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Superiority of MRI in Identifying Vas Deferens and Prostatic Pathologies: A Comparative Study with TRUS in Azoospermia

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Abstract

Accurate imaging is crucial for diagnosing reproductive tract abnormalities in azoospermic patients. This study compares the effectiveness of Transrectal Ultrasound (TRUS) and Magnetic Resonance Imaging (MRI) in evaluating the prostate, seminal vesicles, and vas deferens, with a focus on the diagnostic superiority of MRI. We conducted a comparative analysis involving 41 azoospermic patients who underwent both TRUS and MRI examinations. Key parameters assessed included prostate echogenicity, prostatic cysts, prostatic volume, seminal vesicles, seminal vesicle calcification, and visualization and dilation of the ampullae of the vas deferens and ejaculatory ducts. TRUS identified homogeneous echogenicity in 92.7% of patients, while MRI confirmed it in 100%. Both imaging modalities detected prostatic cysts in 9.8% of patients. MRI showed superior visualization of the right (80.5%) and left seminal vesicles (65.9%) compared to TRUS. MRI was more effective in visualizing the ampullae of the vas deferens and detecting seminal vesicle calcification. Both techniques identified right and left ejaculatory duct dilation in 70.7% and 65.9% of patients, respectively. ROC curve analysis confirmed high diagnostic accuracy for TRUS, but MRI exhibited superior sensitivity and specificity in several areas. While TRUS is effective, MRI shows superior diagnostic capabilities, especially for the vas deferens and seminal vesicles, underscoring MRI's essential role in evaluating azoospermic patients for more accurate diagnoses and better-targeted treatments.

Keywords: TRUS, MRI, Vas Deferens

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1. Introduction

Azoospermia, defined as the absence of spermatozoa in ejaculate, affects approximately 1% of men and accounts for nearly 10 to 15% of all cases of male infertility. The condition can be classified into three main categories: pre-testicular, testicular, and post-testicular causes. Pre-testicular causes are often related to hormonal deficiencies or imbalances, testicular causes involve issues directly within the testes, and post-testicular causes pertain to obstructions or dysfunctions in the reproductive tract beyond the testes. The primary diagnostic tool for azoospermia is semen analysis, which provides crucial information about the presence or absence of sperm and helps guide further diagnostic steps [1]. Over the past three decades, advancements in imaging technologies have significantly improved the evaluation of azoospermia. These imaging modalities are now frequently used in clinical settings as bedside tests or investigations. The most common imaging techniques employed in the assessment of azoospermia include scrotal ultrasound, transrectal ultrasound (TRUS), and magnetic resonance imaging (MRI) [2].

Scrotal ultrasound is widely used due to its accessibility and ability to provide detailed images of the testicles and surrounding structures. TRUS, first introduced in 1957, has become a vital tool in identifying pathologies in the male genital tract, particularly in the distal regions such as the ejaculatory ducts and seminal vesicles. This modality is minimally invasive and provides high-resolution images that are crucial for detecting abnormalities that may contribute to azoospermia [3]. On the other hand, MRI offers comprehensive imaging capabilities and can be particularly useful in complex cases where detailed anatomical information is required. However, MRI is an expensive and resource-intensive option, requiring sophisticated equipment and highly trained radiologists, which limits its routine use in the evaluation of azoospermia [4]. This study aims to identify when to refer to MRI after TRUS, and it can be skipped.

2. Methodology

This descriptive prospective cross-sectional study was conducted in the Urology and Radiology departments of Assiut University Hospital. Our clinical trial number is 17101723. Our ethical committee at Assiut University approved this manuscript in accordance with the Declaration of Helsinki. The study aimed to evaluate adult patients with azoospermia, defined as the absence of spermatozoa in the

ejaculate. Patients included in the study were aged 18 years and above. Exclusion criteria comprised individuals with bilateral small-sized (atrophied) testes and those with bilateral impalpable testes.The sample size for this study was determined by the study period, which spanned from August 2021 to December 2023. Based on consultations with the Research Ethics Committee (RESCU) and a review of similar studies, the sample size was not fixed but dependent on the number of cases fulfilling the selection criteria during the study period. It was estimated that approximately 41 patients would be included, given a population size of 10,000, a confidence level of 90%, and a margin of error of 10%. Data collection included a thorough clinical history of each patient, documenting age, occupation, smoking habits (including cigarette and Goza smoking), wife's age and infertility history, duration of infertility, type of infertility (primary or secondary), any medical illnesses such as diabetes, and history of previous surgeries like orchiopexy or varicocelectomy.

