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Predictive Value of Pathological Vein Diameter for Semen Improvement After Varicocelectomy

Varikokelektomi Sonrası Semen Kalitesinin İyileşmesinde Patolojik Damar Çapının Öngörü Değeri

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Abstract

Objective: To compare the predictive value of clinical varicocele grade, color Doppler ultrasonography (CDUS)–measured venous diameter and pathologically measured venous diameter in predicting postoperative semen parameter improvement after microsurgical varicocelectomy.
Materials and Methods: This retrospective observational study included patients who underwent unilateral subinguinal microsurgical varicocelectomy between January 2022 and June 2025. Preoperative CDUS venous diameters (at rest and during Valsalva), clinical varicocele grade, intraoperatively excised pathological venous diameters, and semen analysis parameters were recorded. Improvement after varicocelectomy was defined as a ≥10% increase in sperm concentration and/or progressive motility. Correlation analyses and univariate and multivariate logistic regression models were used to identify predictors of postoperative improvement.
Results: A total of 55 patients were analyzed, of whom 44 (80.0%) demonstrated postoperative improvement in semen parameters. Pathological venous diameter was significantly larger in the improved group compared with the non-improved group (3.30 vs. 2.98 mm, p = 0.026). Pathological venous diameter showed a significant positive correlation with clinical grade (r = 0.307, p = 0.023), but not with CDUS-measured venous diameters. In multivariate analysis, higher clinical grade (Grade 2: OR = 4.523; Grade 3: OR = 6.544), larger pathological venous diameter (OR = 2.149), and lower preoperative sperm concentration (OR = 0.928) were independent predictors of postoperative semen improvement. CDUS-derived venous diameters were not predictive.
Conclusion: Pathological venous diameter and clinical varicocele grade appear to be more informative than CDUS-measured venous diameter in predicting semen parameter improvement after varicocelectomy. These findings suggest that the anatomical extent of venous dilation may better reflect the potential reversibility of varicocele-related testicular dysfunction.

Keywords: varicocele, varicocelectomy, semen analysis, color doppler ultrasonography, venous diameter

Özet

Amaç: Bu çalışmada, mikroskobik varikoselektomi sonrası semen parametrelerindeki iyileşmeyi öngörmede klinik varikosel evresi, renkli Doppler ultrasonografi (RDUS) ile ölçülen ven çapı ve patolojik olarak ölçülen ven çapının prediktif değerlerinin karşılaştırılması amaçlanmıştır.
Gereçler ve Yöntemler: Ocak 2022–Haziran 2025 tarihleri arasında unilateral subinguinal mikroskobik varikoselektomi uygulanan hastalar retrospektif olarak değerlendirildi. Preoperatif RDUS ile istirahat ve Valsalva sırasında ölçülen ven çapları, klinik varikosel evresi, intraoperatif olarak çıkarılan venlerin patolojik çapları ve semen analiz sonuçları kaydedildi. Varikoselektomi sonrası iyileşme, sperm konsantrasyonu ve/veya progresif motilitede ≥%10 artış olarak tanımlandı. Postoperatif iyileşmenin öngörücüleri korelasyon analizleri ile birlikte univaryant ve multivaryant lojistik regresyon analizleri kullanılarak değerlendirildi.
Bulgular: Toplam 55 hasta analiz edildi ve bunların 44'ünde (%80) semen parametrelerinde postoperatif iyileşme saptandı. Patolojik ven çapı, iyileşme gösteren grupta göstermeyen gruba kıyasla anlamlı derecede daha büyüktü (3.30 vs. 2.98 mm; p = 0.026). Patolojik ven çapı ile klinik evre arasında anlamlı pozitif korelasyon saptanırken (r = 0.307; p = 0.023), RDUS ile ölçülen ven çapları ile anlamlı bir ilişki izlenmedi. Multivaryant analizde; daha yüksek klinik evre (Evre 2: OR = 4.523; Evre 3: OR = 6.544), daha büyük patolojik ven çapı (OR = 2.149) ve daha düşük preoperatif sperm konsantrasyonu (OR = 0.928) postoperatif semen iyileşmesinin bağımsız öngörücüleri olarak belirlendi. RDUS kaynaklı ven çapları prediktif bulunmadı.
Sonuç: Patolojik ven çapı ve klinik varikosel evresi, varikoselektomi sonrası semen parametrelerindeki iyileşmeyi öngörmede RDUS ile ölçülen ven çapına kıyasla daha bilgilendirici görünmektedir. Bu bulgular, venöz dilatasyonun anatomik boyutunun varikosele bağlı testiküler disfonksiyonun potansiyel geri dönüşünü daha iyi yansıtabileceğini düşündürmektedir.

