Testicular arterial supply: effect of different varicocelectomy approaches

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Aim
The aim was to compare the effect of three different approaches of varicocelectomy (laparoscopic, open, and microscopic) on testicular artery depending on preoperative and postoperative testicular duplex.
Patients and methods
This study included 60 patients with primary varicocele collected from Minia Health Insurance and Minia University Hospitals during the period from April 2016 to January 2018. The patients were divided into three groups. Group A included 20 patients who have undergone open varicocelectomy; group B included 20 patients who have undergone open subinguinal varicocelectomy with microscopic assistance; and group C included 20 patients who have undergone laparoscopic varicocelectomy.
Results
There is a significant difference between the three groups as regards operative time. Preoperative and 6-month postoperative semen analyses were improved after surgery but no couple achieved spontaneous pregnancy within the follow-up in all three groups. At 2 weeks postoperative arterial duplex, the testicular artery and the testicular arterial perfusion was not affected or disturbed. There was no statistically significant difference between preoperative and postoperative values of testicular volume. No recurrence after 6 months follow-up was found in both A and B groups, but in group C 20% of cases was recurrent clinically.
Conclusion
No single method has proven superiority over another as the best approach to secure testicular blood supply. We found that there is no statistical difference between the three approaches concerning preservation of the testicular artery from accidental injury or ligation.

Keywords:
minia, testicular artery, varicocelectomy approaches

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Introduction

The testes are originally abdominal organs which have descended to the scrotum during the embryonic life. Blood and lymphatic supply of the testis is distinct from the scrotum, the pouch within which it lies. Most of the blood supply of the testis comes from paired testicular arteries, which arise directly from the abdominal aorta. They descend through the inguinal canal as part of the spermatic cord. Testes also receive collateral blood supply from cremasteric artery and artery of the ductus deferens. Also, the testicular lymph vessels follow the testicular vessels back to the para-aortic lymph nodes [1].

A varicocele is an abnormal enlargement or dilatation of the internal spermatic vein and the pampiniform venous plexus of the testes due to the inversion of venous blood flow within the spermatic cord [2].

Varicoceles are one of the most commonly identified scrotal diseases. Although rare in pediatric populations, its prevalence markedly increases with pubertal development to ~15% by the late teenage years, a rate similar to that in adult populations. Varicocele affects ~15–20% of the normal adult male population and is thought to be the most common treatable cause of male factor infertility. Its prevalence among men with primary male factor infertility is ~35%, while 70–85% of men with secondary infertility present with this condition [3].

Varicocele is usually asymptomatic and discovered accidentally during inguinal region examination, but it may present with pain, swelling, hypofertility or testicular atrophy. Although varicocele-associated infertility is not fully understood, impaired semen analysis in varicocele patients and its correction after

varicocelectomy are two major evidences that varicocele has a direct impact on male fertility [4].

Varicocele-related infertility is considered nowadays a multifactorial process that cannot be accused to one reason. Oxidative stress, scrotal hyperthermia, venous hypertension, apoptosis, and DNA damage are the most accepted theories of varicocele-induced infertility [5].

A variety of surgical and nonsurgical approaches have been advocated for varicocelectomy ranging from open to minimal invasive procedures. They include minimally invasive procedures, such as laparoscopic varicocelectomy and transvenous percutaneous embolization, and traditional open surgical approaches (retroperitoneal, inguinal, and subinguinal) [1].

Varicocelectomy is by far the most commonly performed operation for the treatment of male infertility. The goal of treatment of the varicocele is to obstruct the refluxing venous drainage to the testis while maintaining arterial inflow and lymphatic drainage as much as possible [5].

Although, the current standard of care is to perform open surgical varicocele repair with microscopic assistance to minimize possible complications, no single method has proven superiority over another as a preservative of vascular anatomy and a cure for infertility [6].

The aim of this study was to compare the effect of three different approaches of varicocelectomy (laparoscopic, open, and microscopic) on testicular artery depending on preoperative and postoperative testicular duplex.

Patients and methods

This study included 60 patients with primary varicocele collected from Minia Health Insurance and Minia University Hospitals during the period from April 2016 to January 2018. Institutional ethics committee approval was obtained. Informed consent was taken. We analyzed the radiological findings and differences between the preoperative and postoperative duplexes regarding testicular artery. Patients were hospitalized the day before the surgery and detailed patient history was taken.

