RESEARCH PAPER

Laparoscopic *Versus* Open High Ligation for Adolescent Varicocele: A 6-year Single Center Study

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Objective: The aim of this study was to compare the outcomes of high ligation in adolescents with varicocele between open and laparoscopic surgical approaches. **Design:** Retrospective study. **Setting:** The study was conducted from January 2012 to January 2018, with median follow-up of 36 months, in the division of pediatric surgery at tertiary-care hospital. **Patients**: Data of 537 adolescents who underwent varicocelectomy were classified into two groups, depending on surgical approach. **Intervention:** Open or laparoscopic varicocelectomy. **Main outcome measures:** Indications for surgery, complications, duration of surgery, hospital stay, and recurrences rate. **Results:** The median age of the patients was 15 years. The median (IQR) duration of surgery was 12 (11,15.3) min in laparoscopic and 25 (10,30) min in open group (P<0.001). The most common complication was hydrocele (n=29), which was more common in open group (6.8% *vs* 1.4%; P=0.01). A total of 16 recurrences were recorded, all in open group (P=0.049). In both groups, sperm concentration (P<0.001), morphology (P<0.001) and motility (laparoscopy, P=0.001; P=0.02; open varicocelectomy, P=0.001; P=0.04) improved six months after surgery in patients with varicocele stage I and II. In stage III there was an improvement in sperm concentration (P=0.002; P=0.001) and morphology (P=0.03; P=0.06), while sperm motility (P=0.15; P=0.2) did not significantly recover in either of the groups. **Conclusions**: Laparoscopic and open varicocelectomy are equally effective and result in significant improvement of testicular volume, disappearance of pain, and sperm parameters in adolescents. Based on our findings laparoscopic varicocelectomy is associated with shorter operating time, shorter hospitalization, faster recovery, and fewer complications and recurrences.

Key words: *Complications, Outcome, Spermiogram, Surgery, Varicocelectomy.*

A varicocele is defined as dilated and tortuous veins within the pampiniform plexus of scrotal veins and they are the most common cause of male infertility [1]. The causes of varicocele are multifactorial, but the end result is a pathological dilation of the veins draining the testicles, leading to increased temperature in the seminiferous tubules [2]. Varicocele causes a progressive time-dependent decline in semen quality [3]. Although uncommon below 10 years, incidence increases rapidly in the age group 10 to 18 years [4]. Overall, varicocele occurs in 10% to 15% of children and adolescents and in 40% of the males with infertility [1-5]. Approximately 90% of varicoceles are left-sided and about 10% of varicoceles are bilateral. Isolated right-sided varicoceles are extremely rare, and usually are related with retroperitoneal masses that may compress spermatic veins [1, 3-5].

There are several surgical techniques to treat varicoceles, including open inguinal, subinguinal microscopic and laparoscopic ligation of spermatic veins [5,6]. Each technique has its own advantages and disadvantages, and conflicting results have been achieved in different studies [1,2,5-9], but to date there has been no consensus as to which technique should be considered the gold standard for treatment of varicocele in children and adolescents. The aim of this study was to evaluate the demographic and clinical characteristics and indications for surgery in the children and adolescents undergoing varicocelectomy, and to evaluate postoperative outcomes and effects on testicular volume improvement and semen parameters during a 6-year period between open and laparoscopic high ligation of varicocele.

METHODS

The case records of 556 pediatric patients who underwent varicocelectomy between 1 January, 2012 and 1 January, 2018 at the Clinical department of pediatric surgery,

University Hospital of Split, Croatia, were retro-spectively reviewed. Of these, 19 patients were excluded from the analysis because they met one or more exclusion criteria. Informed consent was obtained from the parents or legal guardians of all the patients for the surgeries. Ethics Committee of the University Hospital of Split approved this study. All patients with symptomatic varicocele younger than 18 years of age who were operated because of varicocele were enrolled in the study. The exclusion criteria were: patients operated in other institutions and followed-up at our outpatient clinic, patients with recurrent varicocele who underwent varicocelectomy before January 2012, and patients with incomplete data or follow-up shorter than 6 months. Based on approach used for varicocelectomy, the patients were divided into two groups *viz*. laparoscopic and open varicocelectomy.

Dilation of the pampiniform plexus vessels greater than 2 mm on ultrasound was considered as varicocele. In all the patients, physical examination, levels of serum LH/FSH, ultrasound of the testicles, and urinary tract were performed. For patients older than 16 years of age, semen analysis was carried out before treatment. Varicocele was graded according to Dubin and Ambler's classification [10]. Indications for varicocelectomy were testicular atrophy (volume discrepancy >20%), persistent pain or testicular discomfort, abnormal semen parameters and elevated serum levels of LH/FSH. The choice of operating procedure was based on the operating surgeon's preference.