A general examination was performed to assess secondary sexual characteristics, such as pubic and axillary hair, and signs of hypogonadism, such as gynecomastia and poor masculinity. Local examinations focused on scrotal examination to evaluate the size and consistency of the testes, the presence of vas deferens, varicoceles and their grade, and chronic epididymo-orchitis. Penile examination was also conducted. The investigations included semen analysis, hormonal profile, TRUS evaluation, and MRI evaluation for selected patients. Semen samples were collected by masturbation after 3-5 days of sexual abstinence, and azoospermia was confirmed by at least two semen analyses. Fructose levels in semen were also tested. The hormonal profile included measurements of FSH, LH, total testosterone, and prolactin. For the TRUS evaluation, patients identified as azoospermic after semen analysis were subjected to a detailed TRUS examination. After obtaining consent, the patient was positioned on their side with knees bent towards the chest, and a lubricated probe was inserted into the rectum to capture images. The prostate was evaluated for volume, echogenicity, central gland, and peripheral zone. The seminal vesicles were assessed for anteroposterior (AP) diameter, consistency, and calcification.

The ampulla of the vas deferens was also measured for AP diameter, and the ejaculatory ducts were checked for dilation. MRI was performed on selected patients using a high-resolution, thin-cut protocol with coronal (oblique), sagittal, and axial views. Sequences included T2, SPAIR, and T1W for the pelvis and abdomen. Clinical and laboratory data were collected and correlated with TRUS findings. The results of TRUS were then compared with MRI to determine the sensitivity and specificity of TRUS. Statistical analysis was performed using SPSS 26 for Windows (SPSS Inc., Chicago, IL, USA). Data were tested for normal distribution using the Shapiro-Wilk test. Qualitative data were represented as frequencies and relative percentages, while quantitative data were expressed as mean ± standard deviation (SD), median, and range. The chi-square test was used for comparing qualitative data, and ROC curve analysis was employed to assess the sensitivity of TRUS compared to MRI. All statistical comparisons were two-tailed, with a significance level of $p \leq 0.05$ indicating significance, $p < 0.001$ indicating a highly significant difference, and $p > 0.05$ indicating a non-significant difference.

3. Results and discussion

3.1. Results

3.1.1. Demographic Data

Study involved a cohort of 41 patients diagnosed with azoospermia. Mean age of these patients was 28.8 years, with a standard deviation of 5.25 years. Marital status among participants showed that 8 patients (19.5%) single, whereas a significant majority of 33 patients (80.5%) married.

3.1.2. Semen Analysis

The semen analysis of the patients revealed several key findings. The mean semen volume was found to be 2.19 mL, with a standard deviation of 1.17 mL. Among the patients, 28 individuals (68.2%) had a semen volume lower than the normal threshold of 1.5 mL, while 13 individuals (31.7%) had a normal semen volume. Regarding the pH levels of the semen, 4 patients (9.8%) exhibited acidic pH levels, whereas a substantial 37 patients (90.2%) had alkaline semen pH levels. The fructose concentration in the semen was another critical parameter measured, with 8 patients (19.5%) showing low fructose levels, and the remaining 33 patients (80.5%) having normal fructose levels. The mean fructose concentration was 200.73 mg/dL, with a standard deviation of 62.47 mg/dL (Table 1).

3.1.3. Comparison of TRUS and MRI Findings

A. Prostate

In the assessment of the prostate using Transrectal Ultrasound (TRUS) and Magnetic Resonance Imaging (MRI), TRUS identified homogeneous echogenicity in 38 patients (92.7%) and non-homogeneous echogenicity in 3 patients (7.3%). MRI, on the other hand, confirmed homogeneous echogenicity in all 41 patients (100%). Both imaging modalities identified prostatic cysts in 4 patients (9.8%). The mean prostatic volume measured by TRUS was 16 mL (SD ± 3.5), while MRI showed a slightly higher mean volume of 18 mL (SD ± 2.9), (Table 2).

