Should Varicoceles Be Managed Surgically or Radiographically? (Surgery)

46

J. Abram McBride, Daniel J. Mazur, and Larry I. Lipshultz

Key Points

- While there are technical considerations for choosing a particular approach for varicocele repair, embolization is unique in that it suffers from a significant rate of initial failure to treat.
- Various approaches to varicocele repair have demonstrated improvements in clinical outcome measurements; however, it is difficult to compare these techniques given the lack of quality, prospective randomized trials.
- Surgery and radiographic approaches offer favorable complication profiles, but only microscopic inguinal or subinguinal varicocelectomy results in the lowest recurrence and complication rates.
- Only the intraoperative use of an operative microscope and microvascular Doppler has been shown to maximally reduce complication rates compared to alternative surgical approaches.
- Recurrent varicoceles may be treated with either surgery or radiographic techniques with equivalent outcomes, although radiographic approaches may be preferred if the recurrence is bilateral or after previous surgery.

Introduction

The varicocele was initially described by Celsus in the first century AD, but effective treatments were not developed until the introduction of the inguinal varicocelectomy by Narath in 1898 [1]. In 1949, Palomo introduced an alternative—the high retroperitoneal ligation approach [2]. But the perception of varicoceles as innocuous conditions remained until 1955 when Tulloch et al. reversed a case of azoospermia by performing a bilateral high retroperitoneal ligation, establishing a new role for varicocelectomy in the treatment of male infertility [3].

In 1978, Lima et al. introduced the first radiographic approach by performing percutaneous transvenous left spermatic vein occlusion [4]. Meanwhile, microsurgical technology was rapidly developing, and some suggested microscopic enhancement during varicocelectomy to prevent inadvertent ligation of the testicular artery [5]. However, the first reported use of microscopic assistance during inguinal

J. A. McBride · D. J. Mazur · L. I. Lipshultz (✉)
Scott Department of Urology, Baylor College of Medicine, Houston, TX, USA
e-mail: larryl@bcm.edu

S. C. Esteves et al. (eds.), *Varicocele and Male Infertility*,
https://doi.org/10.1007/978-3-319-79102-9_46

varicocelectomy was not until 1985, the same year Marmar et al. published the first series utilizing a subinguinal microsurgical technique [6]. Finally, with the advent of laparoscopic surgery in the 1990s, the high retroperitoneal approach became preferentially performed laparoscopically [7].

While radiographic embolization remains in the armamentarium for varicocele treatment, surgical approaches, namely, microscopic inguinal and subinguinal techniques, are considered the standard of care. In this chapter, we will review why surgery is preferred to radiographic approaches by discussing technical considerations and comparing clinical outcomes, complications, recurrences, and cost-effectiveness, highlighting specific situations where radiographic techniques can play a unique role in contrast to surgery.

Technical Considerations

There are technical considerations in performing the various varicocelectomy techniques, which can affect the outcome of the treatment and the preference of one procedure over another. This includes the possibility of an inability to treat with embolization, the optimal surgical equipment, anesthetic concerns, and special considerations in the adolescent and obese populations.

Failure to Treat

One of the most important technical considerations is the possibility of a failure to treat during the initial treatment session with radiographic embolization. This occurs mainly from failure to access the internal spermatic vein. While this can be highly patient and operator dependent, a meta-analysis found a mean failure to treat of 13.05% (range 4.2–27.3%) among five studies [8]. Due to anatomical factors, a failure to treat is significantly more common on the right than the left side, with one series demonstrating an 18.9% failure rate for right-sided embolization attempts vs. 3.2% for left [9].

The failure to treat phenomenon with radiographic approaches is unreported with surgery and should be taken into consideration when counseling patients on the best approach to initial treatment of their varicocele.

Finally, not all centers may have the facilities required for embolization. The necessary microcatheter, specific embolic agents or devices, and specially trained interventional radiologists with experience in internal spermatic vein occlusion procedures will all be needed.

Surgical Equipment

The routine use of the operative microscope and microsurgical techniques during inguinal or subinguinal varicocelectomy is the surgical standard of care. While some surgeons perform these procedures macroscopically or loupe-assisted, several studies have shown that these approaches have higher complication and recurrence rates [10–12].

Similarly, the use of intraoperative Doppler assistance has outperformed non-Doppler-assisted, microsurgical subinguinal varicocelectomy with significantly more spermatic arteries spared (1.9 vs. 1.3), spermatic veins ligated (7.8 vs. 7.0), and shorter operative time (41.9 vs. 52.7 min) in the Doppler-assisted group [13]. These authors prefer to use the 20 megahertz microvascular Doppler system by Vascular Technology™ (VTI) during all varicocelectomy cases. The 1.5 mm tip is significantly smaller than alternative Doppler probes and is well suited to identify the small vessels of the spermatic cord. Indeed, the standardly available, larger Doppler probes carry a higher risk of misidentifying spermatic arteries, leading to possible arterial injury.