Anahtar kelimeler: varikosel, varikoselektomi, semen analizi, renkli doppler ultrasonografi, ven çapı

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Introduction

Varicocele, defined as the dilation and reflux of the pampiniform plexus veins, represents the most common and surgically correctable cause of male infertility [1]. It is identified in approximately 15% of men with primary infertility and up to 80% of those with secondary infertility [2]. The detrimental effects of varicocele on spermatogenesis have long been recognized, with several pathophysiological mechanisms, such as testicular hyperthermia, increased oxidative stress, hormonal dysfunction, and venous stasis, proposed to underlie impaired testicular function [3].

Although physical examination remains the cornerstone of diagnosis, its observer-dependent nature limits diagnostic accuracy [4]. Therefore, scrotal color Doppler ultrasonography (CDUS) has become a widely accepted complementary tool for confirming varicocele and assessing its severity [5]. Scrotal color Doppler ultrasonography provides an objective and quantitative assessment that supports clinical examination, as emphasized in previous reports [6]. In routine practice, a venous diameter >3 mm and reflux lasting longer than 2 seconds during the Valsalva maneuver are commonly regarded as diagnostic thresholds for clinical varicocele [7,8]. Furthermore, Schiff et al. reported in 2006 that patients with a venous diameter ≥3 mm accompanied by Valsalva-induced reflux experienced significant postoperative improvements in sperm count and motility [9].

However, the extent to which ultrasonographically measured venous diameters correspond to the actual macroscopic and morphological characteristics of dilated veins removed during surgery remains insufficiently investigated [10,11]. Only one study to date has shown that intraoperative venous diameters are systematically underestimated by preoperative CDUS [12]. The relationship between surgically measured venous size and postoperative semen improvement, or broader clinical infertility outcomes, thus remains unclear, representing a notable gap in the literature.

Our study aims to address this gap by evaluating the correlation between preoperative CDUS findings and intraoperative venous measurements, as well as exploring the association between surgically measured venous dimensions and postoperative semen parameters.

Material and Methods

This retrospective observational study was conducted by reviewing the medical records of patients who underwent microsurgical varicocelectomy between January 2022 and June 2025. Ethical approval was obtained from the institutional review board on 17 July 2025 (Protocol No. 12/23). No additional interventions were performed, and all data were extracted from the hospital's electronic medical record system.

A priori sample size calculation was performed based on the primary objective of assessing the association between two continuous variables (ultrasonographic vein diameter and surgically measured vein diameter) using correlation analysis. Using G*Power version 3.1, and assuming a moderate effect size ($r = 0.40$), a two-sided alpha level of 0.05, and 80% power ($1–\beta = 0.80$), the minimum required sample size was calculated as 47 patients. In addition, for the secondary outcome evaluating postoperative semen improvement, defined as a ≥10% increase in sperm concentration and/or progressive motility, an a priori sample size calculation was also performed. The calculation was based on a within-patient pre–post comparison of continuous semen parameters underlying this improvement definition. Assuming a moderate standardized effect size (Cohen's $d = 0.40$), a two-sided alpha level of 0.05, and 80% power ($1–\beta = 0.80$), a minimum sample size of approximately 50 patients was required.