B. Seminal Vesicles

The visualization of seminal vesicles using TRUS and MRI showed some discrepancies. The right seminal vesicle could not be visualized in 10 patients (24.4%) using TRUS, compared to 8 patients (19.5%) with MRI. The left seminal vesicle was not visualized in 15 patients (36.3%) by TRUS, whereas MRI could not visualize it in 14 patients (34.1%). For those seminal vesicles that were visualized, both TRUS and MRI provided consistent findings regarding their condition, whether normal, dilated, or atrophic. The cross-sectional diameters measured were comparable between the two imaging techniques. TRUS detected calcification in the right seminal vesicle in 31 patients (75.6%) and in the left seminal vesicle in 26 patients (63.7%). MRI showed calcification in 33 patients (80.5%) on the right and in 27 patients (65.9%) on the left (Table 2).

C. Ampulla of the Vas Deferens

Ability to visualize the ampulla of the vas deferens varied between TRUS and MRI. The right ampulla was not visualized in 16 patients (39%) using TRUS and in 13 patients (31.7%) using MRI. The left ampulla showed similar results, with TRUS failing to visualize it in 19 patients (46.3%) compared to 16 patients (39%) with MRI. When visualized, the sensitivity and specificity of TRUS were high,

with consistent cross-sectional diameter measurements when compared to MRI (Table 2).

D. Ejaculatory Ducts (ED)

Assessment of ejaculatory ducts showed that dilatation of right ED was identified in 29 patients (70.7%) by both TRUS and MRI. The left ED dilatation observed in 27 patients (65.9%) by both imaging techniques. TRUS and MRI were in complete agreement regarding presence of cysts, with TRUS demonstrating 100% sensitivity and specificity for detecting right ED cysts (Table 2).

E. ROC curve analysis

ROC curve analysis comparing TRUS and MRI findings revealed high accuracy of TRUS in diagnosing various conditions, (Fig 1, 2).

- Prostatic Cysts: TRUS demonstrated 100% sensitivity and specificity, with an area under the curve (AUC) of 1.0 ($p < 0.05$). All cases with midline prostatic cysts diagnosed by MRI were also identified by TRUS, confirming its diagnostic reliability.
- Right Seminal Vesicle Visualization: TRUS showed a sensitivity of 93.9% and specificity of 100%, with an AUC of 0.97 ($p < 0.05$). Out of 33 cases with right seminal vesicle visualized by MRI, 31 were also visualized by TRUS.
- Left Seminal Vesicle Visualization: TRUS had a sensitivity of 96.3% and specificity of 100%, with an AUC of 0.98 ($p < 0.05$). In this case, 26 out of 27 visualized seminal vesicles by MRI also seen by TRUS.
- Right Ampulla Dilatation: The sensitivity of TRUS was 83.3% and specificity was 100%, with an AUC of 0.87 ($p < 0.05$). TRUS successfully identified 10 out of 12 cases of right ampulla dilatation diagnosed by MRI.
- Left Ampulla Dilatation: TRUS exhibited a sensitivity of 83.3% and specificity of 100%, with an AUC of 0.88 ($p < 0.05$). Like the right ampulla, TRUS accurately diagnosed 10 out of 12 cases of left ampulla dilatation identified by MRI.
- Right ED Dilatation: TRUS demonstrated perfect diagnostic accuracy, with 100% sensitivity and specificity, and an AUC of 1.0 ($p < 0.05$). All cases of right ED dilatation diagnosed by MRI were also identified by TRUS.
- Left ED Dilatation: TRUS also showed 100% sensitivity and specificity, with an AUC of 1.0 ($p < 0.05$), matching MRI's findings in all cases.
- Right ED Cyst: TRUS identified the single case of right ED cyst diagnosed by MRI, achieving 100% sensitivity and specificity.

