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# Preserving one artery shortens the surgical time and does not affect the efficacy of microsurgical subinguinal varicocelectomy: preliminary findings from a retrospective study

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## Abstract

**Background** To analyze the safety and efficacy of microsurgical subinguinal varicocelectomy(MSV) performed with and without preservation of all testicular arteries and lymphatic system.

**Methods** All of the 98 patients with varicocele who underwent MSV were included in the analysis. Fifty-eight male patients surgically underwent MSV with preservation of all testicular arteries and lymphatic system(Group 1). The other 40 male patients surgically underwent MSV with preservation of a single testicular artery, while the remaining vascular bundle sparing the vas deferens with its vessels was then isolated"*en bloc*," ligated and cut(Group 2). Operative time, semen parameters and complications were then compared.

**Results** Mean operative time for Group 1 was significantly longer than that of Group 2(90.26 ± 21.69 min vs. 79.30 ± 19.58 min, $P = 0.01$). Visual analogue pain scale (VAS) decreased significantly in both groups. Group 1 experienced a decrease from a median of 5 (interquartile range, IQR: 4 ~ 6) to 1 (IQR: 0 ~ 2), $P < 0.001$; similarly, Group 2 saw a reduction from a median of 4 (IQR: 3 ~ 5.75) to 1 (IQR: 1 ~ 2), $P < 0.001$. Additionally, notable improvements were recorded in sperm count and motility in both groups at the 12-month follow-up compared to their pre-operative measurements. For Group 1, sperm count increased from a median of $35.5 \times 10^6$/mL(IQR: 29 ~ 60) to $60 \times 10^6$/mL(IQR: 50 ~ 74.25), and motility from 46.5% (IQR: 32 ~ 56%) to 69%(IQR: 54.5 ~ 79%), both with $P < 0.001$. Group 2 showed similar enhancements, with sperm count rising from a median of $31 \times 10^6$/mL (IQR: 20 ~ 56.25) to $57.5 \times 10^6$/mL(IQR: 51.25 ~ 73.75) and motility from 44% (IQR: 23 ~ 54.75%) to 75% (IQR: 51.25 ~ 80%), $P < 0.001$. The duration of postoperative hospital stay was comparable between the two groups, with both reporting a median stay of 3 days (IQR: 2–3 days, $P = 0.83$). No testicular atrophy and varicocele recurrence was observed in all patients. The incidence rates of hydrocele, wound infection, and orchitis and epididymitis showed no significant disparity between the two

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groups. Specifically, both groups each had a single incidence of hydrocele. Group 1 had one incidence of wound infection, while Group 2 had none. Orchitis and epididymitis occurred once in Group 1, but not in Group 2.

**Conclusion** Our study provides preliminary evidence supporting the implementation of the"*en bloc*" procedure in MSV as a potentially safe and effective option, especially for managing cases with severe adhesion.

**Keywords** Surgical techniques, Complications, Microsurgical, Duration of operation, Varicocele

## Background

Varicocele is the most common surgically correctable cause of male infertility [1]. There are numerous surgical techniques being used in varicocele treatment, such as conventional open varicocelectomy, laparoscopic, microsurgical intervention, or transdermal sclerotherapy and embolization of the testicular vein, each of them having its own advantages and disadvantages, with various studies often having rather conflicting results of their outcomes [2].

Over recent years, microscopic varicocele ligation is regarded as a safe, effective, cosmetic and minimally invasive method with similar results to that of others, and a growing number of researchers have recommended microsurgical subinguinal varicocelectomy (MSV) as the gold standard method for treating varicocele in infertile men for its many advantages, such as quicker recovery, lower recurrence and hydrocele rates, better spermatogenesis improvement and higher spontaneous pregnancy rates [3, 4]. Furthermore, this method allows for the reliable identification and preservation of the testicular and cremasteric arteries, as well as lymphatic channels. Moreover, it ensures the accurate identification of all internal spermatic veins and gubernacular veins [5, 6]. However, the microscopic approach is not without its challenges. It introduces a heightened level of complexity, necessitates a steep learning curve, and results in extended operative times. Nevertheless, these challenges can be addressed by lessening the difficulty of the surgical procedure. In this study, we retrospectively evaluated the safety and efficacy of MSV without preservation all of testicular arteries and lymphatic system.

