# 17 Microscopic Surgical Techniques for Varicocele Repair

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**Key Points**

- Appropriate patient selection is critical to the success of varicocelectomy.
- Choice of varicocelectomy technique will depend upon surgeon experience, available resources, and patient characteristics.
- Subinguinal microsurgical varicocelectomy carries the lowest documented failure and complication rates.
- The majority of varicocele recurrences following repair are due to technical error.
- Results rely upon formal microsurgical training, which should not be bypassed.

## Introduction

The varicocele represents an aberrant dilation of the pampiniform plexus within the spermatic cord. The incidence of varicocele is commonly quoted to be ~15%, with the majority of affected men demonstrating normal fertility [1, 2]. Most varices develop concurrently with puberty, and thereafter, the observed incidence progressively increases with age [3, 4]. Though most varicoceles remain clinically silent, a correlation with male infertility has long been recognized in a subpopulation of afflicted men, an association which serves as the principle rationale for varicocele repair to improve reproductive potential [5]. The practice remains controversial, however, since most of the older literature has not addressed live birth outcomes [6, 7].

Though birth rates remain the ideal endpoint for any fertility intervention, this measure is inherently problematic due to the introduction of female factor, as well as coital frequency. The effect of varicocelectomy requires large sample sizes and non-operated controls to adequately assess the intervention [8]. As a result, much of the evidence supporting varicocele repair has relied upon improvements in semen parameters, an intuitive but flawed surrogate for male fertility [9]. Nonetheless, the link between improved semen parameters with a varicocele intervention has been consistently demonstrated [10, 11]. These data support the clinical observations

**Electronic Supplementary Material** The online version of this chapter (https://doi.org/10.1007/978-3-319-79102-9_17) contains supplementary material, which is available to authorized users.

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S. C. Esteves et al. (eds.), *Varicocele and Male Infertility*,
https://doi.org/10.1007/978-3-319-79102-9_17

commonly quoted to justify varicocelectomy, which include: a higher perceived incidence among individuals with primary and secondary infertility, return of sperm to the ejaculate in men previously azoospermic, and a dosage relationship relating varicocele grade with poorer semen quality [2, 12–16].

Until recently, the reproductive urologist relied upon studies that were predominately based upon observational data to support the use of varicocelectomy. By 2012, however, enough randomized control trials had accumulated to perform adequate meta-analyses to address the endpoint of birth outcomes [17]. Kroese et al. aggregated 10 studies accounting for 894 men, resulting in a statistically significant improvement in birth rates (odds ratio 2.39, CI 1.56–3.66) when restricting their data to subjects with palpable varicoceles and impaired preoperative semen parameters [18]. This expansion of the evidence was supported by other contemporary studies, with the estimated number needed to treat ranging from 5.2 to 17 [11, 18]. Although these data are far from perfect and allows for continued debate, the argument for varicocele repair in the properly selected patient has never been stronger.

## Preoperative Evaluation

Proper patient selection is paramount to success when considering varicocele repair. The indications for varicocelectomy per the major urologic societies are generally in agreement, which includes the American Urological Association (AUA), the American Society for Reproductive Medicine (ASRM), and the European Association of Urology (EAU) [19–21]. Varicocele repair should be considered in men with a palpable varix on physical exam, abnormal semen parameters, and in whom fertility is desired assuming the female partner is fertile or has a treatable infertility diagnosis. Varicocele-related pain is a relative indication, although care must be taken to accurately ascribe the discomfort to the presence of the varicocele [22]. In adolescents, it is agreed that testicular hypotrophy and/or pain is an indication for repair, although the degree of hypotrophy and the timing for intervention are debated. These guidelines provide a reliable means to counsel the infertile man with concomitant varicocele. Of note, isolated teratozoospermia is no longer considered an indication per the most recent rendition of the AUA-ASRM statement [20].

Another relative indication for varicocele repair is androgen deficiency. It is established that varicoceles cause a pan-testicular insult, with impaired Leydig cell function in addition to the dysfunction of Sertoli and germ cell lines [23–25]. Large studies have confirmed the link between varicocele and low serum testosterone, with varicocele repair often improving the testosterone levels in men with worse preexisting testosterone deficiency [2, 26–28]. A subsequent meta-analysis reviewed nine studies totalling 814 subjects [29]. They demonstrated a mean increase of total serum testosterone following varicocelectomy of 97.4 ng/dL (CI 43.7–151.2). These compelling data provide a reasonable indication for varicocele repair in men with coexisting androgen deficiency, a situation that may clinch the decision to treat in otherwise borderline cases. Both the AUA-ASRM joint statement and the EAU have now included language to address the expanding role of varicocele repair in men with low androgen levels [20, 30].

## Options for Varicocele Repair

Multiple treatment modalities have been employed for repair of varicoceles. Table 17.1 presents techniques of varicocele repair with success and complication rates. Surgical complications include postoperative hydrocele (secondary to excessive ligation of lymphatics), hematoma, and varicocele persistence and recurrence.