As such, when choosing to perform an inguinal or subinguinal varicocelectomy, one should use an operative microscope, microsurgical techniques, and a microvascular Doppler to maximize success and minimize complications. If this equipment is not available or the surgeon is uncomfortable with its use, then one may consider embolization as a viable alternative treatment if a skilled interventional radiologist is available.

The Morbidly Obese Patient

While there is limited published data on the complications of inguinal or subinguinal varicocelectomy techniques in the morbidly obese, data from inguinal hernia surgery reports a significantly higher infection rate in this population [14]. Given the increased skin to spermatic cord distance, increased tension on the spermatic cord is sometimes required to bring it high enough for adequate visualization during microscopic varicocelectomy, which may theoretically lead to worse outcomes, at least temporarily. Nevertheless, microscopic varicocelectomy has been shown to be equally effective in improving semen parameters and pregnancy rates in obese men as in normal-weight men [15].

However, embolization is not necessarily easier or safer in the morbidly obese. Vascular access in the morbidly obese is more difficult, even with ultrasound assistance [16]. Additionally, higher rates of vascular complications after catheterization procedures have been reported in morbidly obese patients [17].

Given the increased risk with all approaches to varicocele treatment in the morbidly obese patient, there is no optimal treatment approach when assessing the technical considerations of these procedures.

The Adolescent Patient

While the best approach to varicocele treatment in adolescents has not been established, laparoscopic varicocelectomy is more commonly performed than in the adult. A survey of pediatric urologists found that the most commonly used treatment approach to the adolescent varicocele was laparoscopic (38%) [18]. This is in contrast to the feasibility of microsurgical varicocelectomy in the adolescent population as modern series have shown similar, or lower, hydrocele and recurrence rates with subinguinal vs. laparoscopic approaches [19–22]. While the reason for a preference for the laparoscopic approach among pediatric urologists remains unclear, it may be due to differences in surgical training and comfort with these techniques.

Embolization is an accepted alternative in the adolescent patient, with several small series demonstrating success rates of >90% [23–25]. However, similar to adults, technical and anatomical issues lead to a failure to treat in these studies upward of 7%. Given these concerns, surgical therapy remains the preferred treatment of varicoceles in the adolescent patient; however, most pediatric urologists continue to prefer a laparoscopic approach.

Anesthetic Considerations

In contrast to surgical approaches, embolization is performed under sedation with local anesthesia [26]. While some surgeons may attempt microsurgical varicocelectomy under sedation or regional anesthesia, these authors highly recommend a general anesthetic. This is due to the need for fine microscopic dissection, as even small movements under the operating microscope are highly magnified.

Given the different anesthetic requirements between surgical and radiographic approaches, there may be a role for varicocele embolization in the patient who is unable to undergo a general anesthesia for varicocele treatment due to high risk or patient preference.

Comparison of Clinical Outcomes

The overall body of literature supports that treatment of varicoceles in general improves male fertility outcomes and scrotal pain. However, it is difficult to compare therapeutic outcomes among different techniques for varicocele treatment given the lack of randomized controlled trials.

Male Infertility

Historical meta-analyses of the available, but poor-quality studies led to historical controversy regarding the effectiveness of varicocele treatment for improving male-factor infertility. But high-quality data has since been produced, and

modern meta-analyses clearly demonstrate a benefit to varicocele repair for improving semen parameters and pregnancy rates [27–30]. The majority of this data focuses on outcomes from microsurgical varicocelectomy. A more recent randomized controlled trial comparing microsurgical varicocelectomy to nonintervention in infertile males with varicoceles and semen abnormalities demonstrated significant improvements in both semen parameters and natural pregnancy rates in the treatment arm (odds ratio of natural pregnancy 3.04) [31].

A recent meta-analysis performed exclusively to determine the best technique for fertility-focused varicocele treatment found that microsurgical varicocelectomy techniques had the highest overall spontaneous pregnancy rate at 41.97% compared to 33.2% in the embolization group [8]. A prospective, but non-randomized, study of men with infertility, semen abnormalities, and varicoceles undergoing either subinguinal microsurgical varicocelectomy or embolization demonstrated a similar improvement in sperm quality and pregnancy rates between the groups [32].

In summary, while varicocele treatment clearly improves male-factor infertility, the existing data does not clearly support one treatment approach over another in this regard.

Scrotal Pain

In a review of studies on the surgical techniques of varicocele for pain, microsurgical approaches have demonstrated the best overall success rate. A review of eight studies using microsurgical varicocelectomy demonstrated a mean complete pain resolution rate of 85% and a failure rate of 9% [33]. The same review examined six studies using non-microsurgical varicocelectomy techniques and demonstrated a mean complete pain resolution rate of 72% and failure rate of 10%. In three studies on laparoscopic varicocelectomy for pain, there was a mean complete pain resolution rate of 81% with a failure rate of 14%.