## Methods

### Patients

This is a single-center retrospective study. The study procedures were reviewed and approved by the Medical Ethics Committee of the 920th Hospital of Joint Logistic Support Force (920IEC/AF/31/2021-01). Inclusion criteria: (1) grade II to III varicocele on the left side(according to the Dubin-Amelar criteria) [7]. (2) Presence of scrotal pain. (3) Abnormal semen parameters(defined using reference values established by the World Health Organization in 2010). Exclusion criteria included any of the following: (1) Preoperative left testicular hypotrophy(defined as a volume reduction of more than 20% compared to the right testis). (2) Adolescent varicocele(patients under 18 years of age). (3) Prior history of varicocelectomy. (4) Secondary varicocele caused by conditions such as retroperitoneal tumors, renal tumors, or lymphadenopathy. (5) Genitourinary infections or severe comorbidities, such as diabetes, hypertension, or cardiovascular disease. According to the inclusion and exclusion criteria, 115 patients were initially identified from our hospital records between January 2020 and January 2021. Seventeen cases were excluded due to incomplete clinical data, leaving a total of 98 cases for analysis. Among these, 58 patients were operated by a routine procedure to protect all internal spermatic/testicular arteries and lymphatic vessels under the microscope (Group 1). While 40 patients were experienced by a procedure of preservation of a single internal spermatic artery and resection of "*en bloc*"of the vascular bundle (Group 2). All procedures were performed by a single surgeon (Xu Cao). The diagnosis of varicocele was established mainly by clinical examination and Doppler ultrasonography of the scrotum.

### Surgical technique

#### *MSV with a routine procedure (Group 1)*

Under general anesthesia, the patients were placed in a supine position. Operating surgeon sat on the left side of the patient while the assistant sat on the right side. After a skin incision 1 cm below the superficial inguinal ring, the spermatic cord was separated from the adjacent tissue. A homemade rubber sheet was positioned below the spermatic cord to lift it over the skin incision. The outer surface of the spermatic cord was macroscopically examined and any external spermatic veins that were running parallel to the spermatic cord were identified and ligated with 4−0 silk ties and divided (Fig. 1A). Then a Zeiss operating microscope (Carl Zeiss, Thornwood, NY) was brought into the operative field. Under 8× to 15× power magnification, the external spermatic fascia and cremaster muscle were incised using a high-frequency electrotome (Fig. 1B). We did not use Doppler ultrasound to localize the spermatic arteries. Instead, a few drops of papaverine or lidocaine solution were applied to the spermatic cord to assist in identifying the testicular artery or arteries. Initially, regardless of whether the pulsating artery was observed, we did not actively isolate the area with the most prominent pulsation. Instead, the most