In a large randomized study, Al-Kandari et al. compared traditional open techniques (without microscope assistance) against laparoscopic and subinguinal microsurgical varicocelectomy [31]. A hydrocele developed in 13%, 20%, and 0% of cases in the open, laparoscopic, and microsurgical groups, respectively. The number of recurrences

**Table 17.1** Modalities of varicocele repair: classically reported success rates and complications

| Treatment | Advantages | Disadvantages | Recurrence rate | Complication rate | Source |
|---|---|---|---|---|---|
| Embolization | Minimal pain | Difficult canalization of the right spermatic vein | 3.2–19.3% | Extravasation NR<br>Thrombophlebitis NR | Cayan [32]<br>Cassidy [33] |
| Laparoscopic | Simplified vascular anatomy, short operating time, can address bilateral varices simultaneously | Difficulty visualizing lymphatics | 4.3% | Hydrocele 2.8–20% | Al-Kandari [31]<br>Cayan [32] |
| Microscopic subinguinal | Adequate anatomic visualization, possibly less pain | Complex vascular anatomy | 1.05% | Hydrocele 0–0.4% | Al-Kandari [31]<br>Cayan [32] |
| Microscopic inguinal | Simplified vascular anatomy, adequate visualization | Possibly more incisional pain | 2.1% | Hydrocele 0.7% | Cayan [32] |
| Loupe-assisted high ligation | Simplified vascular anatomy | Incisional pain, poor visualization of structures | 14.9% | Hydrocele 8.2–13% | Al-Kandari [31]<br>Cayan [32] |

was 7, 9, and 1 in the open, laparoscopic, and microsurgical arms, respectively. Improvements in semen parameters and birth rates were similar across all techniques. In a follow-up meta-analysis encompassing 36 studies, Cayan et al. documented comparable outcomes (see Table 17.1) with subinguinal microsurgical varicocelectomy remaining the best performer [32]. Cayan and colleagues also reviewed the published literature for varicocele embolization, reporting a recurrence rate of 12.7%. A subsequent large series by Cassidy and colleagues provides additional details regarding the success of embolization [33]. When including right-sided attempts in the final analysis, which is significantly more difficult to cannulate for the interventional radiologist, failure rates were comparable to that of Cayan et al. at 19.3% for bilateral varices. However, when narrowing to only left varicoceles, the failure rate drops to 3.2%.

For the patient seeking the least likelihood of recurrence, inguinal or subinguinal microsurgery outperforms image-guided techniques. Given the high initial cost and maintenance of an operating microscope, along with the investment of microsurgical training, multiple groups have studied whether traditional loupe magnification is sufficient [34]. In an early study by Goldstein et al., 2.5× loupes were compared against the operating microscope [35]. Their retrospective review demonstrated a recurrence and hydrocele rate of ~9% with loupe assistance, whereas the microscopic technique was characterized by a 0.6% recurrence rate and an absence of postoperative hydroceles over a course of 640 varicocelectomies. A follow-up study by Cayan and colleagues compared a macro-inguinal approach against the micro-subinguinal repair [36]. Similar to the earlier account, the operating microscope imparted a recurrence rate of 2.1% as opposed to 15.5% in the more traditional technique. Finally, in a unique study by Liu et al., an independent surgeon aided by the operating microscope graded intraoperatively the dissection of a colleague who marked arteries, veins, and lymphatics without magnification [37]. Concerningly, an average of 0.74 arteries were marked for ligation and an average of 2.14 veins would have been missed. These data provide clear evidence that the operating microscope is necessary to perform a high-quality varicocelectomy.

From the above data, it is apparent that the microsurgical varicocelectomy provides the most reliable success rates combined with the lowest reported complications. Additionally, the subinguinal approach appears to limit postoperative pain since the external oblique aponeurosis is never violated, although there have been conflicting reports [38, 39]. To this end, we consider the subinguinal microsurgical varicocelectomy the current gold standard for repair.

## Focused Anatomic Review

The vascular pedicle of the testicle is classically described as one artery and one vein that originate asymmetrically. Both the left and right testicular arteries originate from the aorta; while the left internal spermatic vein drains into the left renal vein, the right inserts directly into the vena cava at a sharp angle. This classical anatomy is only present in 80% of men, with atypical origins and collateralization above the iliac canals being common [40]. Upon entering the inguinal canals, these "solitary" vessels begin to branch, with the internal spermatic vein forming the pampiniform plexus (Fig. 17.1). The vessels feeding the external spermatic fascia typically arise from the infe-

