compared with previous studies due to using of routing axial & coronal T2 fat suppression in our study.

DWI is a non-invasive method to visualize changes in the translational motion of water molecules and providing better tissue contrast than conventional MRI (7). Many factors can affect DWI signals including the viscosity of fluid which is the main histological feature (21, 22), changes in the ratio between intra- and extracellular fluid (23), as well as tissue cellularity (24).

In our study, adding DWI to conventional MRI sequences was increasing the sensitivity of detection of the location of nonpalpable testes from 89.1% to 94.6 % and was increasing the overall accuracy from 89.4 % to 94.7 %. It also increased the confidence of diagnosis as DWI confirm the information obtained from conventional MRI due to suppression of fluid in bowel and nulling the signal of blood vessels.

Kantarci et al, relayed on two observers with different experience in interpreting the MRI findings, they concluded that sensitivity of conventional MRI alone was 85% for both observers; accuracy was 86% for observer 1 and 84% for observer 2. After adding DWI to conventional MRI techniques, the sensitivity and accuracy were increased for both observers (sensitivity, 0.91 and 0.88 and accuracy, 0.92 and 0.86). That means by adding DW technique the performance of both observer greatly improved in detecting the undescended testes (25).

Kato et al, using MRI fat suppressed T2-wieghted and DWI for detecting nonpalpable testes pre operatively. They found that the sensitivity was 100%, the positive predictive value was 96.3%, the specificity was 97.3% and the negative predictive value was 100% in all cases in which they performed orchidopexy, including 13 intraabdominal and 13 intracanalicular testes. Therefore, they mentioned that these techniques greatly facilitate the detection of intra-abdominal and intracanalicular testes with high certainty (26). The results of previous studies (25-26) are in agreement with results of our study.

Conclusion:-

In conclusion, DWI being easy to obtain and easy to evaluate in short time, it yields information that complements conventional MRI findings, improving identification and location of nonpalpable undescended testes. We recommend the use of DWI in addition to conventional MRI to increase the preoperative sensitivity and accuracy of identifying and locating nonpalpable testes.

References:-

1. **Elder JS**. The undescended testis: hormonal and surgical management. SurgClin North Am 1988; 68 : 983–1006
2. **Schneck FX**, Bellinger MF. Abnormalities of the testes and scrotum and their surgical management. In Wein AJ, Kavoussi LR, Novick AC, Partin AW, Peters CA eds. Campbell-Walsh Urology , 9th edn, Vol. IV. Chapt 127.Philadelphia: Saunderes Company, 2007: 3761–98
3. **Cisek LJ,** Peters CA, AtalaAet al. Current findings in diagnostic laparoscopic evaluation of the nonpalpable testis. J Urol1998; 160: 1145–9
4. **Kucheria R**, Sahai A, Sami TA, et al. Laparoscopic management of cryptorchidism in adults. EurUrol2005; 48:453–457
5. **Chew G**, Hutson JM. Incidence of cryptorchidism and ascending testes in trisomy 21: a 10 year retrospective review. PediatrSurgInt2004; 20:744–747
6. **Kanemoto K**, Hayashi Y, Kojima Y, Maruyama T, Ito M, Kohri K. Accuracy of ultrasonography and magnetic resonance imaging in the diagnosis of non-palpable testis. Int J Urol2005; 12 : 668–72
7. **Umeoka S**, Koyama T, Saga T et al. Ectopically located gonads in a patient with mixed gonadal dysgenesis: detection by diffusion-weighted MRI. Abdom Imaging 2005; 30: 637–40
8. **Gatti JM**, Ostlie DJ. The use of laparoscopy in the management of non-palpable undescended testes.CurrOpinPediatr2007; 19:349–353
9. **Bammer R**, Auer M, Kelling SL, et al. Diffusion tensor imaging using single-shot SENSE-EPI. MagnReson Med 2002; 48:128–136

10. **Murtz P**, Flacke S, Traver F, et al. Abdomen: diffusion weighted MR imaging with pulse-triggered singleshot sequences. Radiology 2002; 224:258–264
11. **Chow LC**, Brammer R, Moseley ME, et al. Single breath-hold diffusion-weighted imaging of the abdomen. J MagnReson Imaging 2003; 18:377–382
12. **Takahara T**, Imai Y, Yamashita T, et al. Diffusion weighted whole body imaging with background body signal suppression (DWIBS): technical improvement using free breathing, STIR and high resolution 3D display. Radiat Med 2004; 22:275–282
13. **Ichikawa T**, Haradome HH, Hachiya J, et al. Diffusion-weighted MR imaging with single-shot echo-planar imaging in the upper abdomen: preliminary clinical experience in 61 patients. Abdom Imaging 1999; 24:456–461
14. **Yamashita Y**, Tang Y, Takahashi M, et al. Ultrafast MR imaging of the abdomen: echo planar imaging and diffusion-weighted imaging. J MagnReson Imaging 1998; 8:367–374
15. **Low RN**, Gurney J. Diffusion-weighted MRI (DWI) in the oncology patient: value of breath hold DWI compared to unenhanced and gadolinium- enhanced MRI. J MagnReson Imaging 2007; 25:848–858
16. **Ichikawa T**, Erturk SM, Motosugi U, et al. High-b value diffusion–weighted MRI for detecting pancreatic adenocarcinoma: preliminary results. AJR 2007; 188:409–414
17. **Fujii S**, Matsusue E, Kigawa J, et al. Diagnostic accuracy of the apparent diffusion coefficient in differentiating benign from malignant uterine endometrial cavity lesions: initial results. EurRadiol2008; 18:384–389
18. **Thorup J**, Haugen S, Kollin C, et al. Surgical treatment of undescended testes. ActaPaediatr2007; 96:631–637
19. **Maghnie M**, Vanzulli A, Paesano P, et al. The accuracy of magnetic resonance imaging and ultrasonography compared with surgical findings in the localization of the undescended testis. Arch PediatrAdolesc Med 1994;148:699-703.
20. **Desireddi NV**, Liu DB, Maizels M, Rigsby C, Casey JT, Cheng EY. Magnetic resonance arteriography/venography is not accurate to structure management of the impalpable testis. J Urol2008; 180 1805–9
21. **Schaefer PW**, Grant PE, Gonzalez RG. Diffusion-weighted MR imaging of the brain. Radiology 2000; 217: 331– 45
22. **Kim YJ**, Chang KH, Song IC et al. Brain abscess and necrotic or cystic brain tumor: discrimination with signal intensity on diffusion-weighted MR imaging. AJR 1998; 171:1487–90
23. **Silva MD**, Omae T, Helmer KG et al. Separating changes in the intra- and extracellular water apparent diffusion coefficient following focal cerebral ischemia in the rat brain. MagnReson Med
24. 2002; 48 : 826–37
25. **24) Gauvain KM**, McKinstry RC, Mukherjee P et al. Evaluating pediatric brain tumor cellularity diffusion-tensor imaging. AJR 2001; 177 : 449–54
26. **Kantarci M**, Doganay S, Yalcin A, et al. Diagnostic performance of diffusion-weighted MRI in the detection of nonpalpable undescended testes: comparison with conventional MRI and surgical findings. AJR Am J Roentgenol 2010;195:W268-73.
27. **Kato T**, Kojima Y, Kamisawa H, et al. Findings of fat-suppressed T2-weighted and diffusion-weighted magnetic resonance imaging in the diagnosis of non-palpable testes. BJU international 2 010; 107: 290– 294.