Original Article

Testicular arterial blood flow volume in predicting semen improvement following microscopic subinguinal varicocelectomy

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Background: Varicocele is a significant but treatable contributor to male infertility. The efficacy of varicocelectomy in improving sperm quality is not consistent, with only 60–80% of patients experiencing improved semen quality. This prospective cohort study aimed to evaluate the effect of microscopic subinguinal varicocelectomy (MSV) on testicular arterial blood flow volume (TABFV) and to determine the value of preoperative TABFV in predicting the outcome of MSV.

Methods: Patients with varicocele who underwent MSV at the same clinical center between July 2020 and April 2023 were enrolled. All patients underwent ultrasound assessment and at least one semen analysis before and after MSV. Both univariate and multivariate logistic regression analyses were performed to assess the association between pre-MSV variables and semen improvement after MSV. Subsequently, a diagnostic model was developed.

Results: This study enrolled 96 patients with varicocele, including 31 who showed semen improvement after MSV and 65 who did not. The postoperative semen-improved group demonstrated a significant increase in TABFV of the right testis (TABFV-R) and left testis (TABFV-L) (P<0.001). Notably, the postoperative TABFV-L was more than twice the preoperative TABFV-L. Preoperative TABFV-R and a combination of subclinical right-sided varicocele were found to be associated with semen improvement after MSV, and a diagnostic model was developed using these two variables. The diagnostic model exhibited satisfactory performance, with an area under the curve (AUC) of 0.824 [95% confidence interval (CI): 0.735–0.913], which was further validated internally yielding an AUC of 0.824 (95% CI: 0.726–0.900). Additionally, calibration analysis confirmed that the diagnostic model was well calibrated, and the Hosmer-Lemeshow test resulted in a P value of 0.794. The decision curve demonstrated that using this proposed nomogram would yield a net benefit if the threshold probability for semen improvement after MSV exceeded 10%.

Conclusions: TABFV-L demonstrated potential utility in clinical practice for assessing outcomes of MSV, and the diagnostic model incorporating TABFV-R and a combination of right-side varicocele performed well in predicting improvements in semen parameters following MSV.

Keywords: Male infertility; semen analysis; varicocele; varicocelectomy; testicular artery

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Introduction

Varicocele is a significant and treatable contributor to male infertility, affecting approximately 15% of men. It exhibits a high prevalence among males experiencing infertility, accounting for 35% of cases of primary infertility and 80% of secondary infertility (1). It is characterized by the reflux of venous blood into the testicular veins, resulting in an elevation in testicular temperature, oxidative stress, and a reduction in testicular oxygen tension that can impair spermatogenesis (1).

The efficacy of varicocelectomy in improving sperm quality or fertility is not consistent, with only 60–80% of patients experiencing improved semen quality following surgery (2,3) and 25–40% of couples achieving natural pregnancies (4,5). The criteria for varicocelectomy in infertile men remain a topic of debate. Current guidelines from the American Society for Reproductive Medicine, the European Association of Urology, and the American Urological Association primarily recommend the procedure for men with low semen quality and healthy female partners (6-8). However, according to the National Institute for Health and Clinical Excellence guidelines, varicocelectomy should not be considered as a treatment option for infertility due to a lack of insufficient evidence supporting its ability to improve conception rates (9). Therefore, there is an urgent need to introduce new preoperative evaluation parameters for infertile men with varicocele to identify which patients could benefit from varicocelectomy.

Varicocele can lead to impaired testicular reflux, resulting in increased venous pressure. In men with varicocele, there is an average increase of 19.7 mmHg in spermatic plexus pressure compared to controls (10). Venous hypertension is transmitted to the testes, leading to a reduction in arterial blood flow volume as a mechanism to maintaining pressure homeostasis in the testis (11). One study found a significant decrease in testicular artery blood supply among men with varicocele (12). Although the underlying mechanisms of varicocele-induced infertility are still poorly understood, reduced arterial blood supply to the testes is believed to be a major contributing factor. The testicular artery serves as the sole supplier of blood to the testis, and monitoring its blood flow can provide real-time information about the blood supply. However, due to its relatively small size, its detection poses technical challenges. The advancements in ultrasound imaging have significantly enhanced the frame rate, range, and quality of blood flow imaging, thereby revolutionizing our ability to visualize and quantify small spatial blood flow signals and the instantaneous loss of blood flow within the testes.

