EUROPEAN UROLOGY OPEN SCIENCE 52 (2023) 145–152

available at www.sciencedirect.com
journal homepage: www.eu-openscience.europeanurology.com

European Association of Urology

Surgery in Motion: Open Science

Microvascular Doppler–assisted Microsurgical Left Spermatic-inferior Epigastric Vein Anastomosis for Treating Nutcracker Syndrome–associated Varicocele

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Article info

Article history:
Accepted April 18, 2023

Associate Editor:
Silvia Proietti

Keywords:
Left spermatic-inferior epigastric vein anastomosis
Nutcracker syndrome
Varicocele
Microsurgical
Microvascular Doppler

Abstract

Background: Nutcracker syndrome (NCS) is a rare cause of varicocele and its treatment is still controversial.
Objective: To summarize the surgical strategy and outcomes of microvascular Doppler (MVD)-assisted microsurgical left spermatic-inferior epigastric vein anastomosis (MLSIEVA) with microsurgical varicocelectomy (MV) at the same incision for treating NCS-associated varicocele.
Design, setting, and participants: A retrospective analysis of 13 cases of NCS-associated varicocele between July 2018 and January 2022 was performed.
Surgical procedure: A small incision in the body projection corresponding to the deep inguinal ring was chosen as the surgical incision. All patients underwent MLSIEVA and MV with the assistance of MVD.
Measurements: Patients received real-time Doppler ultrasound (DUS) before and after surgery; urine red blood cells and protein were tested, with a follow-up time of 12–53 mo.
Results and limitations: All patients had no intraoperative complications, and all postoperative symptoms of hematuria or proteinuria, scrotal swelling, and low back pain disappeared. Comparing pre- and postoperative DUS, two patients did not show any improvement in their postoperative measurements. However, in the remaining patients, the internal diameter of the renal vein at the hilum portion and at the aortomesenteric angle portion, as well as their ratio, improved significantly compared with preoperative measurements. No complications or recurrence of varicocele was observed during postoperative follow-up.
Conclusions: Our study suggests that MVD-assisted MLSIEVA with MV is feasible with no major short-term complication and effective regarding the treatment of varicocele and NCS.

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https://doi.org/10.1016/j.euros.2023.04.012

Patient summary: We investigated microsurgery mediated by microultrasound for the treatment of varicocele associated with nutcracker syndrome. We found this procedure to be safe and effective with good long-term results.

1. Introduction

Nutcracker syndrome (NCS), also known as left renal vein (LRV) entrapment syndrome, was first reported in 1972 and refers to the posterior aspect of the superior mesenteric artery (SMA) and the anterior aspect of the aorta compresses the LRV, resulting in renal vascular congestion [1]. Classically, NCS mainly refers to anterior NCS, which distinguishes it from the rare posterior NCS in which the posterior aortic LRV is compressed by the anterior aspect of the spinal column and the posterior aspect of the aorta [2,3]. The left spermatic vein is one of the vessels most directly connected to the LRV and is an important collateral pathway to relieve LRV hypertension, so NCS often presents as severe varicocele in male patients [4].

The treatment of NCS is still highly controversial; the high risk of surgery and the inaccurate efficacy of conservative treatment often put patients with NCS-associated varicocele in a dilemma. In this study, we used microvascular Doppler (MVD)-assisted microsurgical left spermatic-inferior epigastric vein anastomosis (MLSIEVA) with microsurgical varicocelectomy (MV) under the same incision for the treatment of NCS-associated varicocele further to investigate the safety and efficacy of this procedure and to highlight the technique and our experience of MLSIEVA.