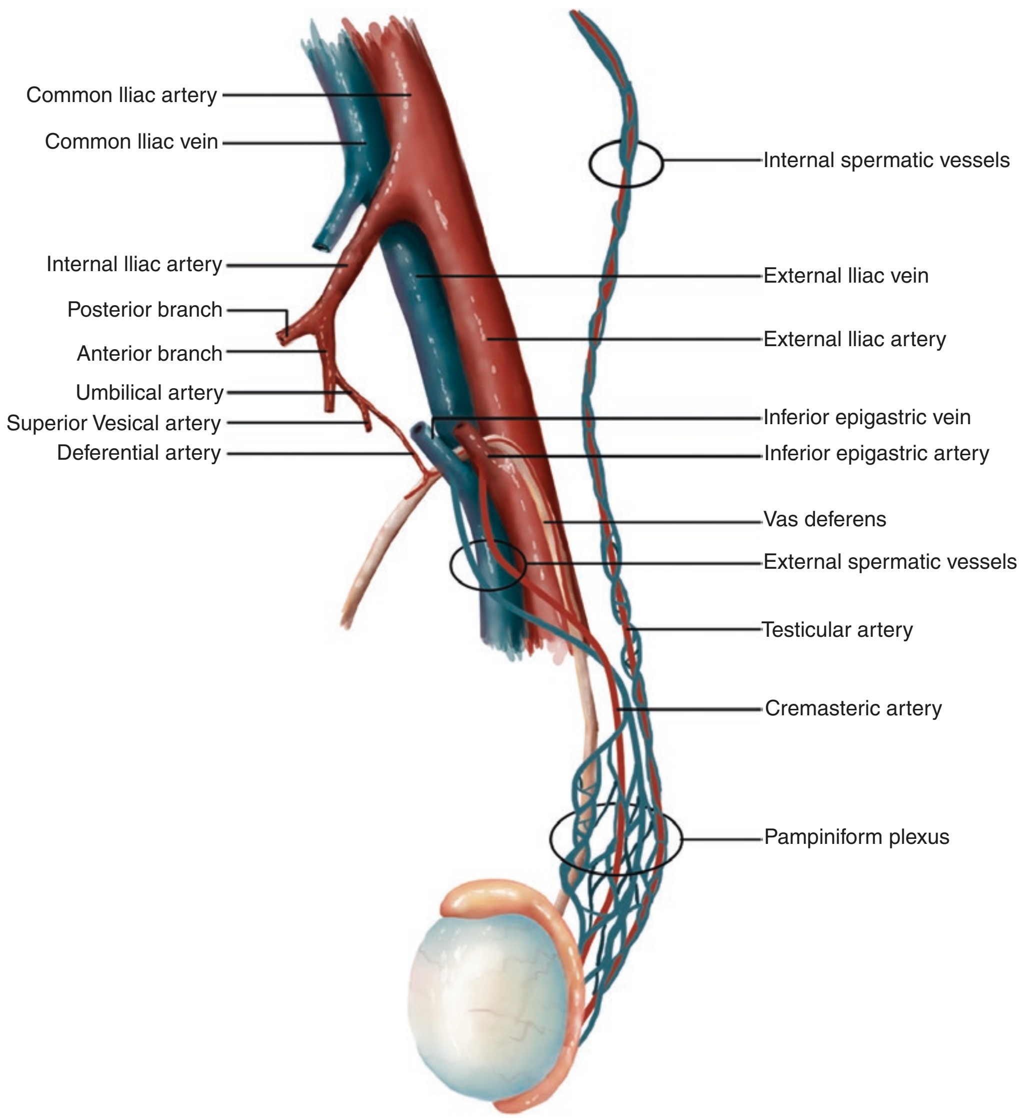


**Fig. 17.1** An overview of vascular anatomy of the testis

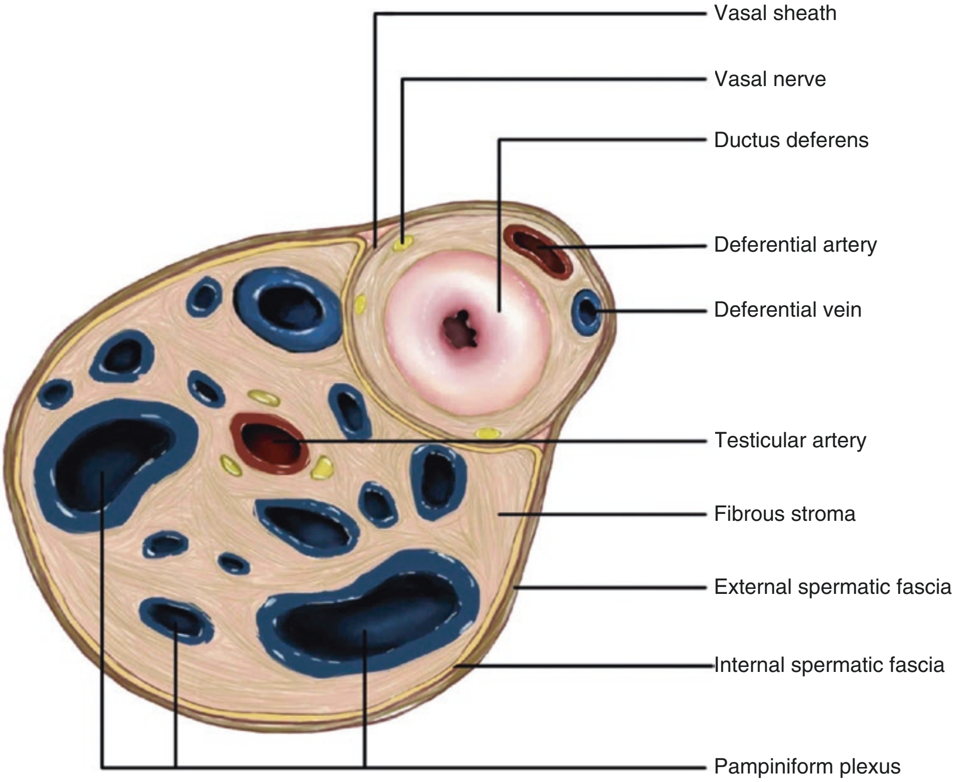


**Fig. 17.2** Cross-sectional anatomy of the spermatic cord, demonstrating the location of the vasal sheath between the internal and external spermatic fascia

rior epigastrics, which may have distal collateralization into the internal spermatics [41]. Finally, an alternative venous outlet of the testis lies in the gubernacular veins, linking the testis circulation with the general scrotal venous system [42, 43]. Both of these alternative venous routes serve as potential etiologies of varicocele recurrence following successful interruption of the internal spermatic vein [35, 42].