Inclusion criteria were patients with primary varicocele, age from 16 to 50 years, patients with no other testicular problems such as inguinal hernia, hydrocele, or testicular tumors and atrophy, patients with no perivous testicular or inguinal operations, and patients with normal preoperative testicular arterial duplex.

Exclusion criteria were patients with secondary varicocele; patients with other testicular problems such as inguinal hernia, hydrocele, or testicular tumors and atrophy; patients with perivous testicular or inguinal operations; and patients with abnormal preoperative testicular arterial duplex.

Investigations for diagnosis such as color Doppler ultrasonography, spermatic venography, thermography, semen analysis, assessment of testicular volume, hormonal assay, and other laboratory tests were done. For preoperative fitness routine investigations such as ECG, laboratory studies, and abdominal ultrasound were done. The indications for intervention were pain, hypofertility, and secondary infertility. The main comparative method is preoperative and postoperative arterial duplex.

Anesthesia for varicocelectomy may be carried out using local, regional, or general type, according to solely with the surgeon and patient's preferences. Laparoscopic varicocelectomy requires general anesthesia, while open high retroperitoneal, inguinal, and subinguinal varicocelectomy are always done under spinal anesthesia.

The included patients in this study were divided into three groups. Group A included 20 patients who have undergone open varicocelectomy; group B included 20 patients who have undergone open subinguinal varicocelectomy with microscopic assistance and group C included 20 patients who have undergone laparoscopic varicocelectomy.

The classic approach in inguinal varicocelectomy involves a 2–3 cm incision over the inguinal canal either trasverse inguinal crease incision or oblique incision along the axis between the anterior superior iliac spine and the pubic tubercle, dissection of subcutaneous tissue, opening of the external oblique aponeurosis and then isolation of the spermatic cord. The coverings of the spermatic cord are opened and the internal spermatic veins are dissected and ligated after identification and isolation of the vas. An attempt is made to identify and spare the testicular artery and lymphatics. The external spermatic veins running parallel to the spermatic cord or perforating the floor of the inguinal canal are identified and ligated.

Subinguinal open procedure

It involves a 2.5 cm skin incision made over external inguinal ring. The subcutaneous tissue is separated until the spermatic cord is exposed. The cord is elevated with a Babcock clamp and the posterior

cremasteric veins are ligated and transected. The coverings of the spermatic cord are opened and the internal spermatic veins are dissected and ligated after identification and isolation of the vas. Sparing testicular artery and lymphatics is a very important trick to minimize the possible procedure complications.

The main advantage of the subinguinal over the inguinal approach is that the former obviates the need to open the aponeurosis of the external oblique, which usually results in more postoperative pain and a longer time before the patient can return to work.

Subinguinal open procedure with microscopic assistance

Although the internal and external spermatic veins can be identified macroscopically, the use of magnification facilitates identification of the smallest tributaries which if unidentified and ligated may cause recurrence. Microsurgical varicocelectomy either using inguinal or subinguinal approaches has been considered the gold stsndard technique for varicocele repair. Nevertheless, these procedures require more skill as compared with other surgical modalities because a higher number of internal spermatic vein channels and smaller diameter arteries are seen at the level of the inguinal canal.

As such, it is important for the surgeon who operates to treat varicocele using microsurgery to obtain appropriate training. It is also important to have adequate microsurgical instruments and a binocular operating microscope with foot control zoom magnification because loupe magnification is insufficient for proper identification of testicular arteries and lymphatics.

Whenever needed, the cord structures are sprayed with papaverine hydrochloride to increase the arterial beat and ease identification of testicular arteries. Alternatively, an intraoperative vascular Doppler flow detector can be used to identify and spare arteries. All dilated veins of the spermatic cord are identified, tagged with vessel loops, then ligated using nonabsorbable sutures and transected. Vasal veins are ligated only if they exceed 2 mm in diameter. Sclerosis of small veins is not used.

Laparoscopic varicocelectomy

The surgeon usually stands on the opposite side of the table from the varicocele, because this provides the appropriate angle for dissection and staple placement. After induction of general anesthesia, a Foley catheter is placed to ensure continuous decompression of the bladder.

Trocars

A 1-cm transverse incision is made immediately above the umbilicus, and then fascia is opened transversally. The abdomen is filled with CO_2 gas (# 15 mmHg) to create a pneumoperitoneum; this is achieved either by Hasson (open) or Verese needle technique. At this time, a 10 mm telescope is inserted into the first trocar.