The primary outcome measures were the treatment outcomes, the frequency of intraoperative or post-operative complications, the rate of recurrence, and the sperm quality and count analysis in 6 months and 1 year postoperatively. The secondary outcome variables were indications for surgical treatment, duration of surgery, hospital stay and the rate of reoperations. The intraoperative complications included access-related complications, such as organ lesions, thermal damage of intra-abdominal organs, and bleeding. Postoperative complications included bleeding into the abdominal wall, wound infection, pain, recurrence and formation of hydrocele.

Open surgical approach: Open high ligation was done through 3-4 cm incision using muscle splitting abdominal approach. Testicular vessels were approached extra-peritoneally. Vessels were double ligated with absorbable sutures (Vycril *Plus* 2/0 - polyglactin 910, Ethicon, Cincinnati, Ohio, USA) and resected. Wound was closed in layers with same absorbable sutures and skin was closed with non-absorbable sutures (Premilene 3/0, Braun Surgical S.A., Rubi, Spain).

Laparoscopic surgical approach: A Veress needle was introduced below the umbilicus and CO_2 insufflated at pressure of 8-12 mmHg depending on the patient's age and body weight. The first trocar was introduced through the same incision. After exploration of the abdominal cavity, two additional 5 mm trocars were introduced in the right and left midclavicular line, 1-2 cm below the horizontal line to the umbilicus, along the lateral border of each abdominal rectus muscle. After identification of spermatic vessels and identification of vas deferens the peritoneum was opened by using laparoscopic scissors in the lateral aspect from a point 1 cm superior to the internal inguinal ring along the testicular vessels to expose them. After mobilization of spermatic vessels, accompanying lymphatic was preserved from the spermatic veins. Non-absorbable polymeric ligating clips (Click'aV Ligating Clips ML; Grena Ltd Think Medical, Brentford-London, UK) were used for ligation of spermatic vessels. Spermatic vessels were resected by using laparoscopic scissors. The trocars were subsequently removed. Skin incisions were closed by non-absorbable skin sutures. Data on all complications and/or recurrences were recorded. Hematoma was treated by haemostatic suture, wound infections were all treated conservatively and for patients with consecutive hydrocele a Jabouley-Winckelmann procedure was performed. All recurrences of varicocele were reoperated by subinguinal approach.

The patients were followed up at our outpatient clinic at the first and fourth week after surgery for detection of any complications. Skin sutures were removed during the first week visit. Follow-up program consisted of physical examination and ultrasound 6 months after surgery to assess testicular size, the presence of late complications, and persistence or recurrence of the varicocele. Semen analysis was performed 6 months and 1 year after surgery for patients older than 16 years of age. Improvement was defined based on primary indication for surgery: reduction of the testicular volume difference below 20%; complete recovery of the spermiogram or recovery in at least in two out of three tested categories (total sperm count, normal sperm morphology, sperm motility); improvement in hormone status to normal baseline values and reduction of the pain one month after surgery.

Statistical analysis: The data were analyzed by using SPSS 24.0 (IBM Corp, Armonk, NY) software. Differences in median values of quantitative variables between the groups of patients were tested with Mann–Whitney U test. The chi-square test was used for the statistical analysis of the categorical data. The difference between pre- and post-operative seminal data was analyzed by using a paired Wilcoxon signed-rank test. All

values of $P<0.05$ were considered to indicate statistical significance.

RESULTS

A total of 537 adolescents, with median age of 15 (IQR 15, 17) years were included in the study. Of that number, 142 (26.5%) were operated laparoscopically and 395 (73.5%) by open approach. Of the total number of patients, left-sided varicocele was found in 533 patients (99.26%), with majority having grade III varicocele (268, 49.9%). Median (IQR) diameters of veins were 3.3 (3.1, 4.8) mm for all patients, with no difference between the groups. With that noted, median diameters of veins in varicocele grades I, II, and III were 2.9, 3.2, and 4.0 mm, in laparoscopic group and 2.8, 3.1, and 4.0 in open group, respectively. The hospital stay, operation time, complication rate, and recurrences were all significantly higher for open varicocelectomy group as compared those operated laparoscopically (***Table* I**).

The most frequent recorded indication for surgical intervention was difference in testicular volume >20% (287, 65.7%) (***Table* I**). Total of 448 patients (108 in Group I and 340 in Group II) had one indication for surgical intervention, whilst in 89 patients (34 in Group I and 55 in Group II) two or more indications for varicocelectomy were recorded. A total of 35 complications were recorded; 32 in open group and 3 in laparoscopic group ($P=0.01$). The most common complication was consecutive hydrocele ($n=29$), followed by wound infection ($n=4$) and wound hematoma ($n=2$). From total of 29 hydroceles, 27 were recorded in open group, and only 2 in laparoscopic group ($P=0.014$). A total of 16 recurrences were recorded, all in open varicocelectomy group ($P=0.049$) (***Table* I**).