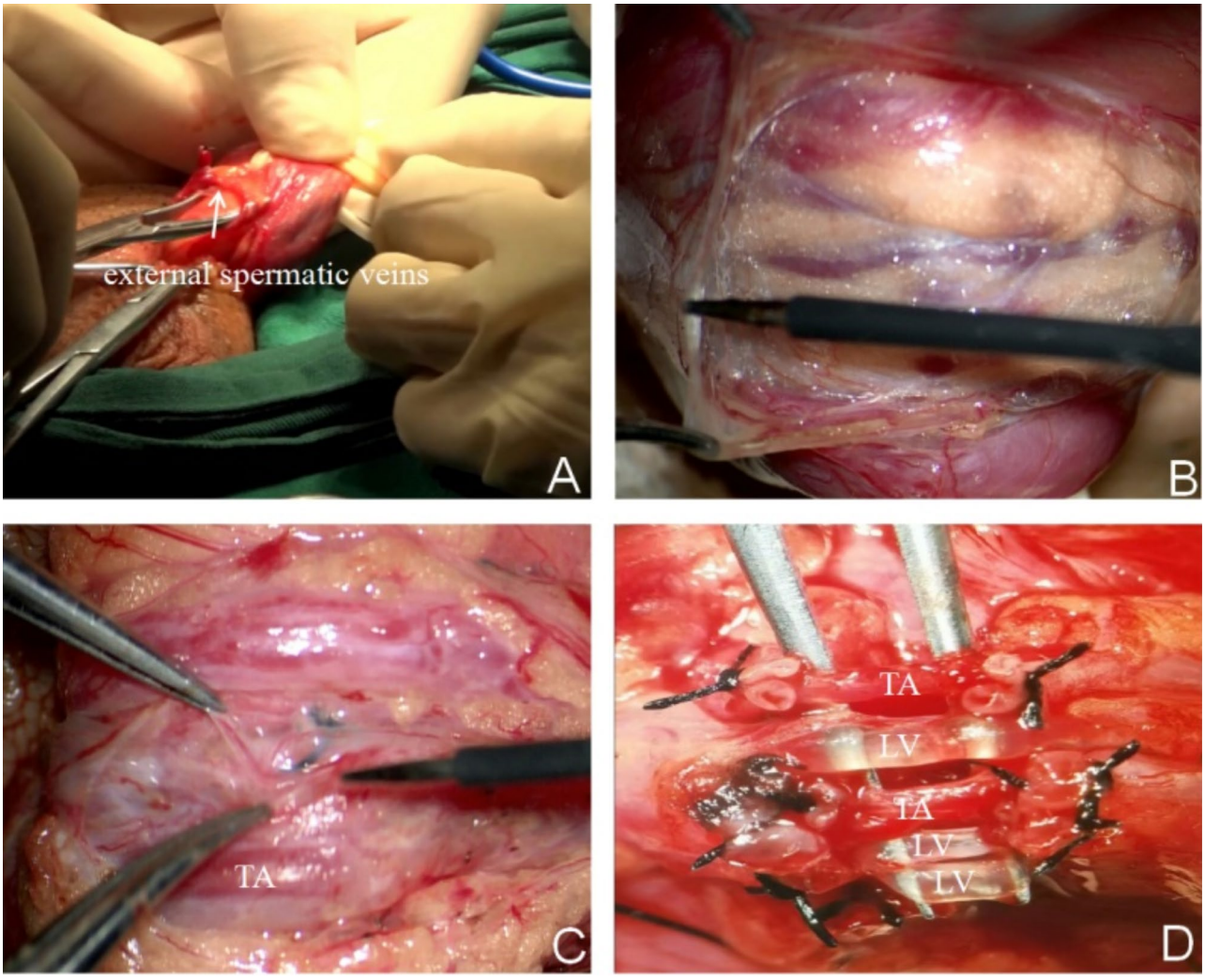


**Fig. 1** MSV with A Routine Procedure. (**A**) External spermatic veins were identified and ligated with 4–0 silk ties and divided. (**B**) Spermatic fasciae were cut with a high frequency electrotome. (**C**) Dissecting the most easily distinguishable veins at the very beginning. (**D**)Except for the vas deferens-associated veins, all veins within the spermatic cord were doubly ligated and divided, while all arteries and identifiable lymphatic vessels were preserved. MSV: microsurgical subinguinal varicocelectomy. TA: testicular artery; LV: lymphatic vessel

easily distinguishable veins were first separated from the surrounding adventitia and lymphatics to prevent arterial spasm (Fig. 1C). Subsequently, the dissection progressed step-by-step, from the superficial to the deeper layers. Smaller veins (less than 2 mm in diameter) were cauterized, while larger veins were doubly ligated with 5–0 silk sutures and divided. This gradual dissection naturally exposed the artery or arteries within the operative field. After careful dissection, the vas deferens-associated vessels, all spermatic arteries and identified lymphatics were isolated and preserved, while all veins within the spermatic cord were doubly ligated and cut (Fig. 1D). The skin was reapproximated with a running subcuticular 5–0 absorbable monofilament suture, reinforced with sterile strips.

#### *MSV with an "en bloc" procedure (Group 2)*

This procedure was similar to the steps described above, with the primary distinction being the preservation of only a single spermatic artery. After incising the cremaster muscle and the external spermatic fascia, venous dissection was performed. If prominent lymphatic vessels within the spermatic cord were encountered prior to the identification of the artery, they were preserved (Fig. 2A). However, if no such prominent lymphatic vessels were observed after identifying the artery, further efforts to preserve them were not undertaken. During the ligation of the veins, further dissection of the spermatic cord was ceased upon identifying and isolating the spermatic artery (Fig. 2B). The remaining vascular bundle sparing the vas deferens with its vessels was then isolated"*en bloc*" (Fig. 2C), ligated with 3–0 silk ties and divided (Fig. 2D).