Previous studies have demonstrated that scrotal Doppler ultrasound parameters, such as spermatic vein diameter, varicocele grade, and duration of venous reflux, along with conventional sperm parameters, sperm DNA fragmentation index, testicular volume, and bilateral varicocelectomy, can serve as predictors for semen improvement following microscopic varicocelectomy (13). However, there is currently a lack of research on using testicular arterial blood flow volume (TABFV) as a predictor for semen improvement after microscopic subinguinal varicocelectomy (MSV).

Therefore, this study aimed to investigate the impact of MSV on TABFV in a homogeneous patient cohort and determine whether TABFV could serve as a predictor for semen improvement following MSV. We present this article in accordance with the STROBE reporting checklist (available at https://qims.amegroups.com/article/view/10.21037/qims-24-105/rc).

Methods

Participant screening and enrollment

This prospective cohort study adhered to the Declaration of Helsinki (as revised in 2013) for medical research involving human subjects and obtained approval from the Ethics Committee of Shengjing Hospital of China Medical University (No. 2020PS123J). All enrolled participants provided written informed consent prior to their involvement. Initially, a total of 146 consecutive individuals with varicocele who sought treatment at the Reproductive Medical Center of Shengjing Hospital of China Medical University between July 2020 and June 2023 and underwent MSV were included. To minimize selection bias, rigorous inclusion and exclusion criteria were established.

The male participants in our study were selected from couples who had been unable to conceive after 12 months or more of unprotected sex. All of them exhibited varicocele upon physical examination, which was subsequently confirmed by ultrasound imaging. The participants expressed a strong desire for surgical intervention. Their female partners either had no abnormalities or had curable conditions and were under the age of 35 years. The male participants underwent microscopic varicocelectomy through a subinguinal incision (41 of whom also underwent simultaneous bilateral procedures due to the presence of subclinical right-sided varicocele), and at least one semen analysis and one ultrasound assessment were conducted before and after the procedure.

The exclusion criteria were the following: (I) presence of

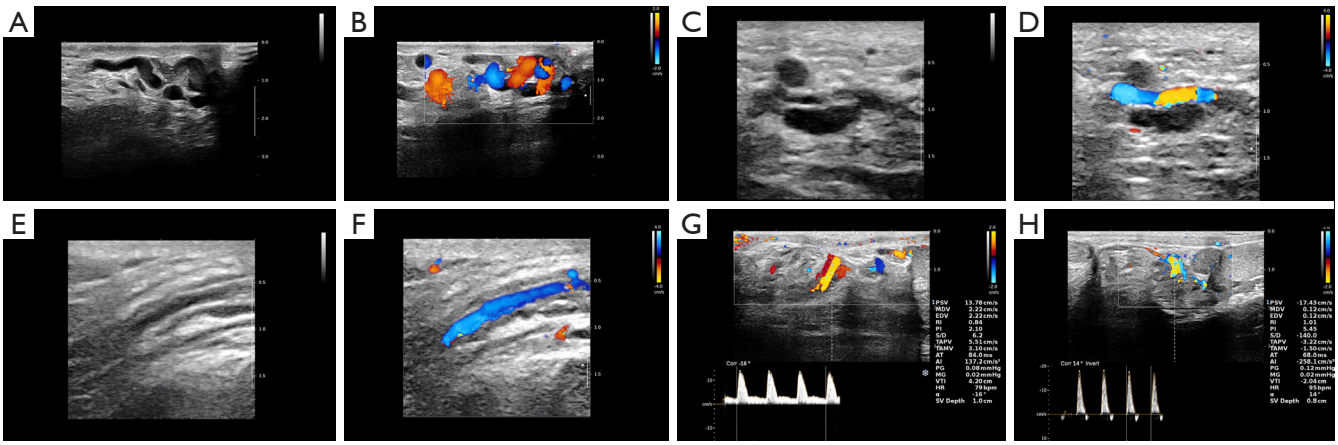

Figure 1 Ultrasound images for the detection of the testicular artery and spermatic vein. (A) Gray-scale ultrasound image of the spermatic vein. (B) Color Doppler flow image of the spermatic vein. (C) Gray-scale ultrasound image of the left testicular artery. (D) Color Doppler flow image of the left testicular artery. (E) Gray-scale ultrasound image of the right testicular artery. (F) Color Doppler flow image of the right testicular artery. (G) Ultrasound blood flow parameters of the testicular artery with a normal spectrum. (H) Ultrasound blood flow parameters indicating abnormality in the testicular artery. PSV, peak systolic velocity; MDV, mean diastolic velocity; EDV, end diastolic velocity; RI, resistance index; PI, pulsatility index; S/D, peak systolic velocity/end diastolic velocity; TAPV, time-averaged peak velocity; TAMV, time averaged mean velocity; AT, acceleration time; AI, augmentation index; PG, peak gradient; MG, mean gradient; VTI, velocity time integral; HR, heart rate; SV depth, maximum valley depth.

obstructive azoospermia; (II) existence of solitary right-side varicocele; (III) absence of at least one ultrasound examination and semen analysis before or after MSV; (IV) occurrence of varicocele relapse, defined as the presence of varicocele 3 months after MSV confirmed through both clinical evaluation and ultrasound assessment; (V) presence of pituitary tumor; and (VI) existence of chromosome abnormalities.