After that two 5 mm trocars are inserted through both the midclavicular lines midway between the umbilicus and the anterior superior iliac spines on both sides. A 5 mm grasper is inserted through the ipsilateral port and a 5 mm scissor is inserted through the contralateral port. Grasping with one hand and using scissors in the other hand, two perpendicular incisions are made in the peritoneum overlying the left or right internal spermatic veins. By lifting the vascular mass, arterial and lymphatic components should be separated from the veins. Then veins are ligated by one or two clips. It is not recommended to cauterize or suture or even cut the veins, to save time. When a 5 mm clip applier is not available, it is possible to change the 10 mm telescope to a 5 mm telescope and 10 mm clips are applied.

The spermatic artery and the lymphatics are easily identified and spared. The collateral veins can also be clipped or coagulated. However, the external pudendal vein, a common cause of varicocele recurrence, is not accessible. This shortcoming of laparoscopic varicocelectomy leads to a recurrence rate of ~5%.

Postoperative follow-up

Patients are discharged either on the day of operation or on the following day. Postoperative care usually includes local dressing and scrotal supporter for 48–72 h and 1 week, respectively. Scrotal ice packing is always recommended to control local edema for the first 48 postoperative hours. Patients are counseled to restrain from physical activity and sexual intercourse for 2–3 weeks. Oral analgesics usually suffice to control postoperative pain. Duplex ultrasonography of testicular blood vessels was done 2 weeks postoperatively.

Results

This study was conducted on 60 patients with primary varicocele. Twenty patients in group A had open inguinal varicocelectomy; 20 others in group B had open subinguinal varicocelectomy with microscopic

assistance, while the last 20 patients in group C had laparoscopic varicocelectomy. The mean age in group A was 27.8±5.79 years (range: 18–48 years), in group B it was 26.8±5.03 years (range: 18–39 years), while in group C it was 25.3±4.74 years (range: 18–36 years).

The affected side in group A was left in 60% of patients and bilateral in 40% of them, while in group B was left in 70% of patients and bilateral in 30% of them, but in group C was left in 30% of patients and bilateral in 70% of them. We noticed that about 45% of the left-sided varicoceles either has also right subclinical varicocele or has been operated on the right side previously.

All included patients in this work has grade III varicoceles on the left side, while the other side was either of grade II, subclinical or previously operated upon.

Operative time in group A ranges between 45 and 64 min with a mean time of about 55.3±5.5 min, in group B ranges between 99 and 120 min with a mean time of about 109.75±6.02 min, while in group C it ranges between 22 and 59 min with a mean time of about 40.1±10.2 min. The difference between groups was statistically significant. It is noted that in both A and B groups we operated on one side even in bilateral cases in one set but in group C 70% of cases were bilateral and were operated bilaterally in the same set.

In group A, 90% of patients who were complaining of pain was cured and the rest was relieved. In group B, 75% of patients who were complaining of pain was cured and the rest was relieved, while in group C, 60% of patients who were complaining of pain was cured and the rest was relieved.

Although, comparing preoperative and 6th-month postoperative semen analysis of almost all our patients, in all groups, sperm density, percent normal morphology, and total motile sperm count were improved after surgery, no couple achieved spontaneous pregnancy within the follow-up in all three groups.

In all the three groups depending on the second week postoperative arterial duplex, the testicular artery and the testicular arterial perfusion were not affected or disturbed. We tested testicular sensation preoperatively, postoperatively, and 6 months later by holding the testicle between the thumbs and fingers of both hands and rolling it gently between fingers. Testicular sensation in all the included patients in this work in the three groups was preserved postoperatively, despite the different approaches.

Testicular volume

Routine scrotal ultrasonography was analyzed for testicular size. There was no statistically significant difference among the preoperative and postoperative values within either group A, B, or C ($P>0.05$). There was also no statistically significant difference in those values for the testes between the three groups ($P>0.05$).