Some data exists supporting embolization as primary treatment of varicoceles for scrotal pain. One study demonstrated that 86.9% of patients had complete resolution of pain at 39 months follow-up after embolization [34]. However, failure rates with this approach tend to be higher than with microsurgical varicocelectomy [32].

As with the treatment of male-factor infertility, data supports the benefit of varicocele repair for scrotal pain, but it is difficult to determine a best technique given the lack of quality, comparative data.

Complications

Both surgical and radiographic approaches to varicocelectomy are generally considered low-risk procedures. However, each approach presents a unique complication profile, which should be considered when deciding on a treatment approach with each individual patient.

Surgical Treatment

Surgery involves general anesthesia to perform either a subinguinal, inguinal, or retroperitoneal incision or a laparoscopic approach to selectively ligate the internal spermatic vein while sparing the arteries and lymphatics. The complications inherent to surgery include recurrence, hydrocele, testicular pain, surgical site pain, testicular atrophy, bleeding, and infection. With the exception of varicocele recurrence and hydrocele, each complication generally occurs in 0–4% of cases depending on surgical approach [32, 35–37].

Despite the diversity of surgical approaches, all demonstrating improved clinical outcomes, only inguinal and subinguinal microsurgical varicocelectomy are associated with the lowest complication and recurrence rates [35, 37, 38]. Indeed, two recent meta-analyses support these findings by demonstrating a lower recurrence rate (1.05% vs. 2.6–14.97%), hydrocele rate (0.44% vs. 2.84–8.24%), and lower likelihood of overall complication (OR 0.05–0.07; 95% CI, 0.02–0.19) with microsurgical compared to retroperitoneal or laparoscopic approaches [8, 39]. Furthermore, the laparoscopic approach is uniquely associated with subcutaneous scrotal emphysema, inferior

epigastric artery injury, severe hemorrhage, and scrotal pain in up to 7% of patients [8].

While the routine use of an operative microscope during inguinal or subinguinal varicocelectomy has been challenged, it does provide superior visualization of the spermatic cord structures, mitigating recurrence and complication rates. Several series comparing microscopic assistance to loupe magnification or none at all have shown significantly lower recurrence (0% vs. 3–14.9%), hydrocele (0% vs. 2.9–5.9%), and testicular artery injury (0% vs. 9.2%) rates using the operative microscope [10–12]. As previously discussed, we recommend the routine use of an operative microscope and microvascular Doppler probe to allow for easier identification of the vascular anatomy.

Whether the inguinal or subinguinal approach is superior remains controversial. Anatomic data has demonstrated a higher number of spermatic vessels with the subinguinal approach due to distal vascular branching [40], which may explain some reports of shorter operative times with the inguinal approach [41]. However, others have shown no difference in operative times [42]. Inherent to the inguinal approach is a larger incision and division of the external oblique aponeurosis, which has been shown to result in increased postoperative pain [43].

Taken as a whole, when assessing complications, these data demonstrate that inguinal or subinguinal microsurgical varicocelectomy with intraoperative Doppler assistance is the gold standard of surgical therapy for varicocele repair.

Radiographic Treatment

In contrast to surgery, radiographic approaches are less invasive and can be routinely performed under local anesthesia or sedation. The predominant radiographic techniques include percutaneous embolization or sclerotherapy [44]. Given the different approach compared to surgery, radiographic treatments present a unique set of possible complications, including failure to treat (as previously discussed).

All radiographic approaches are associated with minor complications. The most common is post-procedural testicular pain or epididymitis persisting for up to 10 days (3–17%) [44–47]. Less commonly, an inguinal hematoma or contrast allergy may also occur [45, 48]. More controversial is the risk of hydrocele. Theoretically, hydrocele should not occur with radiographic approaches given isolated manipulation of the venous system, as shown in several series with zero reported hydroceles [23, 49]. However, one series reported hydroceles in 4.5% of cases [34].

Less common, but potentially higher risk complications have also been reported. Venous perforation with or without dissection into the renal vein or IVC can occur in up to 4% of cases, though often without clinical consequence [44, 48]. Also, endovascular coil migration to the right atrium and pulmonary arteries has been reported, potentially mitigated by proper selection of coil size [50, 51]. Lastly, ischemic colitis and bowel necrosis are rare but reported complications of the use of sclerotherapeutic agents [52, 53].