Instruments and methods (Figure 1)

The diagnostic ultrasound imaging system Aixplorer (SuperSonic Imagine, Aix en Provence, France) was used for conducting gray-scale ultrasound and color Doppler flow imaging. A linear transducer with a frequency of 4–15 MHz was used. The scrotal ultrasound procedure was carried out by a radiographer with a 15-year background in andrology who was blinded to the clinical information.

The patient was positioned in a supine posture during the ultrasound examination. The scrotum and inguinal region were examined with grayscale ultrasound and color Doppler flow imaging. The diagnosis of varicocele was determined using the scoring system established by Chiou *et al.* (14), which closely resembles palpation by a urologist. The internal diameter of the testicular artery was measured, and its cross-sectional area was calculated using the formula for circle area. Pulsed-wave Doppler was used to measure the time-averaged mean velocity (TAMV; cm/s) of the testicular artery. TABFV (cm^3/min) was then calculated as follows: TABFV = testicular artery cross-sectional area × TAMV × 60. TABFV values for both the right testis (TABFV-R) and left testis (TABFV-L) were recorded (*Figure 1*).

The calculation of testicular volume was based on the Lambert formula, which involves multiplying the length, width, and height by a factor of 0.71 (15). The volumes of the left testis (volume-L) and right testis (volume-R) were recorded separately.

The severity of varicocele was classified according to the method specified by Dubin and Amelar (16). The participants were assessed while standing, with grade 1 indicating detectable spermatic veins during the performance of the Valsalva maneuver, grade 2 indicating palpable spermatic veins without the Valsalva maneuver being performed, and grade 3 indicating dilated spermatic veins visible through the scrotal skin.

Semen collection and analysis

The semen samples were obtained by self-stimulation in designated rooms for semen collection after a period of abstinence ranging from 3 to 7 days. Following the guidelines

outlined in the fifth edition of the World Health Organization (WHO) manual (17), a semen analysis was conducted. The parameters evaluated included volume, sperm count, sperm motility, and morphology. Both internal and external quality procedures were implemented by the laboratory.

The preoperative semen results exhibited abnormalities, and the most optimal outcome was selected for inclusion in the analysis. Semen analyses were conducted at least once between 3 to 12 months postoperatively, and the best result was included in the analysis (18). The improvement in semen quality was defined as an increase in parameters within the reference range as specified by the sixth edition of the WHO manual (19). For participants with oligozoospermia, the sperm concentration was required to be 16×10^6/mL, while for participants with asthenozoospermia, either progressive motility was required reach up to 30% or total motility was required to reach 42%. Additionally, for patients with isolated teratozoospermia, when the sperm deformity rate was increased to 4%, it was considered an improvement in the semen. In cases of azoospermia, the presence of spermatozoa in the ejaculate served as a criterion for improved semen quality.

Outcomes

The primary outcome of the study was TABFV. Secondary outcomes included testicular volume, internal diameter of the left spermatic vein, varicocele grade, a combination of subclinical right-sided varicocele, and conventional semen parameters (including semen volume, sperm concentration, total sperm number, total motility, progressive motility, and sperm deformity rate).

Development and validation of a nomogram for predicting semen improvement following MSV

To ensure model accuracy, we restricted the number of events per variable by dividing the total number of events or outcomes by 15. To investigate the significant factors affecting the prediction of semen improvement after MSV, we used both univariate and multivariate logistic regression analyses. To identify independent variables that significantly predict semen improvement following MSV, we further examined variables with a P value of 0.1 or lower from the univariate analysis using multivariate logistic regression to construct a diagnostic model. Based on this model, we developed a nomogram. The discriminatory ability of the model was evaluated by calculating the area under the curve (AUC). We performed internal validation using bootstrapping method with 500× resampling (20). The calibration curve was plotted to assess the concordance between predicted and observed probabilities for postoperative semen analysis improvement. Bootstrap resampling (500 resamples) was employed for generating this plot. The Hosmer-Lemeshow goodness of fit test was also used to assess the model fit. The clinical utility of this nomogram was assessed through the application of decision curve analysis (DCA) (21).