A total of 55 patients aged 18–45 years who had a CDUS and underwent unilateral subinguinal microsurgical varicocelectomy were included. Exclusion criteria were: (i) previous scrotal surgery, (ii) bilateral varicocelectomy, (iii) missing or incomplete CDUS data, and (iv) incomplete follow-up records.

Preoperative CDUS data were obtained from archived radiology reports. All examinations were performed with the patient in the standing position, both at rest and during the Valsalva maneuver. For each patient, the maximum venous diameter measured at rest and during Valsalva was recorded.

During surgery, the dilated pampiniform plexus veins were excised and appropriately submitted to the pathology department. In the pathology unit, all venous segments were measured in millimeters, and the largest venous diameter for each patient was recorded.

Demographic characteristics [age, body mass index (BMI)], clinical parameters (presence of testicular atrophy, clinical grade), semen analysis results (concentration, progressive motility, morphology), preoperative CDUS venous diameters, and pathological venous diameters were evaluated. Testicular atrophy was determined based on CDUS-measured testicular volumes. Postoperative semen parameters were derived from sperm analysis performed at 6 months. Testicular volumes were calculated using the Lambert formula, and a reduction of more than 20% in the volume of the affected testis compared with the contralateral testis was considered indicative of testicular atrophy.

Previous studies have demonstrated that varicocelectomy typically results in an average improvement of approximately 9–10% in sperm concentration or progressive motility, a change considered clinically meaningful [13]. Therefore, improvement after varicocelectomy was defined as a ≥10% increase in sperm concentration and/or progressive motility in the postoperative semen analysis.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 25.0. Normality of continuous variables was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Continuous variables were expressed as mean ± SD or median (IQR), and categorical variables as frequencies and percentages. Correlations between pathological vein diameter and clinical/imaging variables were evaluated using Pearson or Spearman correlation analyses according to data distribution. To identify factors predicting postoperative improvement in semen parameters, a univariate logistic regression analysis was first conducted, and variables with a p value <0.20 were subsequently included in the multivariate logistic regression model. A two-tailed p value <0.05 was considered statistically significant.

Table 1. Demographic and clinical characteristics of the cohort

Variables	All, n= 55	Non-improved group, n=11	Improved group, n= 44	P
Age (years), mean±SD	30.09±7.17	30.18±9.98	30.07±6.43	0.963
BMI (kg/m²), median (IQR)	23.80 (5.10)	24.20 (4.60)	23.50 (5.25)	0.307
Testicular atrophy				
No, n (%)	49 (83.6)	9 (81.8)	37 (84.1)	0.657
Yes, n (%)	9 (16.4)	2 (18.2)	7 (15.9)	
Clinical grade				
1, n (%)	8 (14.5)	4 (36.4)	7 (6.8)	**0.049**
2, n (%)	27 (49.1)	5 (45.5)	24 (54.5)	
3, n (%)	20 (36.4)	2 (18.2)	13 (38.6)	
Preoperative vein diameter (rest) (mm), median (IQR)	3.00 (1.30)	3.00 (1.90)	3.00 (1.25)	0.533
Preoperative vein diameter (Valsalva) (mm), median (IQR)	3.60 (1.50)	3.70 (1.60)	3.60 (1.20)	0.332
Preoperative sperm motility percentage, median (IQR)	22.00 (31.00)	45.00 (66.00)	20.50 (24.00)	0.332
Postoperative sperm motility percentage, median (IQR)	36.00 (32.00)	10.00 (60.20)	36.50 (21.75)	**0.042**
Preoperative sperm concentration (million/mL), median (IQR)	4.00 (7.80)	15.00 (31.90)	3.60 (6.08)	0.146
Postoperative sperm concentration (million/mL), median (IQR)	8.00 (21.80)	4.50 (26.20)	8.25 (20.95)	0.274
Preoperative normal morphology percentage, median (IQR)	1 (2)	1(2)	1(2)	0.297
Postoperative normal morphology percentage, median (IQR)	1 (2)	2 (2)	1 (2)	0.956
Pathological vein diameter (mm), median (IQR)	3.20 (0.97)	2.98 (1.18)	3.30 (0.97)	**0.026**

SD: standard deviation; BMI: body mass index; IQR: interquartile range. Values shown in bold indicate statistical significance ($p < 0.05$).