Theoretically, recurrences following radiographic approaches should be minimal given the operator's ability to identify all venous tributaries within and outside of the spermatic venous system [54]. Yet, recurrences still occur and have been reported in 0–24% of radiographic cases, although greater operator experience is associated with a lower risk of recurrence [8, 39, 44]. However, it is important to note the significantly lower range of reported recurrences with microscopic subinguinal or inguinal varicocelectomy of <2% [55].

In general, radiographic approaches offer a slightly less invasive treatment option that can be performed without general anesthesia but may result in rare, but serious complications and higher likelihood of recurrence than the surgical gold standard of microsurgical varicocelectomy.

Recurrent Varicocele

Regardless of the initial method used to correct a varicocele, recurrence rates are generally low. While the data evaluating treatment of varicocele recurrences are sparse, microsurgical varicocelectomy and percutaneous embolization are both viable options.

Surgical Treatment

There are three series to date evaluating the use of surgical intervention for recurrent varicoceles, but one employed a subinguinal approach without microscopic assistance and will not be discussed. The first includes 54 patients who initially underwent non-microscopic inguinal (74%), retroperitoneal high ligation (10%), microscopic inguinal (4%), or non-microscopic subinguinal (2%) approaches. Postoperative mean serum testosterone, testicular volume and median sperm concentration, percent motility, and total motile sperm count all demonstrated statistically significant improvement after undergoing repeat varicocelectomy via a microsurgical subinguinal approach with no reported recurrences [56]. The second series included 12 patients initially diagnosed with orchialgia, but the method of initial varicocelectomy is unknown. All patients underwent reoperation via a microsurgical subinguinal approach, and no recurrences were reported. Also, a favorable pain response was found in 91% of patients [57].

Radiographic Treatment

Percutaneous embolization offers a less invasive option for recurrent varicoceles as many may have initially undergone a surgical approach. Recurrent varicoceles are associated with increased collateral vasculature, which, in addition to a previously operated field, may make redo surgery technically more difficult [44, 58]. Indeed, up to 93% of recurrent varicoceles are due to incompetent gonadal veins, 66% of which are due to gonadal vein duplication, which is readily identifiable radiographically [54]. A recent series of 28 patients with recurrent left varicoceles after previously undergoing laparoscopic varicocelectomy (39%), retroperitoneal high ligation (25%), or inguinal varicocelectomy (25%) underwent percutaneous embolization, which was feasible in 93% of cases. Post-procedural success was determined by physical examination, revealing 80% of cases resolved, 16% improved, and 4% no change. In those with scrotal content pain, 83% showed resolution or improvement [59]. Other series utilizing either percutaneous sclerotherapy or embolization with post-procedural success evaluated by physical exam have shown similar results [54, 60, 61]. However, detection of recurrent varicocele by physical exam can be very subtle as thickening of the spermatic cord may persist despite resolution of the underlying vascular reflux.

In summary, recurrent varicoceles may be treated with either surgery or radiographic techniques, as insufficient comparable data is available to make a definitive conclusion. These authors advocate consideration of a radiographic approach in cases of varicoceles recurrence after surgery to mitigate the morbidity of a second operation. However, one could consider surgery in the context of a bilateral recurrence, recurrence after initial radiographic procedure, or if the redo surgery can be performed on a different segment of the spermatic cord than the initial operation.

Cost-effectiveness

When multiple therapeutic approaches exist to treat the same condition, one measure of comparison is cost. However, it is important to distinguish between the upfront cost and the overall cost-effectiveness of a treatment. Older studies reported that the cost per treatment was lower for embolization compared to the surgical approaches for varicocelectomy [62, 63]. However, these studies do not account for attempted embolizations that are aborted due to access failure, therapeutic ineffectiveness, or the treatment of recurrences. This is why a comparison of overall cost-effectiveness is more relevant.

A recent analysis demonstrated that microsurgical varicocele repair is more cost-effective than embolization in the treatment of male infertility [64]. Using data pooled from 33 studies, and taking into account the cost of treatment, the recurrence rate, the cost of retreatments, and the pregnancy rates, the authors performed a Markov decision analysis that demonstrated microsurgical varicocelectomy to be the most cost-effective primary treatment strategy for varicoceles. The

reported cost per pregnancy was about 25% less for microsurgical varicocelectomy than embolization.

Conclusion

While several options exist for varicocele treatment, the preferred primary approach is the microsurgical inguinal or subinguinal varicocelectomy. Since the different approaches have all been shown to be effective, but have not been readily studied prospectively, the preference for microsurgical varicocelectomy is largely based on the lower rate of complications and recurrences compared to other techniques. This approach also avoids the unique problem of failure to treat as with embolization procedures. However, there remains a role for embolization when proper surgical instrumentation is not available, anesthetic concerns exist, specific complications are of concern, or in the treatment of recurrent varicoceles.