Statistical analysis

The statistical analyses were conducted using SPSS 25 (IBM Corp., Armonk, NY, USA) and R software version 4.2.0 (https://www.r-project.org/).

The preliminary analysis was performed to describe the ultrasound characteristics and semen analysis results of participants with varicocele before and after MSV. The Kolmogorov-Smirnov normality test was used to evaluate the distribution's normality. Continuous variables are presented as the mean ± standard deviation or as median and the 25th and 75th percentiles, while categorical variables are expressed as frequencies (percentages). Group comparisons were conducted using a *t*-test, Mann-Whitney test, or Chi-squared test. Comparisons of matched data were conducted using the Wilcoxon test and related *t*-test. $P<0.05$ indicated statistical significance.

The diagnostic model was established and evaluated using R software. Univariate and multivariate logistic regression analyses were conducted using the "glm" R package, the generation of the nomogram and calibration curve was accomplished with "rms" R package, plotting of the receiver operating characteristic (ROC) curve and calculation of the AUC were executed using the "pROC" R package, DCA was conducted with the "rmda" R package.

Results

Participant screening and enrollment

The process of participant screening and enrollment is illustrated in *Figure 2*.

Baseline participant characteristics

The baseline participant characteristics are illustrated in *Table 1*.

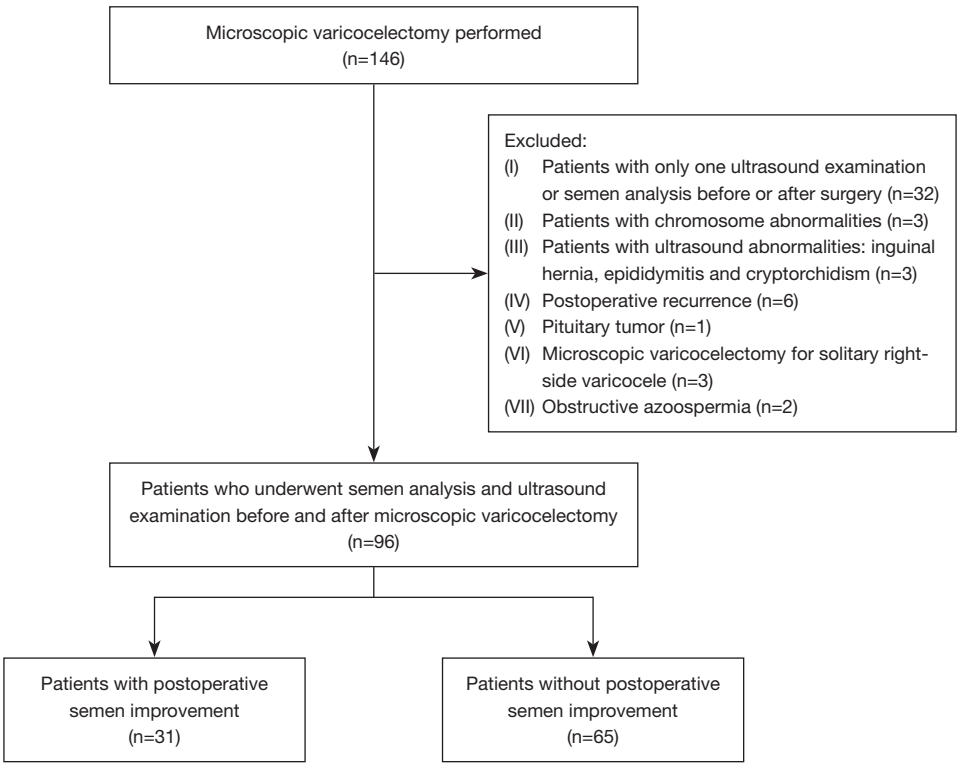

Figure 2 Participant screening and enrollment.

Comparisons of TABFV and semen analysis results between pre- and post-MSV in postoperative semen-improved and non-improved groups

Comparison of TABFV and semen analysis results between pre- and post-MSV is summarized in Table S1. In the postoperative semen-improved group, there was an improvement compared to preoperative values in both TABFV-R and TABFV-L, and the difference was statistically significant (P<0.001). Notably, TABFV-L exhibited more than a twofold increase postoperatively compared to preoperatively. In contrast, in the postoperative semen-nonimproved group, there was only a slight increase in TABFV-L observed (P<0.001).