2. Patients and methods

This retrospective study was approved by the Ethics Committee of Beijing Chaoyang Hospital, Capital Medical University. We collected 13 cases of NCS-associated varicocele between July 2018 and January 2022, having age 18.5 (±3.9) yr and course of disease 10.0 (±14.1) mo (Supplementary Table 1). The patients' clinical manifestations included painful discomfort of the scrotum and its contents (n = 12), recurrent microscopic hematuria (n = 7), recurrent microscopic proteinuria (n = 4), and oligoasthenospermia (n = 3; Supplementary Table 1). Since there are no clear criteria for the indication of surgery for NCS, we suggest the following indications for surgery:

1. On examination, the scrotal skin on the affected side is flaccid and sagging, and a dilated and twisted mass of spermatic veins protruding from the skin can be seen on the scrotal skin surface. A tortuous and dilated vascular mass can be palpated (grade III varicocele; Fig. 1A and 1B).
2. Real-time Doppler ultrasound (DUS) suggests NCS (Fig. 2A).
3. Computed tomography angiography (CTA) shows a "beak sign" of the LRV (Fig. 2C).
4. Ultrasound suggests testicular hypotrophy. Testicular hypotrophy was defined as a volume difference between the testicles of at least 20% [5].
5. For men with fertility requirements, a semen analysis shows a decrease in total sperm count, a decrease in sperm concentration, or a decrease in sperm motility.
6. There exist recurrent pain and discomfort of the back or the scrotum and its contents.
7. There exist gross or microscopic hematuria and proteinuria [4,6].

The exclusion criteria are renal disease, history of surgery in the left inguinal region, urinary tract infection, renal prolapse, urinary stones, and deep vein thrombosis.

Specific surgical steps and surgical techniques were recorded in detail. Postoperatively, renal vein ultrasound was used to detect the internal diameter at the renal vein portal, internal diameter at the angle between the abdominal aorta and the SMA, flow velocity near the portal, and urine red blood cells and urine protein; a semen analysis was conducted if necessary; intra- and postoperative surgical complications were recorded; and patients were followed up for recurrence and other discomforts. The surgery was performed by the same surgeon. SPSS 22.0 statistical software was applied for the statistical analysis, paired t test was used to compare each test index before and after surgery, and $p < 0.05$ was considered a significant difference.

2.1. Preoperative preparation

There are no uniform diagnostic criteria for NCS, and DUS is recommended as the preferred screening method. Preoperative DUS was required for all patients. We recommend that preoperative CTA be performed if necessary, and various computed tomography parameters such as beak sign, beak angle, LRV diameter, and aortomesenteric angle are useful features for diagnosing NCS. Preoperative investigations included urine red blood cells and protein, reproductive hormones, and routine semen examination if necessary (age >18 yr and fertility needs), in addition to biochemistry, liver function, coagulation function, and preoperative infectious diseases.

2.2. Surgical technique

2.2.1. Opening of the extraperitoneal space

After general anesthesia tracheal intubation, the patient was placed supine. The incision was made 1–2 cm above the midpoint of the inguinal ligament (left anterior superior iliac spine and pubic symphysis) near the skin corresponding to the left deep inguinal ring, about 3 cm long (Fig. 3). After incising the skin and separating the subcutaneous tis-

Fig. 1 – Pre- and postoperative varicose vein masses on the surface of the scrotum. (A and B) Preoperative varicose vein masses on the surface of the scrotum are clearly visible on the front and side. (C and D) Postoperative disappearance of venous masses on the scrotal surface.

Fig. 2 – Imaging examinations. (A) The left renal vein (LRV) is compressed between the aorta (Ao) and the superior mesenteric artery (SMA). The inner diameter of the distal end of the left renal vein is shown by arrow A, and the inner diameter of the proximal end of the left renal vein is shown by arrow B. (B) Postoperative DUS showed unobstructed blood flow in the anastomosis of the left spermatic vein inferior abdominal wall, and no thrombosis was observed. (C) The preoperative enhanced abdominal CT shows the beak sign, with the dilated left renal vein indicated by the arrow. CT = computed tomography; DUS = Doppler ultrasound.