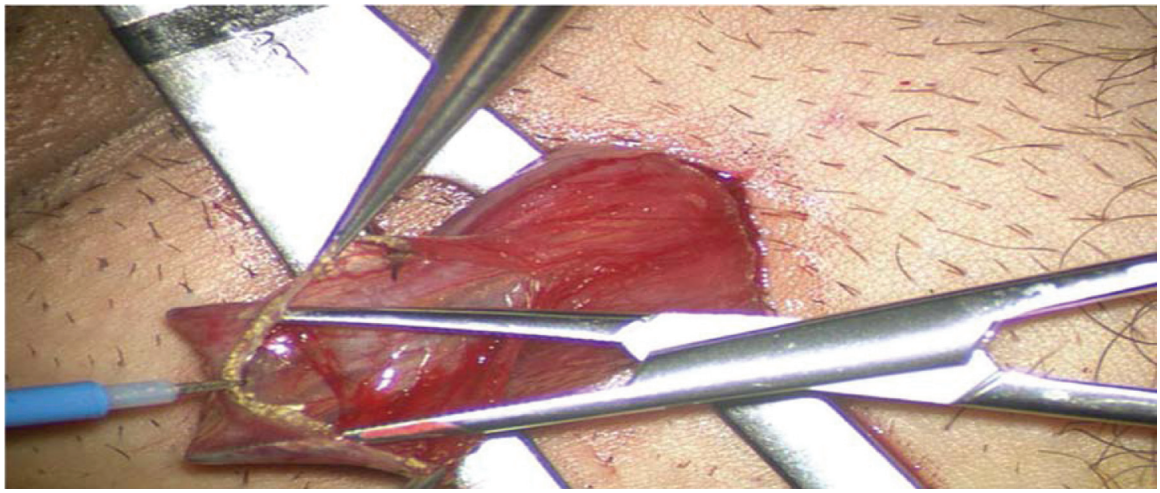
Hematoma was found in only 5% of group A patients, but in groups B and C 0% hematoma was found. In group A, 95% of cases had scrotal edema postoperatively, while only 30% of cases in group B had it. In contrast, 0% of cases in group C had testicular edema postoperatively. Despite the differences in age, side, grade, procedure, and operator, all of the included patients in this work had intact testicular artery duplex postoperatively. Hydrocele was noted in 10% of group A patients and in about 25% of group C patients, while none of group B patients had hydrocele during the follow-up period. No recurrence after 6 months follow-up was found in both A and B groups, but in group C 20% of cases were recurrent clinically (Figs. 1–3, and Table 1–4).

Discussion

Varicocele is a commonly encountered disease in surgery and urology clinics. Doppler is not only helpful for the diagnosis of varicocele, but also can monitor the changes of testicular blood flow parameters before and after varicocelectomy. The arteriovenous system of the testis is highly complex and under a fine regulation to maintain a proper spermatogenesis environment. The testicular, deferential, and cremasteric arteries all provide the blood supply to the testis, and they form numerous anastomoses at the upstream of testicular parenchyma. At this point, they cannot directly reflect testicular microcirculation but Cremasteric artery (CA) and intratesticular artery (ITA), which locate just in the capsule surface and deep parenchyma of the testis, respectively, are more reliable. Normally pampiniform plexus cannot only take away testicular metabolic waste but also play a role in cooling the arterial blood before it reaches the testis, helping ensure the organ stays at the proper temperature, yet the drainage and cooling function are impaired when varicocele arises. Varicocelectomy can partly restore the innate function of plexiform plexus in order to rectify testicular microcirculation [7].

Several clinical studies have investigated the effects of varicocele on testicular blood flow. Tarhan and

Fig. 1



Opening of the spermatic cord coverings, the external spermatic fascia, cremasteric muscle fibers, and internal spermatic fascia are then opened along the direction of the cord with electrocautery.

Fig. 2

Microscopic assistance helps in the identification and ligation of very small veins.