TABFV-R, TABFV-L, and semen analysis results between the semen-improved and -nonimproved groups pre- and post-MSV

Comparisons of TABFV-R, TABFV-L, and semen analysis results between the semen-improved and semen-nonimproved groups pre- and post-MSV are provided in *Table 2*. There was a statistically significant difference between the improved group and the nonimproved group in terms of pre-MSV TABFV-R (P<0.001), TABFV-L (P<0.001), and total motility (P=0.035). However, after MSV, the improved group exhibited significant improvement compared to the nonimproved group in terms of TABFV-R (P<0.001), TABFV-L (P<0.001), sperm concentration (P<0.001), total sperm number (P<0.001), progressive motility and sperm deformity rate (P=0.002).

Development and validation of a diagnostic model for predicting postoperative semen improvement after MSV

Both univariate and multivariate logistic regression analyses were performed to assess the association between the variables and semen improvement after MSV. As presented in *Table 3*, volume-L, volume-R, TABFV-R, TABFV-L, progressive motility, and a combination of subclinical right-sided varicocele showed significant associations with semen improvement (P<0.1) in univariate logistic regression analysis. In the multivariate logistic regression analysis, we identified that TABFV-R and a combination of subclinical right-sided varicocele were independent predictors for

Table 1 Baseline participant characteristics

Variable	Total (n=96)	Nonimproved group (n=65)	Improved group (n=31)	P
Age (years)	32.729±4.775	33.123±5.061	31.903±3.987	0.246
Subclinical right-sided varicocele				0.097
Uncombined	55 (57.292)	41 (63.077)	14 (45.161)	
Combined	41 (42.708)	24 (36.923)	17 (54.839)	
Group-semen				–
Isolated teratozoospermia	10 (10.417)	5 (7.692)	5 (16.129)	
Asthenozoospermia	51 (53.125)	34 (52.308)	17 (54.839)	
Oligozoospermia	24 (25.000)	15 (23.077)	9 (29.032)	
NOA	11 (11.458)	11 (16.923)	0 (0.000)	
Varicocele grade				0.447
1	41 (42.708)	29 (44.615)	12 (38.710)	
2	26 (27.083)	19 (29.231)	7 (22.581)	
3	29 (30.208)	17 (26.154)	12 (38.710)	
Diameter of the spermatic vein (cm)	0.290 [0.270, 0.340]	0.290 [0.270, 0.330]	0.310 [0.250, 0.340]	0.893
Volume-L (mL)	13.060 [10.450, 15.570]	12.820 [9.190, 14.370]	14.840 [12.020, 16.220]	0.006
Volume-R (mL)	14.200 [11.460, 17.250]	13.600 [10.340, 16.120]	16.030 [13.290, 18.370]	0.008

Values are presented as mean ± SD, n (%) or median (25th, 75th percentile). Volume-L, testicular volume of the left testis; Volume-R, testicular volume of the right testis; NOA, nonobstructive azoospermia; SD, standard deviation.

Table 2 Comparisons of TABFV-R, TABFV-L, and semen analysis results between the semen-improved and semen-nonimproved groups pre-MSV and post-MSV

Variable	Pre-MSV			Post-MSV		
	Nonimproved group (n=65)	Improved group (n=31)	P	Nonimproved group (n=65)	Improved group (n=31)	P
TABFV-R (cm^3/min)	1.010 (0.720, 1.180)	1.460 (1.230, 1.610)	<0.001	1.012±0.418	1.758±0.457	<0.001
TABFV-L (cm^3/min)	0.800 (0.470, 0.960)	1.170 (0.810, 1.440)	<0.001	1.030 (0.770, 1.490)	2.350 (1.800, 2.670)	<0.001
Semen volume (mL)	3.400 (2.600, 4.000)	3.200 (2.500, 4.000)	0.872	3.200 (2.300, 4.000)	4.000 (3.000, 4.900)	0.181
Sperm concentration (10^6 per mL)	23.130 (1.800, 43.400)	25.450 (15.640, 44.100)	0.164	22.800 (2.500, 46.200)	63.830 (38.490, 90.280)	<0.001
Total sperm number (10^6 per ejaculate)	67.750 (6.600, 164.980)	78.450 (47.150, 169.780)	0.281	73.500 (12.990, 168.640)	239.330 (144.240, 362.700)	<0.001
Total motility (PR + NP, %)	16.590 (5.450, 27.800)	21.650 (14.870, 36.870)	0.035	19.400 (4.220, 32.410)	48.000 (35.220, 57.620)	<0.001
Progressive motility (PR, %)	11.43 (4.000, 22.930)	17 (10.740, 26.540)	0.073	15.960 (3.380, 27.150)	37.440 (26.190, 45.000)	<0.001
Sperm deformity rate (%)	3.00 (2.00, 4.00)	3.00 (2.00, 4.00)	0.075	3.00 (1.00, 4.00)	4.00 (3.00, 6.00)	0.002

Values are presented as mean ± SD or median (25th, 75th percentile). TABFV-R, testicular arterial blood flow volume of the right testis; TABFV-L, testicular arterial blood flow volume of the left testis; MSV, microscopic subinguinal varicocelectomy; PR, progressive motility; NP, non-progressive motility; SD, standard deviation.