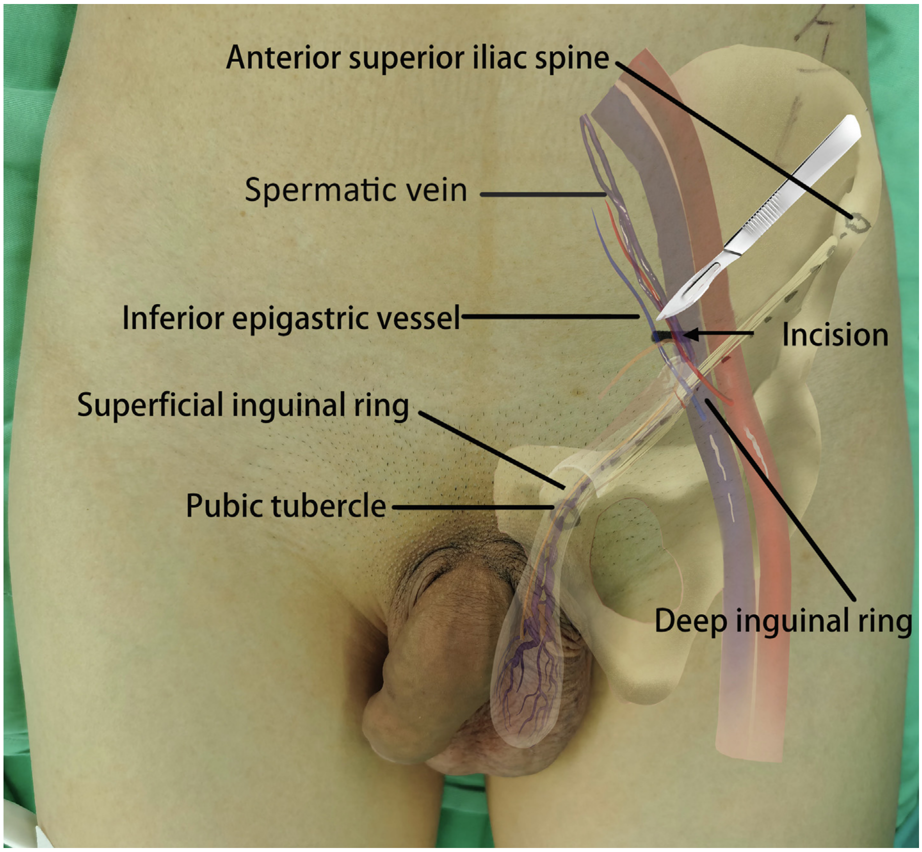

Fig. 3 – The surgical incision was made 1–2 cm above the midpoint of the left anterior superior iliac spine and pubic symphysis line, and a transverse incision of about 3 cm in length was made parallel to the skin near the deep inguinal ring.

sue, the tendon membrane of the external oblique abdominal muscle was incised without incising the external and internal oblique abdominal muscles. The extraperitoneal space was opened at the transverse abdominal muscle's inferior border (Fig. 4A).

2.2.2. Separation of the spermatic cord and inferior epigastric vessels

The spermatic cord was separated near the inguinal canal at the internal ring opening against the peritoneum, raised and separated using appendiceal forceps, and fixed with a rubber strip (Fig. 4B). The inferior epigastric vessels are located medially to the spermatic vein, separated, raised outside the incision, and secured with a rubber strip (Fig. 4C). Care should be taken not to damage the peritoneum and iliac vessels.

2.2.3. Microligation of spermatic vein

The external spermatic fascia, the cremaster muscle, and the internal spermatic fascia are incised sequentially to reveal the varicose veins (Fig. 4D). The ZEISS OPMI VARIO S88 microscope (Carl Zeiss Meditec AG, Jena, Germany) was inserted and magnified five to eight times. After carefully separating the internal spermatic veins, these were ligated individually using a 5-0 silk thread (Fig. 4E). A thicker and unbranched spermatic vein was preserved, while the lymphatic vessels were separated and preserved. A 20 MHz MVD transceiver (Vascular Technology Incorporated, Nashua, NH, USA) with a 1.5-mm-diameter probe was used intraoperatively and applied after fumigation with ethylene oxide. The MVD probe was used to identify the testicular artery (the pulse "whistle" sound could be heard when the MVD probes the arterial surface) and to protect the testicular artery (Fig. 4F). The vas deferens and their accompanying vascular bundle were also isolated and protected. No missed veins are examined.