The remaining venous outlet after successful varicocele repair consists of the paired deferential veins that typically drain into branches of the internal iliac vessels [41]. The deferential vessels lie within an investment containing the vas deferens, which can often be visually distinguished by marked tortuosity. It is worth mentioning that the deferential artery, also a product of the internal iliacs, serves as the principle arterial supply of the testis should the internal spermatic artery be incidentally ligated. The vas deferens and its sheath lies posteriorly between the internal and external spermatic fasciae (Fig. 17.2), a useful feature for excluding the vas deferens during exposure [41, 44].

In regard to varicocelectomy, key features of the vascular anatomy include the progressive branching of both internal spermatic vein and artery. The subinguinal approach, therefore, will be characterized by increasing vascular complexity. The number of veins can often number in the tens, whereas multiple arteries serve as the rule rather than the exception [43, 45]. A firm understanding of these basic anatomical principles is necessary for proficient subinguinal microsurgical varicocelectomy, a prerequisite that is especially pertinent in difficult fields that may be subject to scar, poor visualization, or an exposure placed inadvertently too distal along the cord.

## Surgical Technique

### General Considerations

Prior to incision, proper instruments facilitate success (Table 17.2). Emphasis is placed on the availability of the microdoppler with a 1.2 mm tip, an instrument that will help address the multiple arteries that are expected [46]. Level I evidence now exists highlighting the utility of microdoppler assistance and should now be considered standard of care [47]. A bipolar cautery is also a necessity, providing effective hemostasis without thermal damage to nearby structures. A bipolar with a Jeweler's forcep and 0.4 mm tips are the authors' preference.

The patient is positioned supine with the arms abducted. The decision to sit or stand during the procedure is a matter of surgeon preference. Operating chairs are available that provide distal arm stabilization and chest support, which significantly improves fine motor control. Likewise, if a standing position is chosen, the surgeon should rest their wrists and hands on the patient to preferentially engage only the distal joints and musculature.

**Table 17.2** Minimal necessary equipment for the subinguinal microsurgical varicocelectomy

| Macro | Micro | Disposables |
|---|---|---|
| Operating microscope capable of 20× magnification | Fine tip bipolar hand piece | 4–0 Silk ties |
| Microdoppler | Micro-needle holders × 2 | Surgical clips |
| Cautery generator for both monopolar and bipolar current | Iris scissor | 1" Penrose drain |
| Basic open kit:<br>Small abdominal retractors × 2<br>Toothed and smooth Adson × 2<br>Babcock clamp<br>Small needle driver<br>Clip applier<br>Scalpel<br>Mosquito clamps × 4<br>Schnidt curved clamp<br>Small Metzenbaum scissor | Jeweler's forceps | Vessel loops × 2 |
| | Micro-forceps (smooth or toothed) × 2 | #15 Scalpel blade |
| | | Microdoppler probe and cord |
| | | 3–0, 4–0, and 5–0 absorbable sutures for closure |

Hair is removed with surgical clippers. It is prudent to prep the patient from the umbilicus to two finger breadths below the inguinal crease should it become necessary to extend the incision to optimize exposure. The scrotum should be draped into the field to allow for intraoperative manipulation and delivery of the testis.

### Initial Approach

Multiple incisions have been utilized to accomplish adequate exposure for a subinguinal approach. Our standard practice utilizes a 2–3 cm incision along Langer's lines, located above the external inguinal ring to optimize cosmesis. The size of the incision is gauged to allow for unencumbered delivery of the testis. Marking the proposed incision is most important in bilateral cases to ensure symmetry. The incision is carried down to the dermis sharply and finished with the monopolar cautery using the cutting waveform. The bipolar cautery is an effective means to address cutaneous bleeders without imparting significant thermal injury to the skin. Camper's and Scarpa's fascia are divided over a curved clamp. The external pudendal artery and vein are typically encountered at the inferior aspect of the wound and, more rarely, the superficial epigastric artery and veins may be met at the superior aspect of the wound.

Blunt dissection is then carried into the scrotum over the cord. A curved index finger hooked into the external ring, with a small abdominal retractor drawing distally from this location, will allow for expedient and clean visualization of the spermatic cord. A Babcock clamp is then used to atraumatically deliver the spermatic cord into the field, allowing for a 1" Penrose drain to be placed beneath. Using the Penrose as a manipulator, distally applied counter-tension can be applied to the cord, which allows the surgeon to finger-dissect circumferentially within the inguinal canal. This maneuver frees the cord and delivers a more proximal segment into the exposure. In the senior author's experience, when returning years later for the rare hernia repair in a post-varicocelectomy patient, the prior ligatures are typically observed in the mid-inguinal canal. Thus, the subinguinal technique can approximate the ligation site of an inguinal approach and capitalize on a less-complex vascular anatomy [43, 45].

The spermatic cord is then released and allowed to rest on the Penrose drain. The external spermatic fascia is elevated between two forceps and carefully split with the monopolar cautery, preferably between muscle fibers. A tag suture to mark the proximal apex of this muscle splitting incision is useful for orientation and should the surgeon choose to close this layer at the conclusion of the procedure. Both the surgeon and assistant, thereafter, switch to micro-instruments and exclusively use bipolar cautery for the remainder of the cord dissection. The internal spermatic fascia is elevated in a similar fashion as the external layer utilizing micro-forceps. A fine scissor is then used to incise this layer with care to avoid underlying structures. Placement of clamps along the internal spermatic fascia provides exposure and can be positioned to isolate the vas deferens posteriorly. Again, a more proximal location along the spermatic cord can be obtained by sequentially incising and "marching" these clamps along the internal spermatic fascia towards the external ring. The final exposure consists of the free Penrose drain providing elevation to the cord and four clamps placed to maintain a square of internal spermatic fascia while excluding the vas deferens below (Fig. 17.3).