Results

The demographic, clinical, CDUS, and semen parameters of the entire cohort, along with the comparisons between patients with and without improvement in semen parameters, are presented in **Table 1**. The mean age was 30.09 ± 7.17 years and the median BMI was 23.80 (IQR: 5.10) kg/m². Testicular atrophy was present in 16.4% of the cohort. Clinical grading showed that 14.5% of patients were classified as Grade 1, 49.1% as Grade 2, and 36.4% as Grade 3. Preoperative CDUS revealed a median venous diameter of 3.00 mm (IQR: 1.30) at rest and 3.60 mm (IQR: 1.50) during the Valsalva maneuver. The median pathological venous diameter was 3.20 mm (IQR: 0.97).

Postoperative semen analysis demonstrated overall improvement in sperm parameters. Median progressive sperm motility increased from 22.0% (IQR: 31.0) preoperatively to 36.0% (IQR: 32.0) postoperatively, and median sperm concentration increased from 4.00 (IQR: 7.80) million/mL to 8.00 (IQR: 21.80) million/mL. Sperm morphology did not show any significant change. Based on the study definition of benefit, an increase of at least 10% in sperm concentration and/or motility, 44 patients (80.0%) were categorized into the improved group, while 11 patients (20.0%) showed no meaningful improvement.

Comparison between the improved and non-improved groups revealed no significant differences in age, BMI, presence of testicular atrophy, CDUS-measured preoperative venous diameters, or preoperative semen parameters (all $p > 0.05$). However, pathological venous diameter was significantly larger in the improved group compared with the non-improved group (3.30 mm vs. 2.98 mm; $p = 0.026$). Clinical grade distribution

Table 2. Correlation analysis between pathological venous diameter and clinical grade, preoperative resting vein diameter, and Valsalva vein diameter

Variables	Spearman's rho	95% CI	P
Clinical grade	0.307	0.037-0.535	**0.023**
Preoperative vein diameter (rest)	0.255	-0.019-0.494	0.060
Preoperative vein diameter (Valsalva)	0.247	-0.028-0.487	0.069

CI: confidence interval. Values shown in bold indicate statistical significance ($p < 0.05$).

Table 3. Univariate and multivariate logistic regression analysis for predictors of improvement after varicocelectomy

Variables	Univariate			Multivariate		
	OR	95% CI	p	OR	95% CI	P
Age (years)	0.998	0.909–1.095	0.962			
BMI (kg/m²)	0.893	0.704–1.133	0.352			
Testicular atrophy						
No	Reference					
Yes	0.831	0.220–3.142	0.785			
Clinical grade						
1	Reference					
2	2.400	1.079–5.960	**0.041**	4.523	1.968–15.407	**0.018**
3	3.333	1.395–7.056	**0.023**	6.544	1.350–15.582	**0.031**
Preoperative vein diameter (rest) (mm)	0.672	0.353–1.280	0.227			
Preoperative vein diameter (Valsalva) (mm)	0.658	0.350–1.235	0.192	0.715	0.197–2.592	0.609
Preoperative sperm motility percentage	0.975	0.945–1.005	0.106	0.986	0.947–1.027	0.499
Preoperative sperm concentration (million/mL)	0.925	0.867–0.986	**0.018**	0.928	0.862–0.999	**0.048**
Preoperative normal morphology percentage	0.714	0.388–1.314	0.279			
Pathological vein diameter (mm)	1.384	1.065–6.751	**0.039**	2.149	1.115–8.562	**0.049**

BMI: body mass index; OR: odds ratio; CI: confidence interval. Variables with a univariate p-value <0.20 were included in the multivariate model. Values shown in bold indicate statistical significance ($p < 0.05$).

also differed between the groups ($p = 0.049$), with Grade 3 varicocele being more frequent in the improved group and Grade 1 more common in the non-improved group.