2.2.4. Left spermatic-inferior epigastric vein anastomosis

The preserved distal end of the spermatic vein was ligated, and the proximal end was cut off by clamping with a visible microvascular clip, leaving the proximal end free long enough for anastomosis (Fig. 5). The inferior epigastric vessels were fully free, and the MVD probe was used to identify the inferior epigastric vein (IEV) and arteries carefully, and one of the IEVs was selected. The distal end of the IEV was ligated, and the proximal end was set aside (Fig. 4G). The dissection of the vessel was trimmed, and the tunica adventitia around the dissection was cut to prevent the tunica adventitia membrane into the vascular anastomosis. The vessel was flushed with intravascular heparin saline. End-to-end anastomosis of the proximal end of the preserved internal spermatic vein with the proximal end of the IEV was performed, with 8-0 Pringles interrupted plus continuous sutures. The posterior wall of the vessel was sutured first, followed by the anterior wall of the vessel (Fig. 4H). The lumen was flushed with heparin saline during the last

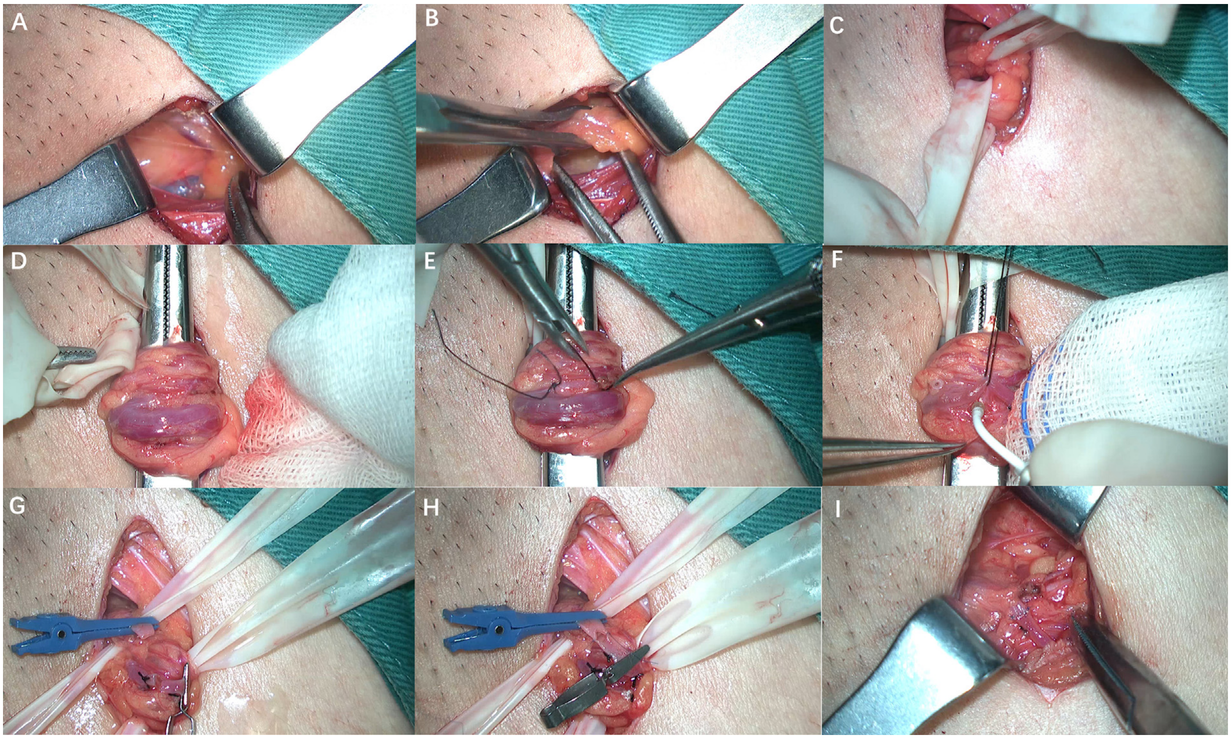

Fig. 4 – (A) Accessing the extraperitoneal space through a small incision near the deep inguinal ring. (B) Using appendage forceps to raise and separate the spermatic cord. (C) Separating and exposing the spermatic cord from the inferior epigastric vessels. (D) Opening the external fascia of the spermatic cord to expose the varicose vein. (E) Ligating the internal spermatic vein, preserving a thicker spermatic vein. (F) Looking for the spermatic artery with MVD. (G) Preparing the anastomosed IEV and internal spermatic vein. (H) Anastomosis of the IEV to the internal spermatic vein. (I) Postoperative results of vascular anastomosis. IEV = inferior epigastric vein; MVD = microvascular Doppler.

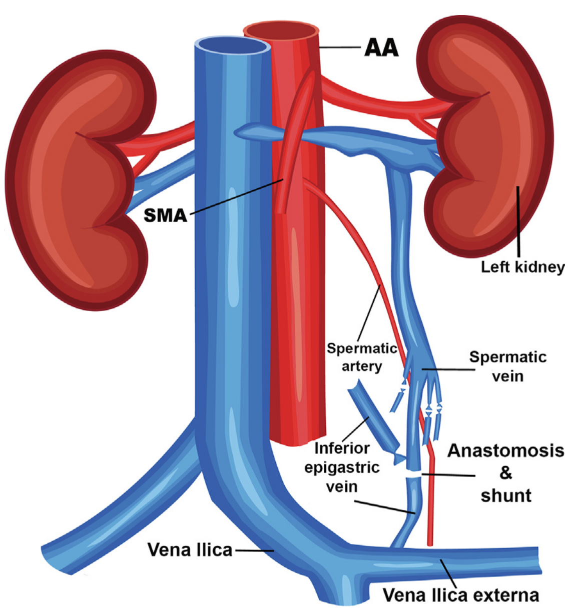

Fig. 5 – Schematic diagram of spermatic cord-inferior epigastric vein anastomosis: ligation of the distal end of the spermatic cord vein, preservation of the spermatic artery and lymphatic vessels, and end-to-end anastomosis of the proximal end of the inferior epigastric vein with the proximal end of the spermatic cord vein. AA = abdominal aorta; SMA = superior mesenteric artery.