Overall, these results indicate that TRUS is a highly effective and reliable imaging modality, comparable to MRI, for evaluating prostatic and seminal vesicle abnormalities, as well as for identifying conditions affecting the ampullae and ejaculatory ducts in patients with azoospermia.

3.2. Discussion

According to the World Health Organization (WHO), infertility is defined as the failure to achieve a clinical pregnancy after 12 months or more of regular, unprotected sexual intercourse. Azoospermia, absence of sperm in semen, can be categorized into obstructive and non-obstructive types. Non-obstructive azoospermia is typically caused by genetic factors and can be treated either medically, using gonadotropin, or surgically, through methods like microdissection testicular sperm extraction (MICRO-TESE) [5]. Obstructive azoospermia (OA) is often due to anatomical anomalies or embryological defects that block sperm transfer. It can also result from infections or trauma. Vasal reconstruction is a common treatment if obstruction is cause. Diagnosing azoospermia involves semen analysis, hormonal profiles, imaging as scrotal ultrasound, TRUS and MRI and lastly testicular biopsy [6]. Idea of this study is different from others as it challenges need for further expensive and advanced investigation, this will provide a rapid solution for infertility patient without compromising treatment they will receive. Mean age of participants was 28.8 years, with 33 patients (80.5%) being married and primarily presenting with primary infertility. All patients otherwise medically healthy. Diagnostic criteria for obstructive azoospermia in semen analysis include acidic pH (below 7), low semen volume (less than 1.5 ml), absence of sperm, and low fructose levels.

Fructose serves as a primary energy source for sperm and its presence indicates functioning vas deferens and seminal vesicles [7]. Our findings aligned with WHO criteria, showing low semen volume in all patients. Only 8 patients had low fructose levels, all of whom found to have obstructed systems. TRUS utilized to identify type of azoospermia. In obstructive cases, TRUS findings include enlarged seminal vesicle diameter (>1.5 cm) and ejaculatory duct diameter (>0.23 cm), suggestive of ejaculatory duct obstruction. Cysts or calcifications along duct further support this diagnosis. These findings may be absent in functional obstructions or partial blockages [8]. Assessment of prostate parameters using TRUS, noting that prostate size generally normal, with only four patients having prostatic cysts. These findings are consistent with previous studies, indicating that prostatic cyst, although rare, is a cause of azoospermia. TRUS of seminal vesicles traditionally involves measuring their dimensions. Recent suggestions include evaluating ejection fraction and volume, which can be more informative in cases of functional obstruction, diabetes mellitus. Due to practical constraints, such as patient refusal to ejaculate at examination, we used classical method. Seminal vesicle agenesis, a rare anomaly with less than 1% incidence, noted in our study.

Ejaculatory duct obstruction identified in about 30% of our patients, slightly higher than the 5% reported in literature, with only two patients showing cysts. All patients underwent pelvic MRI, which corroborated TRUS findings regarding prostate. When comparing TRUS and MRI, TRUS demonstrated excellent sensitivity and specificity for identifying seminal vesicle abnormalities, with 93% sensitivity and 100% specificity. For the vas deferens, TRUS showed 83% sensitivity and 100% specificity. There was no significant difference between TRUS and MRI regarding ejaculatory duct assessment. Results are similar other literatures [9-11]. Our findings are consistent with existing literature, suggests using TRUS as initial investigation, upgrading to MRI if results are inconclusive. MRI offers additional diagnostic parameters and can evaluate the entire reproductive system, identifying conditions like seminal vesicle vasculitis or hemorrhage, which TRUS cannot detect. However, there is no clear recommendation by European Urology Association (EUA) to routinely use MRI for diagnosing obstructive azoospermia while TRUS highly recommended for both diagnostic and therapeutic purposes. MRI is particularly useful in cases with inconclusive TRUS findings, supporting its role as a complementary tool rather than a primary diagnostic modality.