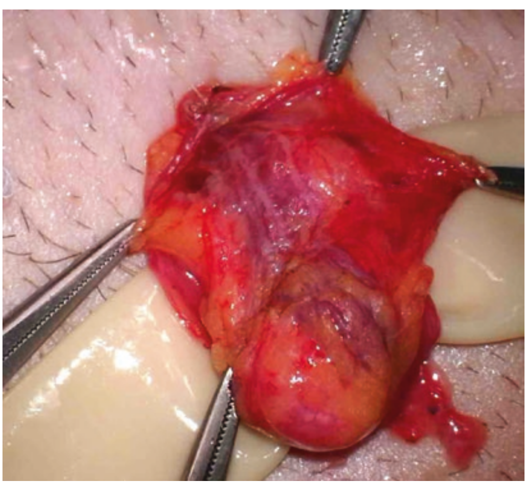

**Fig. 17.3** Image demonstrating proper exposure of the spermatic cord

When reading the subsequent description below, please keep in mind that it remains at the discretion of the surgeon if proximal exposure becomes necessary. Occasionally, an extremely complex vascular anatomy is encountered in the subinguinal region, and in this scenario, the external oblique should be opened. The proximal cord should then be addressed utilizing standard microscopic techniques.

## Vessel Identification and Ligation

Once the vas deferens is identified and isolated, the field is irrigated with saline to allow a coupling interface for the microdoppler. Effective use of the microdoppler probe maintains a 60 degree angle of insonation with just a thin film of irrigation solution between the doppler tip and the underlying tissue. Avoid any pressure on the doppler tip for the best effect. A crude understanding of the arterial anatomy will become evident, i.e., the rough location and number of arteries. This initial survey will help identify an early approach to minimize the risk of arterial injury.

Commonly, a few large obscuring veins will require division prior to approaching the artery. The surgeon should select one to three venous structures that are easily isolated and will optimize visualization of an area of positive doppler signal. Internal spermatic veins are invested in a thin adherent membrane that also contains a network of miniscule lymphatics. To preserve these structures, and to allow for a clean isolation of the vessel, the vein should be firmly grasped with the micro-forceps, while the tips of the micro-needle holder are pressed against the vein wall to bluntly sweep downward. A rent will be created in the surrounding membranous layer through which the vein is regrasped with the micro-forceps. A similar maneuver is repeated on either side of the vein until a tunnel beneath the vessel develops. In this fashion, a vein can be reliably separated from other adherent structures, most notably any small arteries beneath. The micro-forceps are passed through the tunnel and used to grasp two 4–0 silk ties (Fig. 17.4). Using one

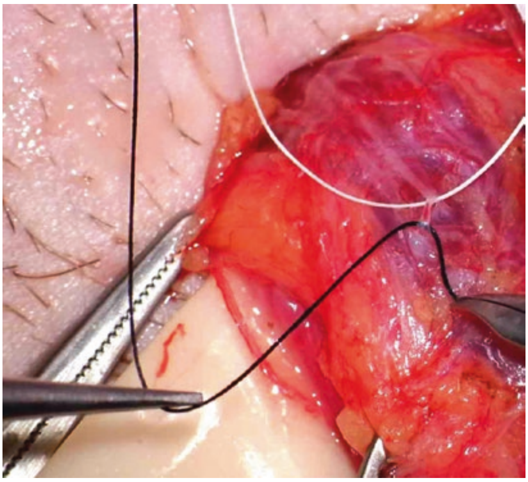

**Fig. 17.4** Vein ligation with two 4–0 silk ties. In this example, an "H" pattern is observed with a branch connecting two veins. An "H" or "X" pattern of interconnected veins is usually indicative of an underlying artery

black and one white tie simplifies finding which two ends go together. The vein is ligated and divided using fine scissors. At times, one or both of the ties can be used as a handle when approaching deeper cord structures. It should also be mentioned that some surgeons prefer to clip the veins in lieu of ties. Our preference is to use silk ties near any arterial structure, with judicious use of clips for more peripheral vessels.

As the artery is approached, it is often surrounded by a dense plexus of small veins. The interconnections often form "X" and "H" patterns and are almost always indicative of an underlying artery (Fig. 17.4). The artery often appears as a small silvery-reddish structure; however, visual identification of arteries is neither sensitive nor specific. A suspected artery should never be grasped. Instead, surrounding venous structures may be handled with the micro-forceps and used to obtain tension and counter-tension against the micro-needle holders. The venous plexus should be ligated and divided until adequate exposure is obtained. A tunnel around the artery is begun by allowing the micro-needle holders to slowly spring open to spread-dissect tissue. The instrument's tips should be placed on either side of the artery with any spreading motion occurring along the axis of the vessel. Again, the surgeon may grasp surrounding venous stumps to provide cord elevation and cautious counter-tension. Adequate depth is obtained when the micro-needle holders can be convincingly passed beneath the artery. The micro-needle holder is then passed a few millimeters beyond the artery, which will invariably elevate additional tissue. With gentle elevation, the micro-needle holders are withdrawn, allowing these additional tissues to slip off the tips. The withdrawing motion is continued until only the artery remains above the instrument, which is confirmed by visualization of a clean arterial wall. The tips of the micro-needle holder must be confirmed beyond the arterial wall prior to the final spreading maneuver, which is conducted by pushing the instrument's tips firmly into one's fingertip prior to spreading.