stitch of the suture tying and then tied to ensure no air in the vessel at the anastomosis. After removing the vascular clamp, the anastomosis was checked for good anastomosis, no anastomotic fistula, and no vascular torsion or folding. The rubber strip was withdrawn, and the anastomosed vein was placed back into the incision. Careful observation was made to determine the absence of a vascular anastomotic fistula (Fig. 4I). Subcutaneous tissues were sutured sequentially, and the surface skin was cosmetically sutured intradermally.

3. Results

A total of 13 patients successfully underwent MVD-assisted MLSIEVA with MV, with an operative time of 148.1 (±24.7) min. The average hospital stay was 5.7 (±1.9) d (Supplementary Table 1). Postoperatively, the discomfort of scrotal swelling and low back pain disappeared, and the dilated and twisted mass of spermatic veins protruding from the skin disappeared on examination (Fig. 1C and 1D). There were no postoperative complications such as wound infection, hydrocele, and testicular atrophy. No recurrence was seen at 12–53 mo of follow-up. Patients were advised to undergo a follow-up examination every 3–6 mo in the 1st year, and the items included routine blood and urine tests and DUS of renal vessels and spermatic veins. In the 13 patients treated with this procedure, all hematuria and proteinuria disappeared 3 mo after surgery. Comparing pre- and postoperative DUS, two patients showed no improvement in the postoperative measurements, while the internal diameter of the renal vein at the renal hilum portion and at the aortomesenteric angle portion and their ratio

Table 1 – Comparison of pre- and postoperative DUS measurements

DUS index	Before operation	After operation	*p* value
RV diameters (cm) (Renal hilus portion)	0.88 ± 0.1	0.81 ± 0.09	0.0174
RV diameters (cm) (AM angle potion)	0.23 ± 0.08	0.24 ± 0.07	0.5366
RV diameter ratio	4.19 ± 1.32	3.67 ± 1.06	0.0140