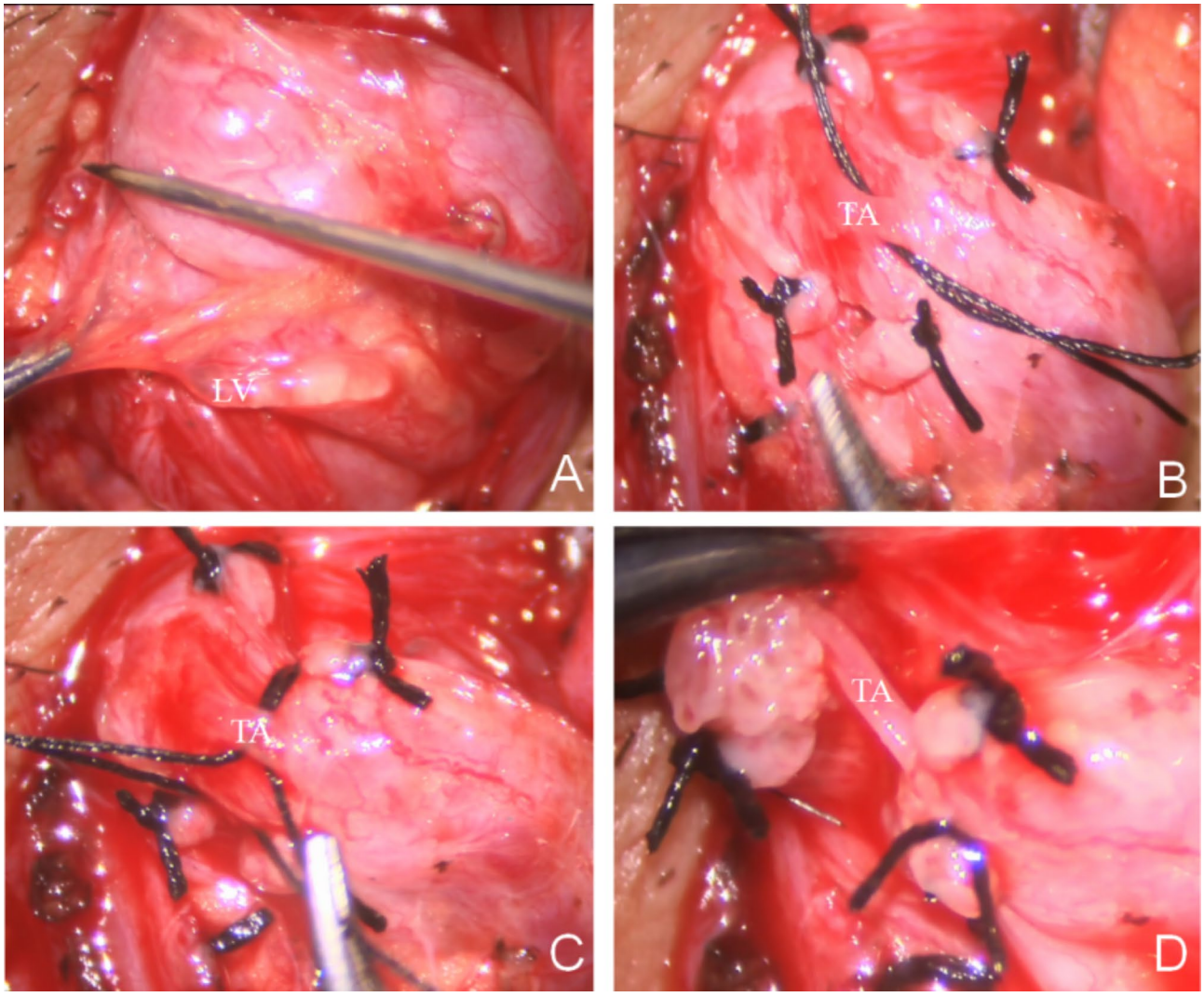


**Fig. 2** MSV with An "*en bloc*" Procedure. (**A**) The lymphatic vessel identified prior to locating the artery was preserved. (**B**) Dissection of the spermatic cord ceased upon identifying and isolating a spermatic/testicular artery. (**C**) The remaining vascular bundle sparing vas deferens with its vessels was then isolated"*en bloc*". (**D**) The vascular bundle was ligated with 3 – 0 silk ties and cut. MSV: microsurgical subinguinal varicocelectomy. TA: testicular artery; LV: lymphatic vessel

### Evaluation of safety and efficacy

All patients were followed up for 12 months. Parameters such as the duration of the operation, length of the postoperative hospital stay, and pain scores, assessed using the visual analogue scale (VAS), were carefully documented. Alongside these, the occurrence of complications including hydrocele, wound infection, epididymitis, and testicular atrophy were also diligently recorded. Perioperative scrotal pain was measured using the VAS which was graded from 0 to 10 at preoperative,3,6 and 12 months postoperative periods. Recurrence of varicocele was determined if physical examination revealed grade II (palpable at rest, not visible) or III (visible at rest) varicocoele and spermatic vein diameter measured by ultrasonograph was ≥3 mm in standing position. Testicular volume was also measured ultrasonographically using the formula: 0.71 × Length × Width × Height [8]. Postoperative testicular atrophy was defined as a 20% or greater reduction in volume of the same testicle after 12 months of follow-up. Semen analysis (semen volume, sperm count and sperm motility) were measured at 3 days before surgery and 3, 6 and 12 months postoperative periods. During the postoperative follow-up period, patients were not prescribed any sperm quality enhancing food supplements or medications.

### Statistical analysis

All statistical analysis was performed with SPSS version 19.0 (IBM Corp., Armonk, NY, USA). The Shapiro-Wilk test was conducted to assess normal distribution. Parametric tests (independent samples t-test) were applied for inter-group comparisons when the data exhibited

a normal distribution (presented as mean±standard deviation). In cases of non-normal distribution, the non-parametric Mann-Whitney U test was employed, and data were presented as median and interquartile range (IQR). Intra-group comparisons utilized parametric paired t-tests for normally distributed data and non-parametric Wilcoxon matched-pairs signed rank tests for non-normally distributed data. Categorical data were evaluated using Pearson's Chi-squared test and Fisher's exact method. A value $P<0.05$ was considered statistically significant.

## Results

### Demographic characteristics of analysed groups of patients

A total of 98 men who underwent MSV were evaluated. The mean age of Group 1 and Group 2 was 21.78±2.87 years and 21.08±2.65 years, respectively, and the body mass index(BMI) was 21.03±1.54 vs.21.42±2.01. Grade III varicocele was observed in 53.4% of patients in Group 1 and 65.0% in Group 2. The preoperative median diameter of the spermatic vein was 3.2 mm (IQR, 2.9 ~ 3.5) in Group 1 and 3.25 mm (IQR, 2.93 ~ 3.5) in Group 2. Testicular volumes were 14.25 mL (IQR: 11.9 ~ 17.1) and 14.9 mL (IQR: 11.33 ~ 17.53) for the left and right testes in Group 1, and 15.6 mL (IQR: 13.5 ~ 17.2) and 14.2 mL (IQR: 12.05 ~ 16.88) in Group 2. The median preoperative scrotal pain VAS for the first and second groups were 5 (IQR: 4 ~ 6) and 4 (IQR: 3 ~ 5.75), respectively. No significant differences were detected between the two treatment groups in terms of patient's age, BMI, grade of varicocele, diameter of the spermatic vein, testicular volume and preoperative scrotal pain VAS($P>0.05$). The characteristics of the patients are listed in Table 1.