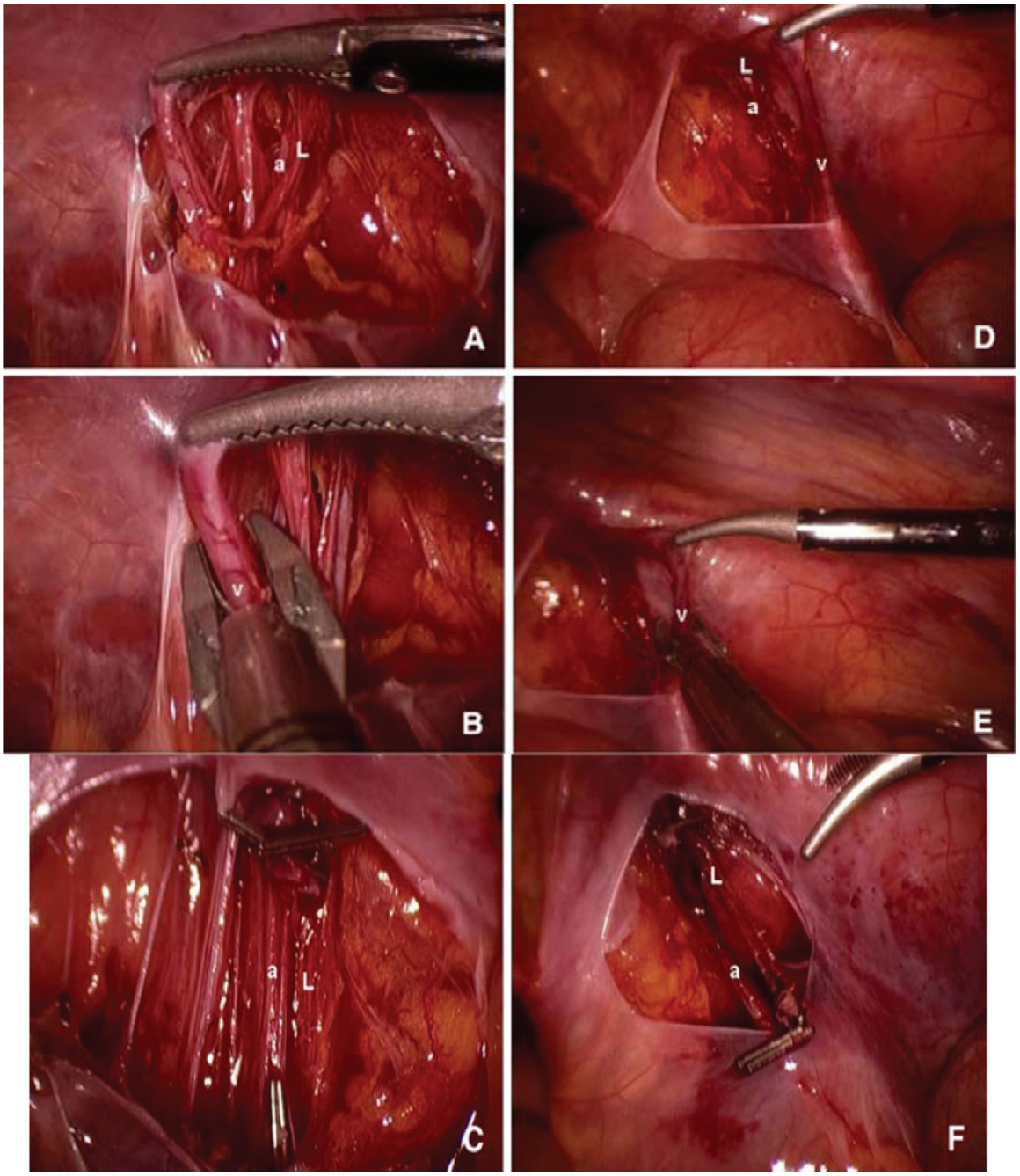
colleagues reported that blood flow in varicocele bearing testicles is less abundant than normal control in men. Akcar and colleagues reported that subclinical varicocele does not affect the intratesticular arterial resistive index (RI), and Ünsal and colleagues proved that increased RI and PI (pulsatility index) values of CA on spectral Doppler examination are indicators of impaired testicular microcirculation in patients with clinical varicocele [8–10].

In our study, we compare the effect of three different approaches of varicocelectomy (laparoscopic, open, microscopic) on testicular artery and the incidence of injury of the artery accidentally during the procedure, depending on preoperative and postoperative arterial duplex.

(1) In group A we used inguinal open procedure, no injury to testicular artery and intact testicular perfusion was found in all cases.
(2) In group B we used subinguinal open procedure with microscopic assistance, no injury to testicular artery and intact testicular perfusion was found in all cases.
(3) In group C we used laparoscopic varicocelectomy, no injury to testicular artery and intact testicular perfusion was found in all cases.