AM = aortomesenteric; DUS = Doppler ultrasound; LRV = left renal vein; RV = renal vein.
Continuous variables are presented as mean ± standard deviation.
LRV diameter ratio = LRV diameters (renal hilus portion)/LRV diameters (AM angle portion).

improved significantly in the remaining patients compared with the preoperative measurements (Table 1). At the same time, blood flow of the anastomosis between the left IEV and the spermatic vein was reviewed, no stenosis was observed, and the anastomosis flow was clear (Fig. 2B).

4. Discussion

Excessive longitudinal extension of the spine during rapid height growth in adolescents leads to a narrowing of the angle between the abdominal aorta and the SMA, which traps the LRV and creates a state of hypertension. The left spermatic vein is an important collateral pathway to relieve LRV hypertension in patients with NCS; therefore, NCS is a common cause of severe or secondary spermatic varicose veins in adolescents [7–9]. We recommend ultrasound screening in patients with left-sided varicocele and a thin slim build. There is no clear standard of care for NCS-associated varicocele. We recommend that conservative treatment, including weight gain, pharmacotherapy (eg, angiotensin-converting enzyme inhibitors and aspirin), and regular follow-up, is the preferred recommendation for patients ≤18 yr of age who are thin and have mild symptoms or a disease duration of <6 mo [4]. Surgical intervention should be undertaken promptly for NCS-associated varicocele with progressive or severe symptoms (e.g., third-degree varicocele, oligoasthenospermia, and recurrent back, abdominal, and testicular pain).

In recent years, an increasing number of procedures have been proposed to treat NCS-related varicocele. Although pure spermatic vein ligation protects testicular function, the presence of LRV entrapment can lead to a further increase in postoperative LRV pressure, which can increase the recurrence rate of varicocele or even cause or exacerbate symptoms such as hematuria [10]. Laparoscopic renal vein grafts have a high reintervention rate of 68% and a high number of complications [11–14]. Autologous left kidney transplantation, although highly effective, is a more invasive procedure. Renal vein stenting is simple and nearly noninvasive but carries the risk of thrombosis, vascular perforation, stent displacement, and long-term or lifelong anticoagulation after stenting [15]. Laparoscopic placement of extravascular stents is a highly invasive procedure with many complications and poor long-term outcomes [16]. The recent emergence of laparoscopic 3D printed extravascular stent placement has achieved good results, but the limitations of 3D printing technology make it difficult to promote it on a large scale, and the long-term efficacy is still unclear [17]. In view of this situation, MLSIEVA with MV was developed as a safe, effective, and easily promoted procedure for treating NCS-associated varicocele [10,18].

The procedure used in this study anastomoses the proximal end of the tortuous and dilated left internal spermatic vein with the proximal end of the left IEV after spermatic vein ligation. Hemodynamically, the reconstructed spermatic IEV allows the relatively high-pressure blood from the LRV to flow into the iliac vein and return to the heart through the inferior vena cava, which can effectively reduce the pressure of the LRV (Fig. 5). Ligation of the spermatic vein also blocks the backflow of blood, further reducing the possibility of recurrence. MVD-assisted MLSIEVA and MV have the following advantages: (1) both NCS and varicocele are resolved in a single surgical incision; (2) MVD can be placed directly on the vessel intraoperatively and has the advantage of being fast, safe, effective, inexpensive, and repeatable; (3) the intraoperative use of MVD can effectively identify the structures within the spermatic cord and can better protect the testicular arteries and lymphatic vessels while adequately ligating the veins, thus avoiding complications such as scrotal edema, testicular atrophy, and hydrocele; (4) MVD is used to identify the inferior epigastric artery and the IEV to avoid anastomosing the spermatic vein to the inferior epigastric artery; (5) compared with other shunts, this procedure does not involve blood vessels from vital organs and has fewer surgical risks [3,19–21]; and (6) postoperative follow-up can identify the size of the anastomosis, blood flow, and presence of thrombosis by DUS of the inferior epigastric vessels. In this study, postoperative ultrasound of the inferior epigastric vessels showed that the anastomosis was clear, and no thrombosis was seen. The flow rate of the anastomosis was much higher than that of the contralateral side, which laterally confirmed that it could play a good role in shunting the flow (Fig. 2B).