Table 3 Univariate and multivariate logistic regression analyses for identifying predictors associated with semen improvement following MSV

Predictor	Univariate analysis			Multivariate analysis			
	Odds ratio	95% CI	P	Beta	Odds ratio	95% CI	P
Age (years)	0.95	0.86–1.04	0.24	–	–	–	–
Diameter of the spermatic vein (cm)	2.51	0.00–5,728.76	0.82	–	–	–	–
Volume-L (mL)	1.16	1.05–1.29	<0.001	–	–	–	–
Volume-R (mL)	1.13	1.03–1.23	0.01	–	–	–	–
TABFV-R (cm^3/min)	19.5	4.54–83.80	<0.001	3.197	24.453	6.118–133.939	<0.001
TABFV-L (cm^3/min)	4.26	1.66–10.95	<0.001	–	–	–	–
Semen volume (mL)	1.08	0.82–1.43	0.59	–	–	–	–
Sperm concentration (10^6 per mL)	1.01	1.00–1.02	0.14	–	–	–	–
Total sperm number (10^6 per ejaculate)	1	1.00–1.00	0.64	–	–	–	–
Total motility (PR + NP, %)	1.02	0.99–1.05	0.17	–	–	–	–
Progressive motility (PR, %)	1.02	1.00–1.05	0.05	–	–	–	–
Grade							
1 (n=41)	–	–	–	–	–	–	–
2 (n=26)	0.89	0.30–2.67	0.84	–	–	–	–
3 (n=29)	1.71	0.63–4.63	0.29	–	–	–	–
Combination of subclinical right-sided varicocele							
Uncombined (n=55)	–	–	–	–	–	–	–
Combined (n=41)	2.07	0.87–4.94	0.1	1.1	3.005	1.083–8.921	0.039

MSV, microscopic subinguinal varicocelectomy; CI, confidence interval; Volume-L, testicular volume of the left testis; Volume-R, testicular volume of the right testis; TABFV-R, testicular arterial blood flow volume of the right testis; TABFV-L, testicular arterial blood flow volume of the left testis; PR, progressive motility; NP, non-progressive motility.

semen improvement (P<0.05). Subsequently, a diagnostic model was developed using these two variables. To present the diagnostic model, a nomogram was constructed (*Figure 3A*), thereby providing a convenient, personalized tool for predicting the probability of semen improvement after MSV. The nomogram has the ability to display the assigned points for each variable at the highest point on the scale. By summing these points (total points), it becomes possible to transform them into a prediction of the potential probability of semen improvement following MSV.

The AUC for this diagnostic model was calculated as 0.824 [95% confidence interval (CI): 0.735–0.913] (*Figure 3B*), which was further validated internally using a bootstrap resampling method with an AUC of 0.824 (95% CI: 0.726–0.900) (*Figure 3C*). The proposed model demonstrated excellent calibration (*Figure 3D*). The Hosmer-Lemeshow test yielded a P value of 0.794, indicates no significant deviation from an optimal alignment between the predicted and observed values. To evaluate its clinical utility, a DCA for the nomogram was performed. The DCA demonstrated that the threshold probability for semen improvement after MSV was more than 10% (*Figure 3E*), supporting the application of this nomogram in predicting semen improvement following MSV.

Discussion

The means to accurately identifying those individuals who will derive maximum benefits from varicocele repair remains elusive. Unfortunately, our study found that varicocele grading, diameter of spermatic vein, routine semen analysis results, testicular volume, and age were not independent predictors for semen improvement after MSV. To enhance prediction performance, a new parameter TABFV was