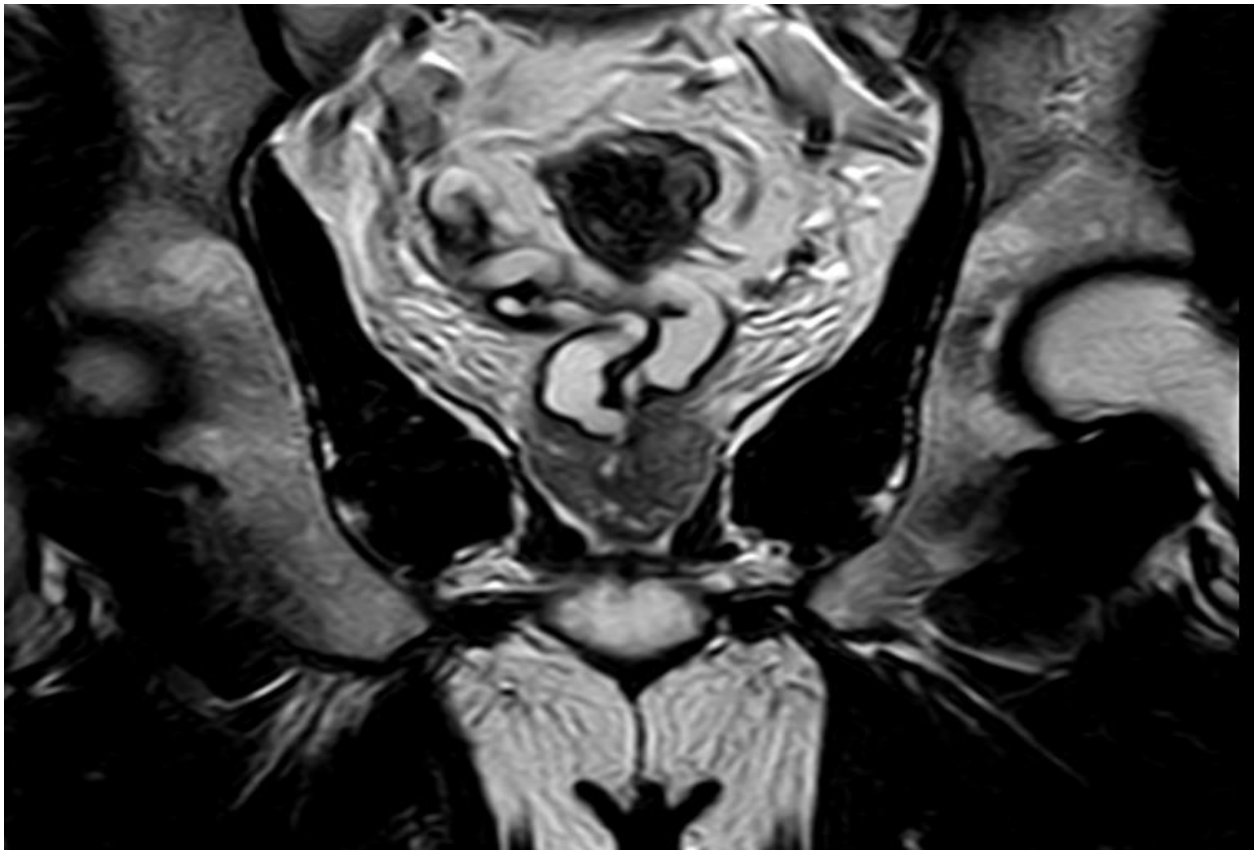

Figure 1. A. MRI T2 image coronal cuts showing Dilated both vasa deferentia (luminal diameter of the right measures +10mm and the left +8mm) showing mild thickening of its wall. Both vasa deferentia pass towards the right lateral pelvic wall (CONGENITAL RIGHT SIDED BOTH VASA DEFERENTIA). Dilated both ejaculatory ducts (luminal diameter of the right measures +7mm and the left +5mm). Non-visualized right and left seminal vesicles. The prostate measures +3.6x3x2.8cm, consistent with #16gm. It shows homogenous signal with no detected abnormal focal lesions.