**Table 1** Demographic characteristics of analysed groups of patients

| | Group 1($n=58$) | Group 2($n=40$) | *P* Value |
|---|---|---|---|
| Age, years | 21.78±2.87 | 21.08±2.65 | 0.22[a] |
| BMI, kg/m$^2$ | 21.03±1.54 | 21.42±2.01 | 0.27[a] |
| Preoperative spermatic vein diameter, mm | 3.2(2.9 ~ 3.5) | 3.25(2.93 ~ 3.5) | 0.47[b] |
| Preoperative testicular size, mL | | | |
| Left side | 14.25(11.9 ~ 17.1) | 15.6(13.5 ~ 17.2) | 0.12[b] |
| Right side | 14.9(11.33 ~ 17.53) | 14.2(12.05 ~ 16.88) | 0.59[b] |
| Grade of varicocele, no(%) | | | 0.26[c] |
| II | 27 (46.6%) | 14 (35.0%) | |
| III | 31 (53.4%) | 26 (65.0%) | |
| Pre-operative VAS | 5.00 (4.00 ~ 6.00) | 4.00 (3.00 ~ 5.75) | 0.10[b] |

*Note*: BMI: body mass index; VAS: visual analogue pain scale; Group 1: microscopic subinguinal varicocelectomies with a routine procedure; Group 2: microscopic subinguinal varicocelectomies with an "*en bloc*" procedure. Data Representation: Normal distribution: Mean±SD; Non-normal distribution: Median (IQR). a, independent samples t-test; b, Mann-Whitney U test; c, Pearson's Chi-squared test

### Intra- and post-operative outcomes in each treatment group

Mean operative time of group 1 was significantly longer than that of group 2(90.26±21.69, range: 55–180 min vs. 79.30±19.58, range: 28–120 min; $P=0.01$). No significant differences were detected in terms of postoperative hospital stay between the two groups(median: 3, IQR: 2 ~ 3 days vs. median: 3, IQR: 2 ~ 3 days, $P=0.83$).

Additionally, postoperative VAS at 3 months(median: 1, IQR: 0 ~ 2 vs. median: 1, IQR: 1 ~ 2, $P=0.27$), 6 months(median: 1, IQR: 0 ~ 2 vs. median: 1, IQR: 1 ~ 2, $P=0.09$), and 12 months(median: 1, IQR: 0 ~ 2 vs. median: 1, IQR: 1 ~ 2, $P=0.14$) also demonstrated no significant differences between the groups.

However, in both groups, the postoperative VAS significantly decreased at the 12-month follow-up appointment compared to pre-operative values(Group 1: median: 5, IQR: 4 ~ 6 vs. median: 1, IQR: 0 ~ 2, $P<0.001$; Group 2: median: 4, IQR: 3 ~ 5.75 vs. median: 1, IQR: 1 ~ 2, $P<0.001$).

Two patients, one from each group, developed a postoperative hydrocele at 2 and 3 weeks respectively. These were gradually absorbed over a period of 3 months following the operation. One case of wound infection and another case of epididymitis were observed in Group 1. No testicular atrophy (0%) was observed in both groups. Furthermore, no varicocele recurrence (0%) was detected in either cohort of treated men. In Group 1, the number of patients with only one testicular artery was 46(79.3%), and the remaining 12(20.7%) patients had two or more testicular arteries(Table 2).

### Preoperative and postoperative semen analysis results

Semen volume at preoperative(3.57±1.39 vs. 3.22±1.29 mL, $P=0.21$), and at 3 months (3.58±1.14 vs. 3.26±0.99 mL, $P=0.15$), 6 months (3.64±1.17 vs. 3.30±1.04 mL, $P=0.14$), and 12 months (3.53±1.29 vs. 3.25±1.28 mL, $P=0.30$) postoperatively demonstrated no significant differences between the groups.

Sperm count and sperm motility showed significant improvement 12 months postoperatively in each group ($P<0.001$). Specifically, the median sperm count for Group 1 increased from 35.50 (IQR: 29.00 ~ 60.00) × $10^6$/mL preoperatively to 60.00 (IQR: 50.00 ~ 74.25) × $10^6$/mL at 12 months postoperatively, while for Group 2, it rose from 31.00 (IQR: 20.00 ~ 56.25) × $10^6$/mL to 57.50 (IQR: 51.25 ~ 73.75) × $10^6$/mL in the same period. Regarding sperm motility, Group 1 saw an improvement from a median of 46.5% (IQR: 32 ~ 56%) preoperatively to 60% (IQR: 50 ~ 74.25%) at 12 months postoperatively. Similarly, Group 2 experienced an enhancement in sperm