We found that there is no statistical difference between the three approaches concerning preservation of the testicular artery from accidental injury or ligation. This was in agreement with Almaramhy and Aly [11] who compare the outcome of magnified and nonmagnified

Fig. 3



Bilateral laparoscopic varicocelectomy (left: a, b, and c; right: d, e, and f). (a, d) The lymphatic vessels and testicular artery were identified and separated from the testicular vein after identifying the arterial pulsation. (b, e) The testicular veins were placed between two hemoclips. (c, f) All veins were cut and testicular artery and lymphatics were preserved. a, testicular artery; v, testicular vein; and L, testicular lymphatics.

varicocelectomy and found that unintentional injury of the testicular artery was reported only in one patient subjected to conventional open varicocelectomy. Also, these results were in agreement with Sunil Telkar *et al.* [12], who reported in his study that no intra-abdominal visceral or vascular injuries were associated with either laparoscopic or open varicocelectomy.

In this study, there is a significant difference between three groups as regards operative time. The least operative time was found in group C which ranged between 22 and 59 min with a mean time of about 40.1 ±10.2 min. This was in agreement with Verma *et al.* [13] who conducted a prospective study comparing laparoscopic and open surgical management of varicocele and they found that laparoscopic varicocelectomy has shorter operating time. The operative time in the microscopic group was significantly longer than that for the other two groups. It ranged between 99 and 120 min with a mean time of about 109.75±6.02 min. A similar result was found by Al-Kandari *et al.* [14] who

Table 1 Patients' demographics

	Group A (*n*=20)	Group B (*n*=20)	Group C (*n*=20)	*P* value
Age (years)				
Range	18–48	18–39	18–36	0.317
Mean±SD	27.8±5.79	26.8±5.03	25.3±4.74	
BMI				
Range	18.9–24.5	21.3–24.9	19.9–24.6	0.311
Mean±SD	22.58±1.47	23.11±1.03	23.16±1.39	
Side [*n* (%)]				
Left	12 (60)	14 (70)	6 (30)	0.031*
Bilateral	8 (40)	6 (30)	14 (70)	
Grade [*n* (%)]				
III	12 (60)	14 (70)	6 (30)	0.031*
II, III	8 (40)	6 (30)	14 (70)	

*Statistically significant.

Table 2 Operative time

	Group A (*n*=20)	Group B (*n*=20)	Group C (*n*=20)	*P* value
Operative time (min)				
Range	45–64	99–120	22–58	
Mean±SD	55.3±5.5	109.75±6.02	40.1±10.2	<0.001*

*Statistically significant.

Table 3 Procedure outcome

	Group A (*n*=20) [*n* (%)]	Group B (*n*=20) [*n* (%)]	Group C (*n*=20) [*n* (%)]
Pain improvement	14 (70)	16 (80)	15 (75)
Infertility	8 (40)	6 (30)	9 (45)
Semen analysis	18 (90)	19 (95)	18 (90)
Preoperative testicular volume (mm)	12.63±3.08	12.71±2.16	12.76±3.03
Postoperative testicular volume (mm)	12.87±2.91	13.01±2.96	12.89±3.33

Table 4 Complications

	Group A (*n*=20) [*n* (%)]	Group B (*n*=20) [*n* (%)]	Group C (*n*=20) [*n* (%)]	*P* value
Injury	0 (0)	0 (0)	0 (0)	–
Recurrence	0 (0)	0 (0)	4 (20)	0.014*
Hydrocele	2 (10)	0 (0)	5 (25)	<0.001*
Hematoma	1 (5)	0 (0)	0 (0)	0.362
Edema	19 (95)	6 (30)	0 (0)	<0.001*

*Statistically significant.

compared outcomes of different varicocelectomy techniques.

We also found that the three different approaches had not affected, disturbed, or compromised the testicular volume, sensation, or arterial perfusion. Similar to our results, Balci *et al.* [15] first evaluated the long-term effects of varicocelectomy on testicular blood flow. In their research, 26 infertile patients with left varicocele were operated and monitored up to the sixth month after the operation, though only ITA was evaluated and the microsurgical varicocelectomy technique was not applied. They found that the mean end diastolic velocity (EDV) value was increased; the RI and PI values were decreased; and the peak systolic velocity (PSV) value was unchanged after the surgery [15].