Figure 1. B. TRUS axial and sagittal views showing dilated both right and left vasa deferentia (luminal diameters are 9.2& 8.2mm respectively)

Table 1. Semen analysis in the studied patients

	Studied patients (n= 41)
Semen volume (>1.5 ml)	
Low volume	28(68.2%)
Normal	13(31.7%)
Mean ± SD	2.19±1.17
Semen PH (7.2-8)	
Acidic	4(9.8%)
Alkaline	37(90.2%)
Fructose in semen (200-400 mg/dL)	
Low fructose	8(19.5%)
Normal fructose	33(80.5%)
Mean ± SD	200.73±62.47

Table 2. Comparison between TRUS and MRI finding regarding prostate, seminal vesicle, ampulla of vas and ED

		TRUS (N=41)	**MRI (N=41)**
Echogenicity of prostate	Homogenous	38(92.7%)	41(100%)
	Not homogenous	3(7.3%)	0
Prostatic cyst	No cyst	37(90.2%)	37(90.2%)
	Midline cyst	4(9.8%)	4(9.8%)
Prostatic volume	Mean ± SD	16±3.5	18±2.9
	Range	10.7:25	13:25
RT seminal vesical	Not visualized	10(24.4%)	8(19.5%)
	Visualized		
	• Normal	17(41.5%)	19(46.3%)
	• Dilated	10(24.4%)	10(24.4%)
	• Atrophic	4(9.8%)	4(9.8%)
	Cross section diameter (mm) in visualized SV	10.3±3.7 (5-19)	10.6±4 (4-20)
LT seminal vesical	Not visualized	15(36.3%)	14(34.1%)
	Visualized		
	• Normal	13(31.7%)	14(34.1%)
	• Dilated	9(22.2%)	9(22.2%)
	• Atrophic	4(9.8%)	4(9.8%)
	Cross section diameter (mm) in visualized SV	10.7±4 (6-18)	10.6±4.4 5:20
RT seminal vesical calcification	Not visualized	10(24.4%)	8(19.5%)
	Visualized		
	• Calcified	0	0
	• Not calcified	31(75.6%)	33(80.5%)
LT seminal vesical calcification	Not visualized	15(36.3%)	14(34.1%)
	Visualized		
	• Calcified	0	0
	• Not calcified	26(63.7%)	27(65.9%)
RT ampulla of Vas	Couldn't be visualized	16(39%)	13(31.7%)
	Visualized		
	• Normal	15(36.3%)	16(39%)
	• Dilated	10(24.4%)	12(29.3%)

		TRUS (N=41)	MRI (N=41)
LT ampulla of vas	**Cross section diameter**		
	• Mean ± SD	4.7±1.9	6±2.1
	• Range	2:8	3:10
	Couldn't be visualized	19(46.3%)	16(39%)
	Visualized		
	• Normal	12(29.3%)	13(31.7%)
	• Dilated	10(24.4%)	12(29.3%)
RT ED	**Cross section diameter**		
	• Mean ± SD	5±1.7	5.7±1.9
	• Range	3:8	3:10
	Dilated	29(70.7%)	29(70.7%)
	Not dilated	12(29.3%)	12(29.3%)
	Cyst	1(2.4)	1(2.4)
	No cyst	40(97.6%)	40(97.6%)
LT ED	Dilated	27(65.9%)	27(65.9%)
	Not dilated	14(34.1%)	14(34.1%)
	Cyst	0	0
	No cyst	41(100%)	41(100%)

MRI showed two interesting cases findings that TRUS didn't identify as one case showed absence of bilateral seminal vesicle while both vas are on same side, this wasn't seen by TRUS. Other case shows a mass like structure in base of prostate by TRUS, further evaluation by MRI identified hypoplastic bilateral seminal vesicle with normal vas different and a Mullerian duct remanent in base of prostate. Our results align with those of other researchers, such as Lotti et al., Xu Chen et al., Ragab H. Donkol, Purohit RS et al., and Heshmat S., suggest reserving MRI for non-conclusive cases after initial TRUS assessment. Sensitivity in diagnosing seminal vesicle abnormalities was 73.3%, according to Xu Chen. Donkol and Heshmat recommend MRI only for non-conclusive cases [12-13].

4. Conclusion

Our study supports the use of TRUS as the primary diagnostic tool for azoospermia, with MRI serving as a valuable secondary modality in complex cases. This approach ensures a thorough evaluation while optimizing resource use and patient care.

Conflict of interest: No conflict of interest is to be disclosed.

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