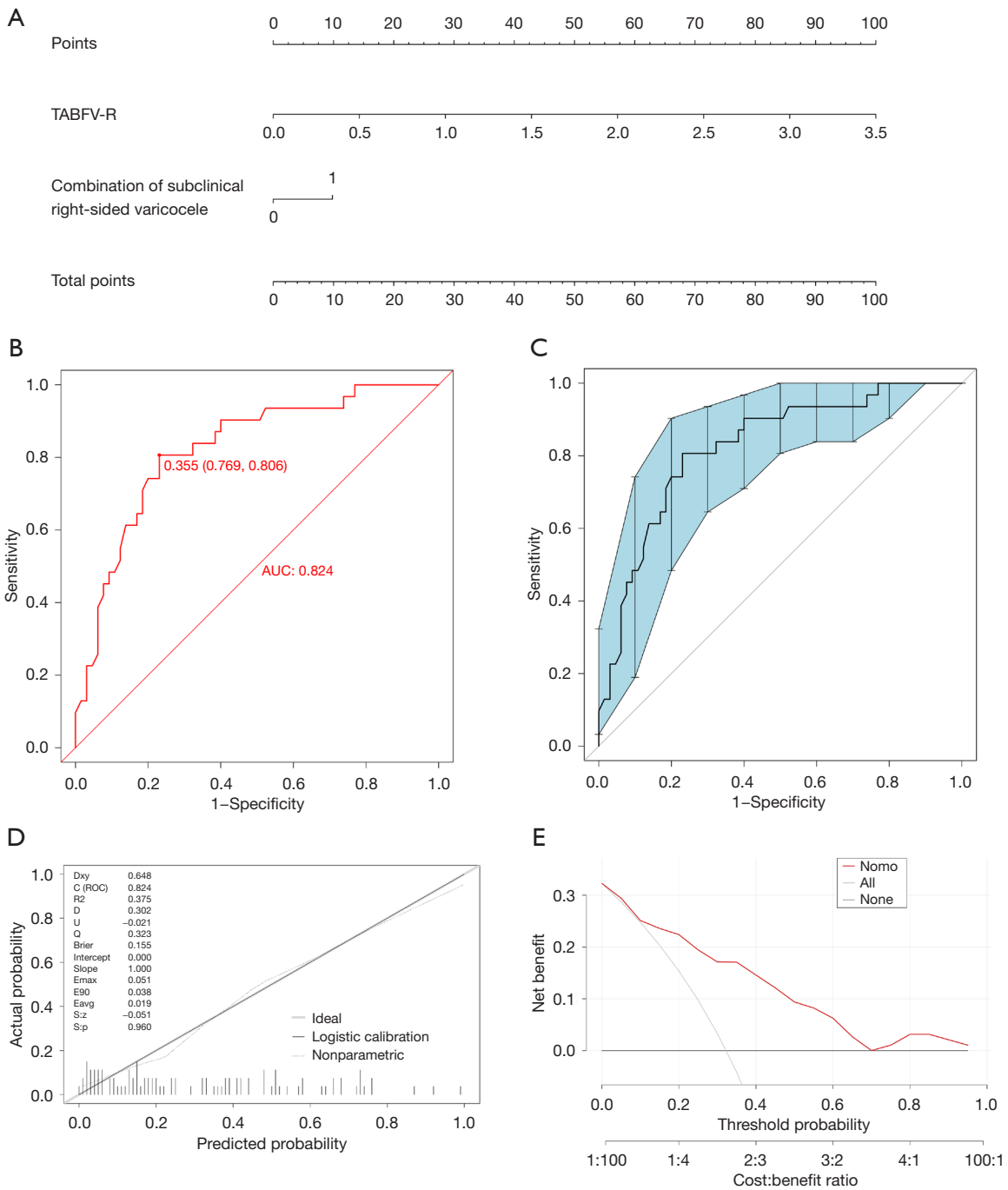

Figure 3 Nomogram for predicting the probability of semen improvement following MSV and verification of the diagnostic model. (A) Nomogram for predicting the probability of semen improvement following MSV. (B) ROC curve of the diagnostic model for predicting semen improvement after MSV. (C) ROC curve of internal validation using the bootstrap method (resampling =500; dotted vertical lines represent the 95% CI). (D) Calibration curve of the diagnostic model demonstrating good fitness between the predicted probability and observed probability. (E) DCA of the nomogram. The net benefit is calculated by adding true positives and subtracting the false positives. For a threshold probability >10%, application of the nomogram would yield greater net benefit compared to either a treat-all or a treat-none strategy. TABFV-R, testicular arterial blood flow volume of the right testis; AUC, area under the curve; ROC, receiver operating characteristic; MSV, microscopic subinguinal varicocelectomy; CI, confidence interval; DCA, decision curve analysis; Nomo, nomogram.

introduced.