Three years after Balci's study, Reyes *et al.* [16] observed the effects of microsurgical inguinal varicocelectomy (not MV) on testicular blood flow. Their results showed that within 6 months after surgery the mean PSV and EDV of left TA increased, and RI and PI values of left CA and ITA decreased. No significant difference was detected between the preoperative and postoperative blood flow parameters in the right TA, CA, and ITA. They believed that PSV and EDV values showed flow velocity; RI and PI values showed resistance against blood flow, so they assumed that the blood flow into the ipsilateral testis increased and the resistance against blood flow in the affected testis decreased after the surgery. Therefore, they concluded that the PSV and EDV values increase in TA and the PI and RI values decrease in CA and ITA, and they were the indicators of an increase in testicular arterial blood flow into the testicular tissue [16].

Regarding semen analysis, treatment of pain, and fertility, our results were very close to each other in the three patient groups. Pain relief was achieved in all patients. Although semen evaluation is not a principal

index in our study, and infertility is neither our target illness, we found that semen analysis has significantly improved postoperatively. Similar to our results, Zhang *et al*. [17] investigated the long-term effects of laparoscopic varicocelectomy and microsurgical subinguinal varicocelectomy on ipsilateral testicular microcirculation using color Doppler flow imaging and found that a significant improvement occurs in testicular blood supply and sperm parameters after both the procedures.

Also, as regards complications, testicular artery injury and hematoma were very rare in all patients in different groups. Hydrocele was noted in 10% of open varicocelectomy patients and in about 25% of microscopic varicocelectomy patients, while none of laparoscopic varicocelectomy patients had hydrocele during the follow-up period. This is not in agreement with Söylemez *et al.* [18] who observed that the number of hydroceles, as a complication of varicocelectomy, was two times higher in laparoscopic than in microscopic varicocelectomy patients. Recurrence of varicocele was only found in laparoscopic varicocelectomy patients. This was also found by Al-Kandari *et al*. [14], who found that the highest frequency of recurrence was in the group treated by laparoscopy.

In this study, scrotal edema was found in almost all open varicocelectomy patients, but in only 30% of microscopic-assisted varicocelectomy patients. On the other hand, none of the patients subjected to laparoscopic varicocelectomy suffered scrotal edema postoperatively. This result was in coherence with Ali *et al*. [19], who evaluated postoperative complications of laparoscopic versus open varicocelectomy among patients in Iraq, and found that hematoma formation and scrotal edema occurred in the study groups but were higher for open technique.

We suppose that the traditional macroscopic open inguinal approach is the easiest, cheapest, and most accepted operation for both surgeons and patients. It is easy for young surgeons to learn and do and it does not require special or expensive equipment. For patients, its wide use, few complications, and high success rates make it the first choice and decrease the chance to convene them to try laparoscopic or microscopic approaches.

We suppose that the application of magnification makes the microanatomy of the spermatic cord sharper, and the high-definition operative field is positive to a better postoperative outcome. The laparoscopic technique allows ligation of the testicular vein high retroperitonealy, where it is a single vein (or two branches maximum) and away from the vas deferens. It also allows to operate on both sides in the same set in a relatively short time. Highly trained and qualified surgeons, very expensive equipment, and requirement of general anathesia are the most stressing challenges for laparoscopic varicocelectomy.

The microsurgical technique (inguinal or subinguinal) is an innovative technique that allows the ligation of all the veins except the vasal vein, while sparing the local arteries and lymphatics, and is proved to reduce the recurrence rate and complications. The subinguinal approach (MV) does not incise the external oblique aponeurosis, reducing pain for the patient, but at the expense of the increased number of veins that must be ligated. As such, MV is considered the gold standard technique for varicocelectomy in adults. Semen evaluation is not a principal index in our study, and infertility is neither our target illness, because merely less than half participants accepted this test.

Conclusion

Although, the current standard of care is to perform open surgical varicocele repair with microscopic assistance to minimize possible complications, no single method has proven superiority over another as the best approach to secure testicular blood supply. We found that there is no statistical difference between the three approaches concerning preservation of the testicular artery from accidental injury or ligation. Identifying the testicular artery is not a big deal, as we found that despite, we were not able to identify the artery in some cases in each group, the artery was not injured and the testicular arterial perfusion has improved postoperatively.

Because the present study covered only a 6-month follow-up period, further studies in larger series, longer periods, and with more time points are needed to test the relationship between testicular perfusion and sperm parameters after different varicocelectomy approaches.

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the paper and he had been involved in drafting the manuscript or revising it critically for important intellectual content.

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Conflicts of interest
There are no conflicts of interest.

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