Confirmation of the artery should then be sought by use of the microdoppler. The positive predictive value of a doppler signal is reliable, however the absence of pulsations is not. The artery may be in spasm or kinked against the internal ring, and it is commonly necessary to irrigate with papaverine to facilitate dilation. In the accompanying Video 17.1, a cleanly isolated artery can also be confirmed by gently elevating the vessel with the micro-needle holder until it blanches. Slowly dropping the instrument toward the cord will reveal an arterial blush. Note that this strategy will not work if another vessel has been isolated with the artery. A confirmed artery should then be marked by a short vessel loop, which can be grasped with the micro-needle holders (Fig. 17.5). Cutting the vessel loop tip to a taper allows easy passage under the vessel. The ends of the loop are secured together with a medium clip.

In the above stepwise fashion, the surgeon progresses through the cord until all internal spermatic veins are ligated and all arteries are surrounded with vessel loops. The plane of ligation should be consistent, as the tortuosity of these vessels can become easily confusing (i.e., the same vessel may be ligated multiple times, which adds unnecessary operative time). At the conclusion of this portion of the procedure, the surgeon should elevate the cord with the middle finger of his nondominant hand (Fig. 17.5). The cord is then spread out and drawn over the tip of the finger to systematically examine for any remaining venous structures. At least two to three lymphatics should be spared to prevent postoperative hydrocele. These structures should have crystal clear fluid within their lumen and may be characteristically identified by a scalloping of the vessel wall (Fig. 17.6). Reinspection of the artery is warranted, as often miniscule veins may be closely adherent, a potential source of recurrence. These structures can either be peeled off the artery using the Jeweler's forceps or cauterized in place using the bipolar on low current settings.

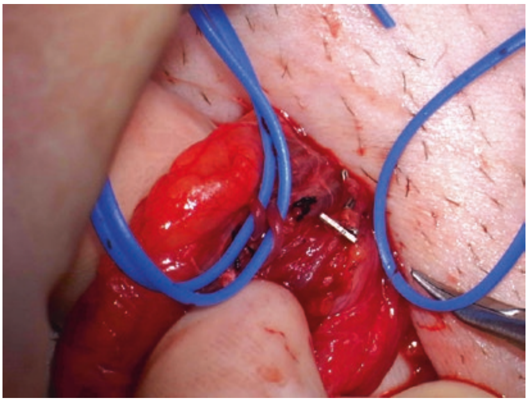

**Fig. 17.5** Confirmed arteries are isolated and identified with vessel loops. In this image, the surgeon is splaying the cord over the middle finger to systematically survey for any missed venous structures. Opposing the thumb against the cord, with the middle finger providing a backing, stabilizes the cord as the surgeon thins the cord to step through each segment of tissue

Preservation of arteries adds considerable time and complexity to the case. It is notable that in other surgical techniques the artery is ligated purposefully (i.e., in laparoscopy). In animal models, ligation of the artery has been observed to decrease intratesticular testosterone and to negatively affect the Johnsen score on testis biopsy [48]. Clinically, multiple groups have observed no significant difference in semen parameters or fertility outcomes when individuals were subjected to either artery preserving or ligating laparoscopic varicocelectomy [49, 50]. The majority of these studies were conducted in adolescent patients, and we contend that the reserve and ability to establish effective arterial collateralization are greater in the pediatric population. Testicular atrophy, although rare, has been observed in the adult population following inadvertent ligation of the testicular artery [51]. Until comparable and robust studies have been conducted in the adult male, preservation of the testicular artery should be considered standard of care during subinguinal microsurgical varicocelectomy.