**Table 2** Intra- and post-operative outcomes in each treatment group

| | Group 1($n=58$) | Group 2($n=40$) | *P* Value |
|---|---|---|---|
| Operation time, min | 90.26 ± 21.69 | 79.30 ± 19.58 | 0.01[*b] |
| Postoperative hospital stay, day | 3 (2 ~ 3) | 3 (2 ~ 3) | 0.83[c] |
| VAS | | | |
| Pre-operative | 5.00 (4.00 ~ 6.00) | 4.00 (3.00 ~ 5.75) | 0.10[c] |
| 3 months | 1.00 (0.00 ~ 2.00) | 1.00 (1.00 ~ 2.00) | 0.27[c] |
| 6 months | 1.00 (0.00 ~ 2.00) | 1.00 (1.00 ~ 2.00) | 0.09[c] |
| 12 months | 1.00 (0.00 ~ 2.00)[a] | 1.00 (1.00 ~ 2.00)[a] | 0.14[c] |
| Complications, no(%) | | | |
| Hydrocele | 1 (1.7%) | 1 (1.7%) | 1.00[d] |
| Wound infection | 1 (1.7%) | 0 (0%) | 1.00[d] |
| Orchitis and epididymitis | 1 (1.7%) | 0 (0%) | 1.00[d] |
| Testicular atrophy | 0 (0%) | 0 (0%) | — |
| Recurrence | 0 (0%) | 0 (0%) | — |
| Number of testicular arteries, no(%) | | | |
| One | 46 (79.3%) | — | — |
| Two or more | 12 (20.7%) | — | — |

*Note*: VAS: visual analogue pain scale; Group 1: microscopic subinguinal varicocelectomies with a routine procedure; Group 2: microscopic subinguinal varicocelectomies with an "*en bloc*" procedure. a, postoperative VAS scores in both Group 1 and Group 2 significantly decreased at the 12-month follow-up compared to preoperative values, Wilcoxon matched-pairs signed rank tests, $P<0.001$. *, $P<0.05$. b, independent samples t-test. c, Mann-Whitney U test. d, Fisher's exact method. Data Representation: Normal distribution: Mean ± SD; Non-normal distribution: Median (IQR)

motility from a median of 44% (IQR: 23 ~ 54.75%) to 75% (IQR: 51.25 ~ 80%) over the same timeframe.

At the 3, 6, and 12 months follow-up appointments, the postoperative values for sperm count and sperm motility did not differ significantly between the two groups ($P>0.05$). At 3 months postoperatively, the median sperm count was 51.5(IQR: 45 ~ 65) × $10^6$/mL for Group 1 and 52.5(IQR: 40 ~ 68.75) × $10^6$/mL for Group 2. The median sperm motility at this point was 61%(IQR: 45.75 ~ 72%) for Group 1 and 63%(IQR: 44.25 ~ 72.75%) for Group 2.

By 6 months postoperatively, the median sperm count for Group 1 was 57.5 (IQR: 50 ~ 67.5) × $10^6$/mL, while for Group 2, it was 55 (IQR: 42.25 ~ 72.5) × $10^6$/mL. The median sperm motility was 66.5% (IQR: 50 ~ 75%) for Group 1 and 69% (IQR: (53.25 ~ 80%) for Group 2.

Finally, at 12 months postoperatively, the median sperm count for Group 1 was 60 (IQR: 50 ~ 74.25) × $10^6$/mL, and for Group 2, it was 57.5 (IQR: 51.25 ~ 73.75) × $10^6$/mL. The median sperm motility was reported at 69% (IQR: 54.5 ~ 79%) for Group 1 and 75% (IQR: 51.25 ~ 80%) for Group 2 (Table 3).

**Table 3** Preoperative and postoperative semen analysis results

| | Group 1($n=58$) | Group 2($n=40$) | *P* Value |
|---|---|---|---|
| Semen volume, mL | | | |
| Preoperative | 3.57 ± 1.39 | 3.22 ± 1.29 | 0.21[b] |
| 3 months | 3.58 ± 1.14 | 3.26 ± 0.99 | 0.15[b] |
| 6 months | 3.64 ± 1.17 | 3.30 ± 1.04 | 0.14[b] |
| 12 months | 3.53 ± 1.29 | 3.25 ± 1.28 | 0.30[b] |
| *P* Value | 0.28[a] | 0.49[a] | |
| Sperm count, $n\times 10^6$/ejaculate | | | |
| Preoperative | 35.50 (29.00 ~ 60.00) | 31.00 (20.00 ~ 56.25) | 0.33[c] |
| 3 months | 51.50 (45.00 ~ 65.00) | 52.50 (40.00 ~ 68.75) | 0.73[c] |
| 6 months | 57.50 (50.00 ~ 67.50) | 55.00 (42.25 ~ 72.50) | 0.59[c] |
| 12 months | 60.00 (50.00 ~ 74.25) | 57.50 (51.25 ~ 73.75) | 0.49[c] |
| *P* Value | <0.001[d] | <0.001[d] | |
| Sperm motility, % | | | |
| Preoperative | 46.50 (32.00 ~ 56.00) | 44.00 (23.00 ~ 54.75) | 0.60[c] |
| 3 months | 61.00 (45.75 ~ 72.00) | 63.00 (44.25 ~ 72.75) | 0.79[c] |
| 6 months | 66.50 (50.00 ~ 75.00) | 69.00 (53.25 ~ 80.00) | 0.30[c] |
| 12 months | 69.00 (54.50 ~ 79.00) | 75.00 (51.25 ~ 80.00) | 0.40[c] |
| *P* Value | <0.001[d] | <0.001[d] | |