Most of the children showed improvement in their indication for surgery after varicocelectomy. There were no significant differences between the groups in improvement of tested parameters regarding surgical technique **(*Table* II)**.

For laparoscopic varicocelectomy sperm concentration ($P<0.001$), morphology ($P<0.001$), and motility ($P=0.001$; $P=0.02$) improved 6 months after surgery in patients with varicocele grades of I and II, respectively. However, in grade III varicocele, only sperm concentration ($P=0.002$) and morphology ($P=0.03$) improved whereas motility ($P=0.1$) did not change significantly. For open varicocelectomy sperm concentration ($P<0.001$), morphology ($P<0.001$), and motility ($P=0.001$; $P=0.04$) improved 6 months after surgery in patients with varicocele grades of I and II, respectively. However, in grade III varicocele, only sperm concentration ($P=0.001$) improved, while morphology ($P=0.06$) and motility ($P=0.2$) did not change significantly. There was no statistically significant difference in tested parameters in two compared

TABLE I BASELINE CHARACTERISTICS AND TREATMENT OUTCOMES OF ADOLESCENTS WITH VARICOCELE ($N=437$)

Characteristic	*Laparoscopic varicocelectomy (n=142)*	*Open varicocelectomy (n=395)*
Lateralization		
Left	141 (99.3)	392 (99.2)
Bilateral	1 (0.7)	3 (0.8)
Grade		
Grade I	9 (6.3)	33 (8.4)
Grade II	65 (45.8)	162 (41)
Grade III	68 (47.9)	200 (50.6)
Vein diameter (mm)*	3.4 (3.1-4.8)	3.2 (2.9-4.8)
Treatment outcomes		
Hospital stay (d)*	1 (1, 1)	1.3(1, 1)
Operation time (min)$^{\$*}$	12 (11, 15.25)	25 (10, 30)
Complications$^{\#}$	3 (2.1)	32 (81)
Consecutive hydrocele$^{\#}$	2 (1.4)	27 (6.8)
Wound hematoma	1 (0.7)	1 (0.3)
Wound infection	0 (0)	4 (1)
Recurrence$^{\#}$	0 (0)	16 (4.1)
Follow-up (mo)$^{\$*}$	43(16, 46)	32 (24, 56)
Indication for surgery		
Testicular atrophy	80 (45.2)	207 (47.9)
Pathological spermiogram	41 (23.2)	87 (20.2)
Hormonal status disorder	11 (6.2)	45 (10.4)
Subjective discomfort/pain	45 (25.4)	93 (21.5)

*All values in n (%) except *median (IQR); $^{\$}P<0.001$; $^{\#}P=0.01$.*
Note: Some patients had more than one indication for surgical treatment.

TABLE II IMPROVEMENT IN VARIOUS OUTCOME PARAMETERS AFTER VARICOCELE TREATMENT

Parameter	*Laparoscopic varicocelectomy n* (%)	*Open varicocelectomy n* (%)
Spermiogram	34/41 (83.0)	71/87 (81.6)
Pain	41/45 (91.1)	84/93 (90.4)
Testicular atrophy	71/80 (88.8)	183/207 (88.4)
Elevated LH/FSH	6/11 (54.6)	25/45 (55.5)

All P>0.05 for comparison between laparoscopic and open surgery; LH: Lutenizing hormone, FSH: Follice stimulating hormone.

techniques and solely the technique does not affect the final outcome of the spermiogram (***Table* III**).

DISCUSSION

In this study indications for varicocelectomy, duration of surgery, complication and recurrence rates as well as the improvement after surgery between laparoscopic and open varicocelectomy were retrospectively observed. In majority of the patients from both groups significant improvement in sperm parameters, testicular volume, and disappearance of pain was recorded, so we can conclude that both techniques are equally effective in treatment of varicocele in adolescents. On the other hand, laparoscopic varicocelectomy showed benefits in significantly shorter operating time, shorter hospitalization and faster recovery and has fewer complications and recurrences rates.

Retrospective character and lack of randomization in selected operative technique are the main limitations of this study, although we have implemented multiple plausibility checks and cross validations in our data collection tool. Further prospective and randomized studies are needed to confirm results of this study.