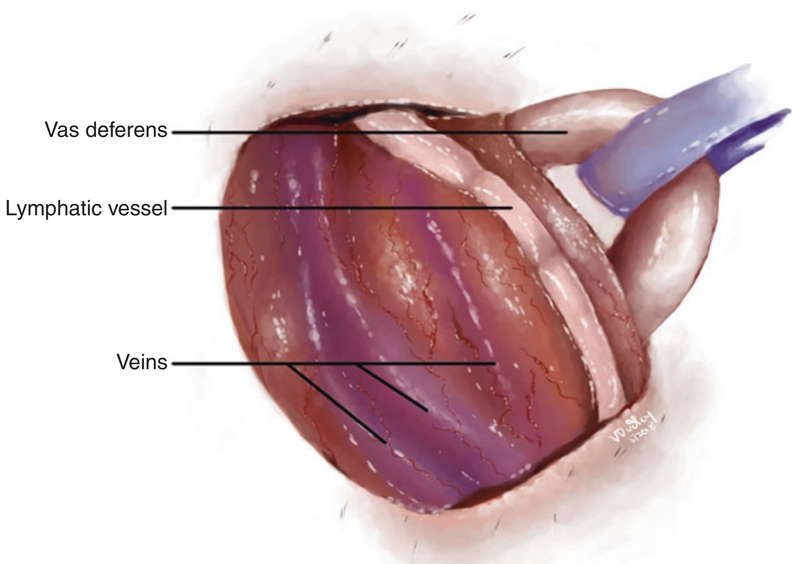


**Fig. 17.6** Identification of lymphatics within the spermatic cord by the scalloping pattern

## Alternative Venous Drainage of the Testis

As outlined previously, recurrence following varicocelectomy may occur due to redundant venous drainage of the testis through either external spermatic veins or via a gubernacular tract [41–43]. While running the cord over the middle finger, any cremasteric veins should be clipped and divided. Attempts should be made to identify and preserve the cremasteric artery, which can be identified via the blanching technique (see Video 17.1). We are able to identify and preserve at least one cremasteric artery in 90% of cases. The underlying Penrose drain is then elevated and the base of the wound inspected. Any external cremasteric vessels not enclosed by the Penrose should then be addressed.

Delivery of the testicle to visualize gubernacular veins remains debated [52, 53]. Early accounts established this collateral system as a rare cause of varicocele recurrence, and we argue that these vessels should be taken to optimize outcomes [35, 42, 54]. Two recent randomized control trials have found benefit in terms of recurrence rates when the gubernacular veins were ligated, although an earlier trial found no clinically significant advantage [55–57]. In our practice, we continue to deliver the testis. Even if gubernacular collaterals are not contributing to the varicocele, and they are simply "vents" for the increased venous pressure that occurs after ligating the internal and external spermatic veins, ligating these vents further increases the venous pressure, and when rerunning the cord, we have been shocked at how often previously undetected internal or external spermatic veins have enlarged and become visible. We are convinced that rerunning the cord after ligation of the gubernacular veins has significantly reduced our failure rate.

Upon delivery of the testis, the gubernaculum can be bluntly thinned to improve visualization (Fig. 17.7). In a similar fashion to screening the spermatic cord, the middle finger of the nondominant hand is placed under the gubernaculum and provides elevation. The tissue is then systematically drawn over the finger using the aid of the micro-needle holder. Any encountered vascular structure entering the tunica vaginalis is clipped and divided. Should a small amount of hydrocele fluid be identified, a window can be optionally created in the tunica vaginalis with hemostasis obtained by the monopolar cautery. Occasionally, a formal hydrocelectomy is warranted.

**Fig. 17.7** Delivery of the testis with blunt dissection to thin the gubernaculum. Only vessels passing between the gubernaculum and the tunica vaginalis require intervention

## Final Assessment and Closing

Adequate hemostasis must be ensured prior to returning the testis to the scrotum. At the conclusion of the ligation, a strong impulse should be palpable distal to the plane of dissection when the spermatic cord is squeezed above the testis. A lack of impulse should prompt another screen of the cord until the surgeon is convinced that every venous structure except for the vasal veins has been interrupted. The impulse maneuver also provokes sites of bleeding that need to be addressed with the bipolar cautery or further ties.

Although optional, we prefer to close the external spermatic fascia to reestablish the anatomic planes and to cover the exposed testicular arteries. This closure should be accomplished loosely with 2–3 interrupted 5–0 absorbable sutures. Subsequent steps include closure of the Scarpa's and Camper's fasciae. The skin is typically reapproximated with deep dermal interrupted sutures, followed by a running subcuticular stitch reinforced with steristrips.

## Postoperative Counseling

As is common with all varicocele repair techniques, the subinguinal microsurgical varicocelectomy is an outpatient procedure. We advise our patients to ice the scrotum for 48 hours following the surgery and to wear an appropriately sized scrotal supporter. The use of perioperative celecoxib has been found useful in similar procedures [58]. Narcotic utilization following varicocelectomy is highly variable, but does not typically pass post-op day three or four.

Patients may return to desk work in two to 3 days with cautious activity. As the inguinal canal remains intact, there is no increased risk for hernia. Heavy lifting should still be avoided as the resulting intra-abdominal pressure will tend to stress venous hemostasis in the scrotum. We evaluate our patients 4 weeks post-op following the procedure to ensure proper healing of the wound and at 3 and 6 months to evaluate for failure. When the varicocelectomy fails, this is almost always detectable at 4 weeks by a persistent impulse on Valsalva and persistent veins that collapse when supine. After repair of large varicoceles, thrombosed veins may take up to 3 months to resolve, and there should be no impulse on Valsalva and no change in the cord from the upright to the supine position. A repeat semen analysis can be obtained at 3 and 6 months to evaluate for improvement [59]. This interval is also adequate to evaluate for testicular atrophy.

## Brief Comments Regarding the Recurrent Varicocele

Varicocele recurrence may be confirmed by either physical exam or ultrasound. Due to post-op scarring, it is important to note that the sensitivity of the physical exam may be substantially decreased. It only requires one patent vein to eventually cause filling and dilation of all venous structures distal to any ligated segments. It is impossible to perfectly dissect the ligature plane from an earlier varicocelectomy, and so it is difficult to accurately identify which veins were previously ligated when encountering these dilated vessels through a new surgical approach. Therefore, it is rare to identify the solitary vein that was missed initially. Although external spermatic and gubernacular veins were extensively discussed, the vast majority of varicocele recurrences occur due to a missed internal spermatic vein [60]. These represent technical errors.