The correlation analysis examining the relationship between pathological venous diameter and preoperative CDUS-measured venous diameters at rest and during the Valsalva maneuver, as well as clinical varicocele grade, is presented in **Table 2**. Correlation analysis demonstrated that pathological venous diameter had a significant positive correlation with clinical grade ($r = 0.307$; 95% CI: 0.037–0.535; $p = 0.023$). In contrast, no statistically significant correlation was observed between pathological venous diameter and ultrasonographically measured venous diameters, either at rest ($r = 0.255$; $p = 0.060$) or during the Valsalva maneuver ($r = 0.247$; $p = 0.069$).

The logistic regression analysis performed to identify independent predictors of improvement in semen parameters is presented in **Table 3**. Multivariate results showed that higher clinical grade was independently associated with a greater likelihood of postoperative improvement (Grade 2: OR = 4.523, $p = 0.018$; Grade 3: OR = 6.544, $p = 0.031$). Lower preoperative sperm concentration also predicted improvement (OR = 0.928; $p = 0.048$). Additionally, pathological venous diameter emerged as an independent predictor of postoperative benefit (OR = 2.149; $p = 0.049$). No significant associations were found for age, BMI, testicular atrophy, preoperative venous diameters, motility, or morphology.

Discussion

In this study, we investigated the relationship between preoperative CDUS findings, surgically excised venous dimensions, and postoperative semen outcomes in patients undergoing microsurgical varicocelectomy. The key finding of our analysis is that the pathological venous diameter, rather than the CDUS-measured vein diameter, demonstrated a significant association with both clinical varicocele grade and postoperative improvement in semen parameters. Although CDUS remains a widely used diagnostic tool, its measurements showed no significant correlation with the actual venous size determined by pathology. Importantly, clinical grade, larger pathological venous diameter, and lower preoperative sperm concentration emerged as independent predictors of postoperative improvement.

Color Doppler ultrasonography is widely used as a complementary tool in varicocele evaluation, yet previous evidence shows that both its diagnostic performance and its ability to predict varicocelectomy outcomes remain inconsistent. Cocuzza et al. demonstrated that the diagnostic accuracy of physical examination varies significantly according to examiner experience, while CDUS provides a more objective and standardized assessment that improves interobserver agreement compared with physical examination alone [11]. However, Wosnitzer et al. reported that preoperative ultrasound measurements systematically underestimate venous diameter

relative to intraoperative findings, indicating a structural discrepancy between sonographic appearance and true anatomic vein size [12]. Regarding postoperative semen improvement, Schiff et al. showed that men with a venous diameter ≥3 mm accompanied by Valsalva-induced reflux experienced significantly greater gains in sperm concentration and motility following varicocelectomy [9]. In contrast, Babai et al. found that CDUS-detected reflux had no measurable effect on baseline semen parameters and did not predict postoperative improvement [14]. In the present study results also indicate that CDUS-derived venous measurements alone do not reliably reflect the true venous anatomy and are limited in predicting varicocelectomy success. Instead, pathologically measured venous diameter, together with clinical varicocele grade emerged as the parameters most closely associated with postoperative semen improvement, suggesting that true anatomic dilatation may better capture the reversible pathophysiological burden of varicocele.