Varicocelectomy aims to interrupt venous reflux within the spermatic veins and improve the blood supply to the testis. However, traditional ultrasound evaluation methods do not assess testicular blood supply improvement. The testicular artery is the sole vessel supplying the testis, and monitoring its blood flow volume can directly evaluate testicular blood supply. In this study, we devised a nomogram that can be used for predicting semen improvement after MSV that incorporates two variables: TABFV-R and subclinical right-sided varicocele. The nomogram demonstrated good discrimination, calibration, and clinical utility. Additionally, we calculated TABFVs before and after MSV and found that while all patients experienced an increase in TABFV-L post-surgery, those in the semen-improved group had a more significant increase of over twice their preoperative value. This suggests that TABFV-L is a suitable indicator for evaluating MSV success in subfertile males.

The guidelines from both the European Association of Urology and the American Urological Association do not provide any specific recommendations for addressing a subclinical varicocele on the right side in the presence of a left-sided varicocele. Performing simultaneous bilateral repair yielded a higher rate of improvement in semen parameters. This is consistent with previous research findings. For instance, one study compared the results of treating infertile men with left clinical and right subclinical varicoceles through either unilateral or bilateral repair. Both groups demonstrated improvement; however, the bilateral group exhibited significantly greater enhancements in sperm concentration, progressive motility, and morphology (22). There remains limited research in this area, and no clear recommendations can be made, and thus further studies are needed.

We identified the criteria for semen improvement in patients after MSV in our study, which needed to meet the criteria of the sixth edition of the WHO Manual (19). These criteria are based on the lower fifth percentile of this distribution in a cohort of 1,953 men with proven fertility and supplemented with data from approximately 3,500 additional men across 12 countries (23). This set of criteria represents the minimum standard for semen quality that is indicative of a man's actual fertility potential. Men who fulfill these criteria possess natural fertilization capability.

We recruited male individuals diagnosed with varicocele who experienced difficulties in conceiving a child with their female partners, including individuals with asthenozoospermia, oligozoospermia, nonobstructive azoospermia, and isolated teratozoospermia. Asthenozoospermia stands out as the leading factor contributing to male infertility, and clinical decision-making often relies on the assessment of total motile sperm count. Hamilton *et al.* demonstrated that the correlation between prewash total motile sperm count and spontaneous ongoing pregnancy rates is more significant than that reported in the WHO 2010 classification system (24). Therefore, effective treatment for asthenozoospermia holds significant importance for infertile men. Additionally, we did not exclude patients with nonobstructive azoospermia due to previous reports suggesting that varicocelectomy may restore sperm presence in ejaculate samples among men exhibiting hypospermatogenesis or late maturation arrest in testicular histology evaluation (25,26). This method has the potential to eliminate the necessity of surgical procedures for retrieving sperm before or during *in vitro* fertilization cycles (27). Unfortunately, our study did not identify any spermatozoa in ejaculate samples after MSV was performed on patients with nonobstructive azoospermia. This outcome may be attributed to the absence of preoperative histopathological evaluations conducted on the patients (28). The usefulness of varicocelectomy in men with isolated teratozoospermia is not specifically addressed by the guidelines provided by European Association of Urology and the American Urological Association. Limited research has been conducted on the advantages of varicocelectomy in men with isolated teratozoospermia, and the findings from the few studies have been inconclusive (29-31).

This study involved certain limitations that should be addressed. First, the natural conception rate is an additional parameter for assessing the efficacy of varicocele repair in males experiencing infertility; however, follow-up can be challenging. In addition, some participants in our study opted for assisted reproductive technology to impregnate their female partners. Therefore, we solely used routine semen parameters as indicators of MSV success. Second, all participants were exclusively recruited from our Center for Assisted Reproduction. Although treating varicocele may potentially address the underlying etiology causing male-factor infertility, assisted reproductive technology can bypass abnormal semen parameters to achieve pregnancy. A significant female factor necessitating *in vitro* fertilization might eliminate the need for varicocele repair. Finally, despite the large number of varicocele patients seen at our center, very few patients are eligible for varicocele repair. Therefore, because of the small sample size of this study

and the lack of external validation, further large-sample, multicenter studies are needed.

Conclusions

TABFV-L demonstrated potential utility in clinical practice for assessing outcomes of MSV, and the diagnostic model incorporating TABFV-R and right-side varicocele performed well in predicting improvements in semen parameters following MSV.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://qims.amegroups.com/article/view/10.21037/qims-24-105/rc

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims.amegroups.com/article/view/10.21037/qims-24-105/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and was approved by the Ethics Committee of Shengjing Hospital of China Medical University (No. 2020PS123J). Written informed consent was provided by all participants.

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