*Note*: a, postoperative 12 months versus preoperative, paired t-tests; b, independent samples t-test; c, Mann-Whitney U test; d, postoperative 12 months versus preoperative, Wilcoxon matched-pairs signed rank tests; Group 1: microscopic subinguinal varicocelectomies with a routine procedure; Group 2: microscopic subinguinal varicocelectomies with an "*en bloc*" procedure. Data Representation: Normal distribution: Mean ± SD; Non-normal distribution: Median (IQR)

## Discussion

Surgical treatment of varicocele is still one of the most common important treatments for male infertility. Surgery regimens for varicocele is various, including open inguinal (Ivanissevich technique) or retroperitoneal high ligation (Palomo technique), laparoscopic repair, inguinal or subinguinal microsurgical varicocelectomy. The advantage of open retroperitoneal high ligation lies in its simplicity and shorter surgical duration, especially in situations where the equipment and expertise required for microsurgical subinguinal varicocelectomy are not accessible [9]. However, it is associated with a higher incidence of postoperative hydrocele and recurrence rates [3]. The advantage of laparoscopic varicocelectomy lies in its ability to treat bilateral varicoceles simultaneously. However, it may leave 1 ~ 3 surgical scars on the abdomen [10]. Inguinal or subinguinal microsurgical varicocelectomy requires specialized microsurgical techniques, but offers advantages such as minimal tissue trauma, rapid recovery, low recurrence rates, and fewer complications. The subinguinal approach is associated with diminished postoperative pain and expedited recovery in comparison to the inguinal approach. This advantage arises because the external oblique aponeurosis remains undisturbed, and the spermatic cord is meticulously isolated through dissection immediately beneath the external inguinal ring

[11]. Nowadays, researchers recommend that MSV technique should be elected as first-line treatment for varicocele whenever possible [2, 12, 13]. In the current study, we recount our experience in implementing MSV utilizing an "*en bloc*" technique. This strategy enhanced the efficiency of the surgical procedures, without increasing the risk of complications such as hydrocele, wound infection, epididymitis, and testicular atrophy.

Compared to laparoscopic techniques, the microscopic technique involves dissection of the spermatic vessels at a more distal and superficial location, making it easier to preserve all arteries and lymphatics without the need to enter the abdominal cavity. However, the veins in this area exhibit a plexiform pattern with numerous branches, making the procedure technically challenging. The learning curve is longer, and there is a risk of missing varicose veins. Studies have shown that in laparoscopic high ligation of the spermatic veins for the treatment of varicocele, there is no significant difference in the postoperative outcomes between complete ligation of the spermatic cord vascular bundle(*en-bloc*) without preserving the arteries and lymphatics, and ligation of the spermatic veins while preserving the arteries and lymphatics [14, 15]. Neither approach has been associated with major severe complications. These findings are consistent with our current research. The key distinction in our study is that we performed the "*en-bloc*" ligation at a more distal location while preserving one branch of the internal spermatic artery. This raises an important question regarding the necessity of preserving all the internal spermatic arteries during such procedures and its potential impact on postoperative outcomes. Penn and colleagues reported a 14% incidence rate of testicular atrophy when the testicular artery was purposefully ligated during renal transplantation [16], whereas two separate meta-analyses have shown that preservation of the internal spermatic artery may result in higher recurrence rate in varicocelectomy [17, 18]. Some research indicates that without preservation all of testicular arteries during surgery can lead to impaired spermatogenesis and reductions in testicular volume [19–22]. However, some research suggests that even if the testicular artery is mistakenly ligated, the presence of the vas deferens artery and the cremasteric artery would not result in adverse outcomes [14, 15, 23, 24]. Our study indirectly supports this view if we encounter such a situation in patients undergoing the *"en-bloc"* method, because there may be multiple arteries present in this group of patients. In our study, we discovered that a single testicular artery was predominant in patients from Group 1 (those with all arteries preserved), accounting for 79.31% (46/58) of the total patients. In contrast, the proportion of patients with two or more arteries was 20.69% ($n=12$). Lee et al. observed that a single artery was present in 61.3% of cases [13], a finding that was echoed by Raman et al., who reported a similar occurrence at 69% [25]. These results are in alignment with our study. However, other research indicates a higher prevalence of multiple testicular arteries [11, 26]. Irrespective of the situation, our study suggests that the MSV *"en-bloc"* approach, which involves preserving a single testicular artery, may enhance semen quality and is unlikely to result in testicular atrophy. The testicle receives its blood supply from three primary arterial sources: the testicular artery, vasal artery, and cremasteric artery. These arteries are interconnected through vascular communications (collaterals), forming a robust network that ensures an uninterrupted blood supply [27, 28]. In our *"en-bloc"* group, we consistently preserved one testicular artery. However, in cases where multiple testicular arteries were present, the *"en-bloc"* approach might have inadvertently ligated the remaining arteries. Despite this, the robust collateral circulation provided by the vasal and cremasteric arteries likely compensates for any potential compromise in testicular arterial supply. Our findings are also consistent with studies on laparoscopic high ligation for varicocelectomy, which demonstrate that *"en-bloc"* ligation of vascular bundles at a more proximal level, even without preserving any testicular arteries, does not result in adverse consequences [29–31]. Furthermore, in group 2, a noticeable reduction in operation time was observed. This suggests that the outcomes are promising with regard to safety and ease of execution through "*en-bloc*" ligation of the spermatic cord vascular bundles. This contributes significantly to relevant studies, specifically in situations where the testicular artery is enveloped by a nearby varicose venous plexus and adheres to the surrounding veins, presenting a substantial challenge in dissection. Our method offers a potentially applicable surgical technique and provides a new perspective and reference for surgical decision-making in these types of patients.