Review Criteria

An extensive search of studies examining the surgical or radiographic treatment of varicoceles was performed using search engines such as PubMed, MEDLINE, and Google Scholar. Pertinent literature published within the past 30 years was evaluated. Literature describing the history of varicocele treatment published prior to the 30-year search period was also evaluated. In order to hone our search, the following keywords were used: "varicocele," "varicocelectomy," "varicocele repair," "varicocele surgery," "varicocele embolization," "varicocele sclerosis," "varicocele repair success," "varicocele surgery complications," and "varicocele embolization complications." Articles not published in English were not evaluated. For individual varicocele treatment modalities, meta-analyses, randomized controlled trials, and single-center or retrospective cohort series were evaluated. For treatment complications, meta-analyses, randomized controlled trials, single-center or retrospective cohort series, and review articles were evaluated. Data that were solely published in conference or meeting proceedings or websites were not included.

Multiple Choice Questions and Answers

1. Which of the following is a unique consideration specific to embolization compared to surgery?
   (a) Treatment of the obese patient
   (b) Treatment of the adolescent patient
   (c) **Failure to initially treat**
   (d) Type of anesthetic required
2. Which of the following is the only optical surgical instrument that has been shown to reduce postoperative complications following surgical varicocelectomy?
   (a) Magnifying loupes
   (b) **Operative microscope**
   (c) Laparoscopic camera
   (d) Robotic endoscopic camera
3. Which of the following complications is not associated with surgical varicocelectomy?
   (a) Incisional infection
   (b) Hydrocele
   (c) Varicocele recurrence
   (d) **Renal vein dissection**
4. Which of the following is the most commonly encountered complication following percutaneous radiographic treatment for varicocele?
   (a) Endovascular coil migration
   (b) Arterial perforation
   (c) **Testicular pain**
   (d) Inguinal hematoma
5. Which of the following surgical approaches to varicocelectomy has demonstrated superior complication rates in the pediatric and adolescent populations?
   (a) **Microscopic varicocelectomy**
   (b) Laparoscopic varicocelectomy

(c) Retroperitoneal high ligation varicocelectomy
(d) Percutaneous anterograde embolization