Because pathological venous diameter is obtained intraoperatively and confirmed postoperatively, it cannot be used for preoperative patient evaluation, surgical indication, or decision-making. Therefore, its clinical utility differs fundamentally from that of clinical varicocele grade and preoperative CDUS parameters. Nevertheless, pathological vein diameter appears to reflect the true anatomic severity of venous dilatation more accurately than ultrasonographic measurements and may be more closely associated with the reversibility of varicocele-related testicular dysfunction. From a practical perspective, this finding mainly informs postoperative patient counselling, as larger excised venous diameters are associated with a higher likelihood of meaningful improvement in semen parameters. Indirectly, it also reinforces the importance of careful physical examination and clinical grading over sole reliance on CDUS-derived vein diameter in routine clinical practice.

The lack of correlation between CDUS-measured venous diameters and pathological vein size in our study can be explained by several technical and physiological factors known to affect ultrasonographic assessment. Venous measurements on CDUS are influenced by probe pressure, patient position, and dynamic venous distension, which can lead to systematic underestimation [12]. The finding that pathological venous diameter correlates with postoperative semen improvement may reflect the greater reversibility of advanced venous congestion: larger varicoceles are associated with more pronounced testicular hyperthermia, oxidative stress, and impaired spermatogenesis [3,15,16]. Thus, once abnormal venous drainage is corrected surgically, men with more severe underlying venous dilation may experience greater functional recovery. The independent predictive value of higher clinical grade is aligned with this interpretation, as clinical grading reflects the degree of venous dilation and reflux. Furthermore, the association between lower preoperative sperm concentration and greater postoperative improvement is consistent with prior evidence showing that men with more severely impaired baseline semen parameters often exhibit the most measurable postoperative gains following varicocelectomy [13].

A major strength of this study is that it directly compares preoperative CDUS findings with pathologically measured venous diameters, a relationship that has received limited attention in the literature. The use of homogeneous surgical technique performed by a single experienced microsurgeon minimizes procedural variability and enhances internal validity. Additionally, the integration of imaging, clinical, pathological, and postoperative semen parameters provides a comprehensive assessment of factors influencing reproductive outcomes after varicocelectomy.

However, several limitations must be acknowledged. The retrospective design introduces inherent risks of missing data and potential selection bias. Pathological venous measurements may be influenced by tissue handling and formalin fixation, which can introduce minor variations compared with in vivo anatomy. Semen analysis results are subject to natural intra-individual variability, and multiple ejaculates were not consistently available for all patients. Additionally, although semen improvement was assessed, patients' actual fertility outcomes were not evaluated, representing an important limitation. Furthermore, because this was a single-center study with a relatively modest sample size, the generalizability of the findings may be restricted. Prospective multicenter studies with standardized intraoperative venous measurements are needed to validate these observations and to better define the prognostic value of actual venous morphology in predicting postoperative reproductive outcomes.

Conclusion

In conclusion, pathological venous diameter emerged as a significant predictor of postoperative improvement in semen parameters, whereas CDUS-measured vein diameters showed no meaningful correlation with either actual venous anatomy or reproductive outcomes. Clinical grade and lower preoperative sperm concentration were also independently associated with greater postoperative benefit. These findings suggest that the true structural severity of venous dilation, better reflected by pathological measurement than by ultrasonography, may play a more decisive role in the reversibility of varicocele-related testicular dysfunction. Further prospective studies incorporating standardized intraoperative measurements are warranted to validate these results and refine prognostic assessment in men undergoing varicocelectomy.

Ethics Committee Approval: Ethical approval was obtained from the Ethics Committee of Antalya Training and Research Hospital on 17 July 2025 (Protocol No. 12/23).
Informed Consent: An informed consent was obtained from all the patients.
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References

[1] Baazeem A, Belzile E, Ciampi A, Dohle G, Jarvi K, Salonia A, et al. Varicocele and male factor infertility treatment: a new meta-analysis and review of the role of varicocele repair. Eur Urol 2011;60(4):796-808. https://doi.org/10.1016/j.eururo.2011.06.018