Another integral part of MSV is the preservation of lymphatic vessels. However, dissecting lymphatic capillaries and some small lymphatic vessels in the operation area increase the operation difficulty during the actual operation. Meanwhile, some studies report that deliberately sparing redundant lymphatic vessels increases the chance of recurrence [32, 33]. In the present study, we found no significant difference between the treatment groups in the incidence of hydrocele (1/58 vs. 1/40) or the recurrence rate of varicocele (0% vs. 0%). This outcome may be attributed to our meticulous preservation of the vas deferens and its accompanying vascular system. Even if some lymphatic vessels within the spermatic cord were inadvertently ligated, the lymphatic drainage could still be maintained through the lymphatic vessels preserved within the vas deferens system.

Previous studies showed that MSV had better therapeutic effects to manage scrotal pain [34, 35]. In the current study, there were concerns that scrotal pain would not relieve or get worse when patients were treated by "*en-bloc*" procedure. Instead, we observed comparable VAS score postoperation in both groups, which implied that "*en-bloc*" procedure was also efficient in relieving scrotal pain. Our study found that sperm count and motility were significantly increased at postoperative 12-month follow-up in all of our patients irrespective of treatment grouping compared to preoperative values, which was similar to previously reported results [18, 36–38]. This indicates that the "*en-bloc*" procedure is also effective in improving semen quality.

There was no significant difference in complications in terms of hydrocele, recurrence, wound infection, epididymitis and testicular atrophy between the two treatment cohorts. This implies that "*en-bloc*" ligation does not notably augment the risk of surgical complications. Anecdotally, one patient experienced wound infection 3 days after surgery and another patient developed epididymitis 7 days postoperation in Group 1. We hypothesize that these may be associated with the extended surgical duration, however, due to the limited number of cases, additional investigation is necessitated.

Due to the fact that this study is a single center retrospective study with a small sample size, there may be research bias. The patients with bilateral and right varicocele were not included in the study for the sake of the convenience of the comparison. Future rigorous prospective studies are needed and research should expand these initial data by examining a larger cohort of patients over a longer follow-up period.

## Conclusion

Our study provides preliminary evidence supporting the implementation of the "*en bloc*" procedure in MSV as a potentially safe and effective option, especially for managing cases with severe adhesion. However, given the study's limitations, our findings should be considered exploratory and need to be further validated through more extensive and in-depth prospective research.

### Abbreviations

| | |
|---|---|
| MSV | Microsurgical subinguinal varicocelectomy |
| VAS | Visual analogue pain scale |
| BMI | Body mass index |
| IQR | Interquartile range |

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Not applicable.

### Author contributions

Xu Cao involved in study design/planning, data collection/entry, data analysis/statistics, data interpretation, preparation of manuscript, literature analysis/search and funds collection. Chen Tian involved in data interpretation, preparation of manuscript and literature analysis/search. Wei Feng and Shu-xian Zhu participated in study design/planning. Kai Chen and Yu-hang Zheng involved in data collection/entry. Jian-zhong Yao involved in study design/planning, data collection/entry and funds collection.

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### Data availability

The full dataset generated and analyzed during the current study are available from the corresponding author on reasonable request.

## Declarations

### Ethics approval and consent to participate

The study procedures were approved by the Medical Ethics Committee of the 920th Hospital of Joint Logistic Support Force (920IEC/AF/31/2021-01). All participants provided written informed consent prior to their enrollment in the study. It is worth noting that our study is retrospective in nature. During the preoperative consultation, the surgical consent form provides detailed information regarding two different surgical strategies that may be adopted based on the severity of adhesions in the surgical area. It also outlines potential complications and associated risks. Furthermore, patients were clearly informed that their clinical data could be utilized for academic publication purposes, with the strict assurance that all personal identifiers would be removed or anonymized to protect their privacy and confidentiality. Clinical trial number: not applicable.

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interests.

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