References

1. Noske HD, Weidner W. Varicocele--a historical perspective. World J Urol. 1999;17(3):151–7.
2. Palomo A. Radical cure of varicocele by a new technique; preliminary report. J Urol. 1949;61(3):604–7.
3. Tulloch WS. Varicocele in subfertility; results of treatment. Br Med J. 1955;2(4935):356–8.
4. Lima SS, Castro MP, Costa OF. A new method for the treatment of varicocele. Andrologia. 1978;10(2):103–6.
5. Silber SJ. Microsurgical aspects of varicocele. Fertil Steril. 1979;31(2):230–2.
6. Marmar JL, DeBenedictis TJ, Praiss D. The management of varicoceles by microdissection of the spermatic cord at the external inguinal ring. Fertil Steril. 1985;43(4):583–8.
7. Hagood PG, Mehan DJ, Worischeck JH, Andrus CH, Parra RO. Laparoscopic varicocelectomy: preliminary report of a new technique. J Urol. 1992;147(1):73–6.
8. Cayan S, Shavakhabov S, Kadioglu A. Treatment of palpable varicocele in infertile men: a meta-analysis to define the best technique. J Androl. 2009;30(1):33–40. https://doi.org/10.2164/jandrol.108.005967.
9. Cassidy D, Jarvi K, Grober E, Lo K. Varicocele surgery or embolization: Which is better? Can Urol Assoc J. 2012;6(4):266–8. https://doi.org/10.5489/cuaj.11064.
10. Cayan S, Acar D, Ulger S, Akbay E. Adolescent varicocele repair: long-term results and comparison of surgical techniques according to optical magnification use in 100 cases at a single university hospital. J Urol. 2005;174(5):2003–6.; discussion 6-7. https://doi.org/10.1097/01.ju.0000176488.44895.7b.
11. Gontero P, Pretti G, Fontana F, Zitella A, Marchioro G, Frea B. Inguinal versus subinguinal varicocele vein ligation using magnifying loupe under local anesthesia: which technique is preferable in clinical practice? Urology. 2005;66(5):1075–9. https://doi.org/10.1016/j.urology.2005.05.009.
12. Silveri M, Adorisio O, Pane A, Colajacomo M, De Gennaro M. Subinguinal microsurgical ligation--its effectiveness in pediatric and adolescent varicocele. Scand J Urol Nephrol. 2003;37(1):53–4. https://doi.org/10.1080/00365590310008703.
13. Guo L, Sun W, Shao G, Song H, Ge N, Zhao S, et al. Outcomes of microscopic subinguinal varicocelectomy with and without the assistance of doppler ultrasound: a randomized clinical trial. Urology. 2015;86(5):922–8. https://doi.org/10.1016/j.urology.2015.08.002.
14. Pessaux P, Lermite E, Blezel E, Msika S, Hay JM, Flamant Y, et al. Predictive risk score for infection after inguinal hernia repair. Am J Surg. 2006;192(2):165–71. https://doi.org/10.1016/j.amjsurg.2006.05.003.
15. Pham KN, Sandlow JI. The effect of body mass index on the outcomes of varicocelectomy. J Urol. 2012;187(1):219–21. https://doi.org/10.1016/j.juro.2011.09.033.
16. McGrath TM, Farabaugh EA, Pickett MJ, Wagner DK, Griswold-Theodorson S. Obesity hinders ultrasound visualization of the subclavian vein: implications for central venous access. J Vasc Access. 2012;13(2):246–50. https://doi.org/10.5301/jva.5000051.
17. Cox N, Resnic FS, Popma JJ, Simon DI, Eisenhauer AC, Rogers C. Comparison of the risk of vascular complications associated with femoral and radial access coronary catheterization procedures in obese versus nonobese patients. Am J Cardiol. 2004;94(9):1174–7. https://doi.org/10.1016/j.amjcard.2004.07.088.
18. Pastuszak AW, Kumar V, Shah A, Roth DR. Diagnostic and management approaches to pediatric and adolescent varicocele: a survey of pediatric urologists. Urology. 2014;84(2):450–5. https://doi.org/10.1016/j.urology.2014.04.022.
19. Hassan JM, Adams MC, JCt P, Demarco RT, Brock JW 3rd. Hydrocele formation following laparoscopic varicocelectomy. J Urol. 2006;175(3 Pt 1):1076–9. https://doi.org/10.1016/S0022-5347(05)00402-7.
20. Yaman O, Soygur T, Zumrutbas AE, Resorlu B. Results of microsurgical subinguinal varicocelectomy in children and adolescents. Urology. 2006;68(2):410–2. https://doi.org/10.1016/j.urology.2006.02.022.
21. VanderBrink BA, Palmer LS, Gitlin J, Levitt SB, Franco I. Lymphatic-sparing laparoscopic varicocelectomy versus microscopic varicocelectomy: is there a difference? Urology. 2007;70(6):1207–10. https://doi.org/10.1016/j.urology.2007.09.036.
22. Glassberg KI, Poon SA, Gjertson CK, DeCastro GJ, Misseri R. Laparoscopic lymphatic sparing varicocelectomy in adolescents. J Urol. 2008;180(1):326–30discussion 30-1. https://doi.org/10.1016/j.juro.2008.03.064.
23. Storm DW, Hogan MJ, Jayanthi VR. Initial experience with percutaneous selective embolization: A truly minimally invasive treatment of the adolescent varicocele with no risk of hydrocele development. J Pediatr Urol. 2010;6(6):567–71. https://doi.org/10.1016/j.jpurol.2010.01.003.
24. Fayad F, Sellier N, Chabaud M, Kazandjian V, Larroquet M, Raquillet C, et al. Percutaneous retrograde endovascular occlusion for pediatric varicocele. J Pediatr Surg. 2011;46(3):525–9. https://doi.org/10.1016/j.jpedsurg.2010.08.014.
25. Malekzadeh S, Fraga-Silva RA, Morere PH, Sorega A, Produit S, Stergiopulos N, et al. Varicocele percutaneous embolization outcomes in a pediatric group: 7-year retrospective study. Int Urol Nephrol. 2016;48(9):1395–9. https://doi.org/10.1007/s11255-016-1340-x.
26. Baigorri BF, Dixon RG. Varicocele: a review. Semin Intervent Radiol. 2016;33(3):170–6. https://doi.org/10.1055/s-0036-1586147.