[2] Jensen CFS, Østergren P, Dupree JM, Ohl DA, Sønksen J, Fode M. Varicocele and male infertility. Nat Rev Urol 2017;14(9):523-33. https://doi.org/10.1038/nrurol.2017.98

[3] Agarwal A, Hamada A, Esteves SC. Insight into oxidative stress in varicocele-associated male infertility: part 1. Nat Rev Urol 2012;9(12):678-90. https://doi.org/10.1038/nrurol.2012.197

[4] Diegidio P, Jhaveri JK, Ghannam S, Pinkhasov R, Shabsigh R, Fisch H. Review of current varicocelectomy techniques and their outcomes. BJU Int 2011;108(7):1157-72. https://doi.org/10.1111/j.1464-410X.2010.09959.x

[5] Liguori G, Trombetta C, Garaffa G, Bucci S, Gattuccio I, Salamè L, et al. Color Doppler ultrasound investigation of varicocele. World J Urol 2004;22(5):378-81. https://doi.org/10.1007/s00345-004-0421-0

[6] EAU Guidelines. Edn. presented at the EAU Annual Congress Madrid 2025. Arnhem, The Netherlands: EAU Guidelines Office; 2025.

[7] Horstman WG, Middleton WD, Melson GL, Siegel BA. Color Doppler US of the scrotum. Radiographics 1991;11(6):941-58. https://doi.org/10.1148/radiographics.11.6.1749858

[8] Shridharani A, Owen RC, Elkelany OO, Kim ED. The significance of clinical practice guidelines on adult varicocele detection and management. Asian J Androl 2016;18(2):269-75. https://doi.org/10.4103/1008-682X.172641

[9] Schiff JD, Li PS, Goldstein M. Correlation of ultrasound-measured venous size and reversal of flow with Valsalva with improvement in semen-analysis parameters after varicocelectomy. Fertil Steril 2006;86(1):250-2. https://doi.org/10.1016/j.fertnstert.2005.12.038

[10] Agarwal A, Esteves SC. Varicocele and male infertility: current concepts and future perspectives. Asian J Androl 2016;18(2):161-2. https://doi.org/10.4103/1008-682X.172819

[11] Cocuzza MS, Tiseo BC, Srougi V, Wood GJA, Cardoso JPGF, Esteves SC, et al. Diagnostic accuracy of physical examination compared with color Doppler ultrasound in the determination of varicocele diagnosis and grading: Impact of urologists' experience. Andrology 2020;8(5):1160-6. https://doi.org/10.1111/andr.12797

[12] Wosnitzer M, Dabaja A, Goldstein M. Preoperative ultrasound varicocele vein diameter underestimates intraoperative assessment. Fertil Steril 2014;102(3):e188. https://doi.org/10.1016/j.fertnstert.2014.07.635

[13] Agarwal A, Cannarella R, Saleh R, Boitrelle F, Gül M, Toprak T, et al. Impact of Varicocele Repair on Semen Parameters in Infertile Men: A Systematic Review and Meta-Analysis. World J Mens Health 2023;41(2):289-310. https://doi.org/10.5534/wjmh.220142

[14] Babai M, Gharibvand MM, Momeni M, Khazaeli D. Comparison of pre-operative and post-operative (varicocelectomy) sperm parameters in patients suffering varicocle with and without reflux in Doppler ultrasonography. J Family Med Prim Care 2019;8(5):1730-4. https://doi.org/10.4103/jfmpc.jfmpc_170_19

[15] Hamada A, Esteves SC, Agarwal A. Insight into oxidative stress in varicocele-associated male infertility: part 2. Nat Rev Urol 2013;10(1):26-37. https://doi.org/10.1038/nrurol.2012.198

[16] Esteves SC, Miyaoka R, Roque M, Agarwal A. Outcome of varicocele repair in men with nonobstructive azoospermia: systematic review and meta-analysis. Asian J Androl 2016;18(2):246-53. https://doi.org/10.4103/1008-682X.169562