We choose the IEV as our ideal anastomosis vessel mainly because it has the following advantages:

1. The IEV is relatively constant and easy to find, running between the transversus abdominis fascia and the mural peritoneum, and is located inferiorly within the spermatic cord tissue. The IEV can be exposed by dissecting the aponeurosis of obliquus internus abdominis and the transverse fascia and pushing the peritoneum medial to the spermatic vessels.
2. The IEV is of the same caliber as some of the varicose and thickened spermatic veins, and the end-to-end anastomosis is small, with little tension, making the procedure simple. The anastomosed vessels are less likely to form turbulent blood flow and, therefore, less likely to cause platelet aggregation to form thrombus and obstruct the vessels.
3. The IEV is superficial, and the procedure can be completed with a unilateral incision in the left groin and does not require access to the abdominal cavity.

To ensure the results of this procedure, the following points need to be noted intra- and postoperatively: (1) a small incision close to the deep inguinal ring should be selected correctly, which can accurately locate the spermatic cord and the IEV underneath the spermatic cord, and our experience preoperatively without the use of ultrasound to assist in finding the vessels; (2) intraoperative MVD is used to carefully identify the vessels to ensure that the testicular artery and the inferior abdominal wall artery are not damaged; (3) the broken ends of the finer vessels are cut diagonally to ensure consistent lumen of the anastomosis, and the veins are anastomosed with 8-0 vascular sutures and the knots should not be tied too tightly to avoid vessel wall damage or ischemia; (4) tension-free sutures are ensured when anastomosing the vessel, allowing sufficient freeing of the perivascular tissue to reduce tension while avoiding vessel distortion; (5) interrupted sutures are used to fix both sides, and continuous external sutures are used to close the posterior wall and anterior wall of the vessel to ensure that the anastomosis is smooth and to avoid embedding the outer membrane of the vessel into the anastomosis to prevent thrombosis; and (6) postoperative anticoagulant drugs can be given in appropriate amounts to prevent postoperative thrombosis. In our experience, patients receiving subcutaneous low-dose low-molecular heparin for 3 consecutive days starting from the 1st postoperative day can prevent postoperative thrombosis.

The limitations of this study are as follows: (1) this is a retrospective study, and it is difficult to conduct a randomized controlled trial due to the low prevalence of NCS-associated varicocele; (2) the number of cases in this study is small, and it is necessary to continuously summarize the cases further to confirm the feasibility of surgery and long-term clinical efficacy; and (3) this study is a single-center study, and it is expected that a multicenter study can be conducted later to increase the sample size.

5. Conclusions

Our study suggests that MVD-assisted MLSIEVA with MV is feasible with no major short-term complication and effective regarding the treatment of varicocele and NCS. However, our study still has limitations, and extensive, multicenter, and long-term follow-up observations are still needed to confirm its feasibility and efficacy further.

Author contributions: Long Tian had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Han, Li.
Acquisition of data: Li, Lei.
Analysis and interpretation of data: Han, Yin, Tian.
Drafting of the manuscript: Han, Li.
Critical revision of the manuscript for important intellectual content: Yin, Tian.
Statistical analysis: Han, Li.
Obtaining funding: None.
Administrative, technical, or material support: Yin, Tian.
Supervision: Yin, Tian, Han.
Other: None.

Financial disclosures: Long Tian certifies that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (eg, employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: None.

Funding/Support and role of the sponsor: None.

Ethics 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. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patients for publication of this paper and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

Acknowledgments: The authors would like to acknowledge Ms. Yiran Ma for her help in image drawing.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.euros.2023.04.012.

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