The most important issue regarding varicocele in adolescents is to define true indications for varicocelectomy in that age group and to filter the patients who really need and would benefit from surgical treatment [5]. Although there are ethical issues regarding adolescent sperm analysis, clinicians agree that a spermiogram may be done in adolescents over the age of 16, because many studies have shown improvement of sperm quality after varicocelectomy [5,10]. In general, in adolescent population, varicocelectomy is indicated in cases of pathological spermiogram, testicular atrophy, elevated FSH/LH and varicocele associated with persistent pain and discomfort. After establishing proper indications for surgical treatment the question remains what technique is superior for the pediatric patients as well as cost/benefit aspect. The laparoscopic approach for varicocelectomy has gained popularity, especially in pediatric patients, because of its minimally invasive nature, safeness and simplicity [11]. The question remains what is the optimal age for varicocelectomy in adolescents. The median of age at the time of surgery in our study is in accord with the data published in the literature, where an average age range is from 15 to 18 years [12,13]. Our data regarding hospital stay after surgery correlates with various studies where it ranges from 24 to 66 hours for laparoscopic approach and 26-72 hours in open approach [8-9,14].

In our study, median of operation time for laparoscopic varicocelectomy was significantly shorter compared to open technique which is not in accordance with most of the published studies [6,9,10], although there is another study reporting shorter operative time in laparoscopic approach [7]. Higher level of skill and training in laparoscopy of our surgeons can be the cause for shorter operation time of laparoscopic varicocelectomy in our study. The most significant complications after varicocelectomy are recurrence of varicocele and the formation of hydrocele. In our study, no recurrence of varicocele was observed in laparoscopic group, while in the group operated by open approach the rate of recurrence was 4.1% as similar to other published studies [8,14,15]. In our study, the incidence of consecutive hydrocele in the laparoscopic group was significantly less than in the open group. In literature an incidence of hydrocele formation after varicocelectomy is equal or even higher in laparoscopic approach [1,4]. Our results in favor of laparoscopic approach could be explained by expertise of the surgeon in laparoscopy as well as careful sparing of lymph vessels [16-18]. It has been shown that sparing the lymph drainage is associated with lower incidence of postoperative hydrocele which requires surgical intervention [16].

Many studies show that both laparoscopic and open varicocelectomies are equally efficient, although laparoscopic approach could show advantages in terms of shorter hospital stay, reduced operation time and faster postoperative recovery with benefit from greater

TABLE III TREATMENT OUTCOMES DUE TO CHANGES IN SPERMIOGRAM BEFORE TREATMENT AND 1 YEAR AFTER THE SURGERY

	Laparoscopic varicocelectomy			*Open varicocelectomy*		
	Before surgery	*12 mo after surgery*	*P value*	*Before surgery*	*12 mo after surgery*	*P value*
Total sperm count (milions/mL)	19.05 (16.9, 24.1)	41.9 (33.8, 45.1)	0.0001	22.6 (17.4, 26.2)	40.1 (31.8, 44.1)	0.0001
Normal sperm morphology (%)	35.8 (34.3, 39.9)	64.2 (59.8, 69.9)	0.001	35.2 (29.8, 39.5)	61.9 (48.5, 68.1)	0.002
Sperm motility (%)	31.4 (26.5, 35.4)	47.6 (38.4, 52)	0.02	32.1(30, 38.3)	44.8(37.9, 51)	0.03

All values in median (IQR); P>0.05 for comparison between laparoscopic and open varicocelectomy for all three outcomes.

WHAT IS ALREADY KNOWN?

- Laparoscopic and open varicocelectomy are equally effective and result in significant improvement of testicular volume, disappearance of pain, and sperm parameters in adolescents.

WHAT THIS STUDY ADDS?

- Laparoscopic varicocelectomy is associated with significantly shorter operating time, shorter hospitalization, and has fewer complications and recurrences rates.

likelihood of consent to treatment due to better cosmetic results [8,19,20]. Also better cosmesis and easier treatment by laparoscopy is in bilateral varicocele where operation can be done through the same ports, or to perform other procedures simultaneously, such as inguinal hernia surgery and orhidopexy [8,20]. Spermiogram findings after varicocelectomies in a long-term follow-up show an increase in total sperm count, but not the sperm motility [21]. Most of the published data correlates with our findings which showed no statistically significant difference between supra-inguinal, sub-inguinal or inguinal varicocelectomy regarding total count and motility of sperm in spermiogram and that all operation techniques led to statistically significant improvement in spermiogram [15,17,22].

Based on our findings laparoscopic and open varicocelectomy are both equally efficient in treatment of varicocele in adolescents. Laparoscopic varicocelectomy has significantly lower rate of postoperative complications and recurrences as well as shorter operative time in comparison with open approach. Faster recovery and shorter hospital stay are also noted after laparoscopic approach.

Contributors: MJ: Conceptualized and designed the study, analyzed data, wrote the paper; MT: Collected the data, helped in analysis and drafted the manuscript; JT: Hellped collecting the data and drafted the manuscript; TS: Performed literature review, drafted and revised manuscript; ZP: Supervised and revised manuscript critically for important intellectual content and also performed statistical analysis of the data and wrote results section. *Funding*: None; *Competing Interest*: None stated.

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