27. Evers JH, Collins J, Clarke J. Surgery or embolisation for varicoceles in subfertile men. Cochrane Database Syst Rev. 2008;(3):CD000479. https://doi.org/10.1002/14651858.CD000479.pub3.
28. Schauer I, Madersbacher S, Jost R, Hubner WA, Imhof M. The impact of varicocelectomy on sperm parameters: a meta-analysis. J Urol. 2012;187(5):1540–7. https://doi.org/10.1016/j.juro.2011.12.084.
29. Baazeem A, Belzile E, Ciampi A, Dohle G, Jarvi K, Salonia A, et al. Varicocele and male factor infertility treatment: a new meta-analysis and review of the role of varicocele repair. Eur Urol. 2011;60(4):796–808. https://doi.org/10.1016/j.eururo.2011.06.018.
30. Agarwal A, Deepinder F, Cocuzza M, Agarwal R, Short RA, Sabanegh E, et al. Efficacy of varicocelectomy in improving semen parameters: new meta-analytical approach. Urology. 2007;70(3):532–8. https://doi.org/10.1016/j.urology.2007.04.011.
31. Abdel-Meguid TA, Al-Sayyad A, Tayib A, Farsi HM. Does varicocele repair improve male infertility? An evidence-based perspective from a randomized, controlled trial. Eur Urol. 2011;59(3):455–61. https://doi.org/10.1016/j.eururo.2010.12.008.
32. Bou Nasr E, Binhazzaa M, Almont T, Rischmann P, Soulie M, Huyghe E. Subinguinal microsurgical varicocelectomy vs. percutaneous embolization in infertile men: prospective comparison of reproductive and functional outcomes. Basic and clinical andrology. 2017;27:11. https://doi.org/10.1186/s12610-017-0055-x.
33. Shridharani A, Lockwood G, Sandlow J. Varicocelectomy in the treatment of testicular pain: a review. Curr Opin Urol. 2012;22(6):499–506. https://doi.org/10.1097/MOU.0b013e328358f69f.
34. Puche-Sanz I, Flores-Martin JF, Vazquez-Alonso F, Pardo-Moreno PL, Cozar-Olmo JM. Primary treatment of painful varicocoele through percutaneous retrograde embolization with fibred coils. Andrology. 2014;2(5):716–20. https://doi.org/10.1111/j.2047-2927.2014.00253.x.
35. Ghanem H, Anis T, El-Nashar A, Shamloul R. Subinguinal microvaricocelectomy versus retroperitoneal varicocelectomy: comparative study of complications and surgical outcome. Urology. 2004;64(5):1005–9. https://doi.org/10.1016/j.urology.2004.06.060.
36. Shiraishi K, Oka S, Ito H, Matsuyama H. Comparison of the results and complications of retroperitoneal, microsurgical subinguinal, and high inguinal approaches in the treatment of varicoceles. J Androl. 2012;33(6):1387–93. https://doi.org/10.2164/jandrol.112.016444.
37. Watanabe M, Nagai A, Kusumi N, Tsuboi H, Nasu Y, Kumon H. Minimal invasiveness and effectivity of subinguinal microscopic varicocelectomy: a comparative study with retroperitoneal high and laparoscopic approaches. International journal of urology: official journal of the Japanese Urological Association. 2005;12(10):892–8. https://doi.org/10.1111/j.1442-2042.2005.01142.x.
38. Cayan S, Kadioglu TC, Tefekli A, Kadioglu A, Tellaloglu S. Comparison of results and complications of high ligation surgery and microsurgical high inguinal varicocelectomy in the treatment of varicocele. Urology. 2000;55(5):750–4.
39. Wang J, Xia SJ, Liu ZH, Tao L, Ge JF, Xu CM, et al. Inguinal and subinguinal micro-varicocelectomy, the optimal surgical management of varicocele: a meta-analysis. Asian J Androl. 2015;17(1):74–80. https://doi.org/10.4103/1008-682x.136443.
40. Hopps CV, Lemer ML, Schlegel PN, Goldstein M. Intraoperative varicocele anatomy: a microscopic study of the inguinal versus subinguinal approach. J Urol. 2003;170(6. Pt 1):2366–70. https://doi.org/10.1097/01.ju.0000097400.67715.f8.
41. Shiraishi K, Oka S, Matsuyama H. Surgical comparison of subinguinal and high inguinal microsurgical varicocelectomy for adolescent varicocele. International journal of urology: official journal of the Japanese Urological Association. 2016;23(4):338–42. https://doi.org/10.1111/iju.13050.
42. Orhan I, Onur R, Semercioz A, Firdolas F, Ardicoglu A, Koksal IT. Comparison of two different microsurgical methods in the treatment of varicocele. Arch Androl. 2005;51(3):213–20.
43. Johnson D, Sandlow J. Treatment of varicoceles: techniques and outcomes. Fertil Steril. 2017;108(3):378–84. https://doi.org/10.1016/j.fertnstert.2017.07.020.
44. Halpern J, Mittal S, Pereira K, Bhatia S, Ramasamy R. Percutaneous embolization of varicocele: technique, indications, relative contraindications, and complications. Asian J Androl. 2016;18(2):234–8. https://doi.org/10.4103/1008-682x.169985.
45. Gandini R, Konda D, Reale CA, Pampana E, Maresca L, Spinelli A, et al. Male varicocele: transcatheter foam sclerotherapy with sodium tetradecyl sulfate--outcome in 244 patients. Radiology. 2008;246(2):612–8. https://doi.org/10.1148/radiol.2462061295.
46. Gazzera C, Rampado O, Savio L, Di Bisceglie C, Manieri C, Gandini G. Radiological treatment of male varicocele: technical, clinical, seminal and dosimetric aspects. Radiol Med. 2006;111(3):449–58. https://doi.org/10.1007/s11547-006-0041-4.
47. Urbano J, Cabrera M, Alonso-Burgos A. Sclerosis and varicocele embolization with N-butyl cyanoacrylate: experience in 41 patients. Acta radiologica (Stockholm, Sweden: 1987). 2014;55(2):179–85. https://doi.org/10.1177/0284185113493774.
48. Seyferth W, Jecht E, Zeitler E. Percutaneous sclerotherapy of varicocele. Radiology. 1981;139(2):335–40. https://doi.org/10.1148/radiology.139.2.7220877.
49. Iaccarino V, Venetucci P. Interventional radiology of male varicocele: current status. Cardiovasc Intervent Radiol. 2012;35(6):1263–80. https://doi.org/10.1007/s00270-012-0350-z.
50. Chomyn JJ, Craven WM, Groves BM, Durham JD. Percutaneous removal of a Gianturco coil from the pulmonary artery with use of flexible intravascular forceps. J Vascul Inter Radiol: JVIR. 1991;2(1):105–6.