A number of options exist in addressing the recurrent varicocele. A general rule is to approach the spermatic cord with a different exposure to avoid the site of maximum scar tissue. Amelar preferred the use of embolization for the recurrent varicocele, a strategy that benefits from concurrent venography to define the patent vasculature [61]. In the senior author's experience, the subinguinal approach often remains viable despite a previous subinguinal microsurgical varicocelectomy. The safety of this approach has been established by a small series by Grober et al. [62] The prior plane of dissection is easily identified by the presence of clips and surgical ties. A site just proximal or distal to the prior ligatures will often facilitate effective repair. Should unfavorable conditions prevail, the external oblique can be opened to facilitate a proximal approach. Finally, the gubernacular and external spermatic veins must be addressed during a procedure for the recurrent varicocele.

## The Role of Microsurgical Training—A Call for Further Study

The subinguinal microsurgical varicocelectomy requires the development of a complex and demanding set of skills. The tissue handling techniques required for successful repair cannot be gleaned from a review of this type. In other areas of urology, objective measures are now being developed to assess trainee proficiency and to define a learning curve to judge competency. For instance, studies such as Abboudi et al. have begun to define the minimal case experience required to perform a robotic-assisted laparoscopic prostatectomy [63]. Along similar lines, the benefits of simulation have now been clearly delineated for techniques such as laparoscopy [64].

In our center, we utilize a microsurgical training lab to teach suture handling and tying under the operating microscope [65, 66]. We have observed a minimal requirement of 500 microsurgical knots to obtain an appropriate level of proficiency for progression to an animal model. Other centers have also attempted to develop a systematic method for microsurgical training [67–69]. Continued work is required to mature this field and to ensure the optimal and standardized training of future urologists.

## Conclusions

Varicocelectomy provides an effective treatment for male infertility and androgen deficiency in the appropriately selected patient. Multiple options exist to achieve repair, and the ultimate selection hinges on surgeon experience, available resources, and patient characteristics. The best evidence supports subinguinal microsurgical varicocelectomy as the gold standard. The technical steps of the subinguinal microsurgical varicocelectomy rely upon appropriate exposure of the testicular artery, a systematic approach to vein ligation, and preservation of the vas deferens and lymphatics. The majority of early and late failures are due to missed internal spermatic veins. To avoid this technical error, we recommend multiple passes through the spermatic cord to inspect for missed veins. These structures will dilate over the course of the operation, which will facilitate identification and ligation. Finally, considerations for approaching the recurrent varix are outlined. These procedures can be challenging due to postsurgical scarring with subsequent loss of anatomic planes. All internal spermatic veins must be ligated again, and alternative routes of venous return (gubernacular and external spermatic veins) must be addressed. It should be stressed that, despite the detail of this review, our remarks cannot substitute for an appropriate and extensive foundation of microsurgical training.

**Review Criteria**

A systematic review was conducted using PubMed and Google Scholar. Search dates were restricted to January 1950 through May 2018. Study identification was conducted using the following search criteria: “varicocele”, “varicocelectomy”, “male infertility”, “varicocele recurrence”, “varicocele embolization”, “microsurgical”, “subclinical”, “semen parameters”, “pregnancy rates”, “reactive oxygen species”, “DNA fragmentation”, “azoospermia”, “oligospermia”, “scrotal hyperthermia”, “venous reflux”, “post-operative pain”, “hydrocele”, “surgical training”, “gubernacular”, “external cremasteric”, “venography”, “testicular hypotrophy”, “ultrasound”, “varicocele grading”. Only literature published in the English language was reviewed.

## Multiple Choice Questions and Answers

1. When unusually complex vascular anatomy is encountered during a subinguinal exposure, an accepted surgical strategy is:
   (a) Spermatic cord-freeing techniques to gain more proximal access
   (b) Extension of the skin incision and committing to an inguinal approach
   (c) Deferring particularly difficult or small veins, especially when adherent to the artery, until after testis delivery to allow time for venous dilation
   (d) **All of the above**
2. Proper use of the microdoppler includes all of the following except:
   (a) Ensuring a proper angle of insonation
   (b) Utilizing known arteries as an intraoperative control to rule out equipment malfunction
   (c) Minimization of tissue compression
   (d) **The presence or absence of a pulsating waveform is reliably indicative of an artery and vein, respectively**

3. The following are effective strategies of addressing the recurrent varicocele except:
   (a) The region of maximal scar formation may be avoided by choosing an alternative exposure than that of the original repair
   (b) **The subinguinal approach should be avoided for the failed subinguinal microsurgical varicocelectomy**
   (c) The surgeon may choose to dissect the spermatic cord proximally or distally to that of the original repair
   (d) Delivery of the testis with ligation of the gubernacular veins is mandatory
4. The most common cause of varicocelectomy failure is:
   (a) **Dilation of unidentified internal spermatic veins**
   (b) Patent gubernacular veins
   (c) Missed external cremasteric veins
   (d) Proximal collateralization of the right and left venous systems
5. Regarding the diagnosis of a varicocele, ultrasound is a useful adjunct to the physical exam when:
   (a) There is suspected varicocele recurrence following a repair
   (b) Prior scrotal or inguinal surgery precludes adequate palpation of the spermatic cord
   (c) The testis is high-riding or retractile
   (d) **All of the above**

**Source of Funding** Frederick J. and Theresa Dow Wallace Fund of the New York Community Trust, the Mr. Robert S. Dow Foundation; Irena and Howard Laks Foundation.

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