51. Sivanathan C, Abernethy LJ. Retrograde embolisation of varicocele in the paediatric age group: a review of 10 years' practice. Ann R Coll Surg Engl. 2003;85(1):50–1.
52. Boscolo-Berto R, Macchi V, Porzionato A, Morra A, Vezzaro R, Loukas M, et al. Ischemic colitis following left antegrade sclerotherapy for idiopathic varicocele. Clin Anatomy (New York, NY). 2018;31:774. https://doi.org/10.1002/ca.23066.
53. Vicini P, Di Pierro GB, Grande P, Voria G, Antonini G, De Marco F, et al. Large bowel infarct following antegrade scrotal sclerotherapy for varicocele: A case report. Can Urol Assoc J. 2014;8(9–10):E641–3. https://doi.org/10.5489/cuaj.1822.
54. Jargiello T, Drelich-Zbroja A, Falkowski A, Sojka M, Pyra K, Szczerbo-Trojanowska M. Endovascular transcatheter embolization of recurrent postsurgical varicocele: anatomic reasons for surgical failure. Acta Radiologica (Stockholm, Sweden: 1987). 2015;56(1):63–9. https://doi.org/10.1177/0284185113519624.
55. Rotker K, Sigman M. Recurrent varicocele. Asian J Androl. 2016;18(2):229–33. https://doi.org/10.4103/1008-682x.171578.
56. Grober ED, Chan PT, Zini A, Goldstein M. Microsurgical treatment of persistent or recurrent varicocele. Fertil Steril. 2004;82(3):718–22. https://doi.org/10.1016/j.fertnstert.2004.03.028.
57. Chawla A, Kulkarni G, Kamal K, Zini A. Microsurgical varicocelectomy for recurrent or persistent varicoceles associated with orchalgia. Urology. 2005;66(5):1072–4. https://doi.org/10.1016/j.urology.2005.05.052.
58. Rais-Bahrami S, Montag S, George AK, Rastinehad AR, Palmer LS, Siegel DN. Angiographic findings of primary versus salvage varicoceles treated with selective gonadal vein embolization: an explanation for surgical treatment failure. J Endourol. 2012;26(5):556–60. https://doi.org/10.1089/end.2011.0387.
59. Kim J, Shin JH, Yoon HK, Ko GY, Gwon DI, Kim EY, et al. Persistent or recurrent varicocoele after failed varicocoelectomy: outcome in patients treated using percutaneous transcatheter embolization. Clin Radiol. 2012;67(4):359–65. https://doi.org/10.1016/j.crad.2011.10.007.
60. Mazzoni G, Minucci S, Gentile V. Recurrent varicocele: role of antegrade sclerotherapy as first choice treatment. Eur Urol. 2002;41(6):614–8.. discussion 8
61. Punekar SV, Prem AR, Ridhorkar VR, Deshmukh HL, Kelkar AR. Post-surgical recurrent varicocele: efficacy of internal spermatic venography and steel-coil embolization. Br J Urol. 1996;77(1):124–8.
62. Johnsen N, Tauber R. Financial analysis of antegrade scrotal sclerotherapy for men with varicoceles. Br J Urol. 1996;77(1):129–32.
63. Abdulmaaboud MR, Shokeir AA, Farage Y, Abd El-Rahman A, El-Rakhawy MM, Mutabagani H. Treatment of varicocele: a comparative study of conventional open surgery, percutaneous retrograde sclerotherapy, and laparoscopy. Urology. 1998;52(2):294–300.
64. Kovac JR, Fantus J, Lipshultz LI, Fischer MA, Klinghoffer Z. Cost-effectiveness analysis reveals microsurgical varicocele repair is superior to percutaneous embolization in the treatment of male infertility. Can Urol Assoc J. 2014;8(9–10):E619–25. https://doi.org/10.5489/cuaj.1873.