OUTCOMES OF SINGLE-STAGE LAPAROSCOPIC ORCHIOPEXY FOR THE TREATMENT OF INTRA-ABDOMINAL UNDESCENDED TESTES

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Single-stage laparoscopic orchiopexy is a common treatment option for intra-abdominal undescended testes with sufficiently long spermatic vessels. This technique has been routinely performed at many major pediatric surgical centers, including the Viet Nam National Children's Hospital. A retrospective study was conducted to evaluate the outcomes of single-stage laparoscopic orchiopexy for intra-abdominal undescended testes at the National Children's Hospital from January 2021 to June 2024. A total of 41 patients with 45 testes underwent surgery; the median age was 31 months old (11 - 137). All testes were located in the lower abdomen, and most were associated with a patent deep inguinal ring (77.8%; 10 cases not described). No intraoperative or early postoperative complication was recorded. Twenty-six patients with 30 testes were followed up for an average duration of 19.6 ± 9.8 months; among them, 24 testes (80%) were located in the scrotum, 5 testes (16.7%) were positioned high, and 1 testis (3.3%) was atrophic. Postoperative testicular volume increased significantly compared with preoperative values ($p < 0.05$). No late complication was observed during follow-up. The single-stage vessel-sparing laparoscopic orchiopexy is a safe and effective procedure for the treatment of intra-abdominal undescended testes. Further studies with larger sample sizes and appropriate control groups are needed to comprehensively evaluate the overall efficacy of this technique.

Keywords: Undescended testis, laparoscopy.

I. INTRODUCTION

Undescended testis (UDT) is one of the most common congenital anomalies in male children, characterized by the absence of one or both testes in the scrotum. At birth, the incidence of UDT in male infants ranges from 1.0 - 4.6%.[1] Failure to treat UDT in a timely manner can lead to complications such as torsion of the undescended testis, malignant transformation, infertility, and psychological distress related to body image during adolescence.[2,3] The milestone marking the advent of orchiopexy was in 1877, when Scottish surgeon Thomas Annandale successfully performed the first operation to bring and fix a testis into the scrotum in a 3-year-old boy.[4] His success, attributed in part to Joseph Lister's principles of antisepsis, opened a new era in the surgical management of this condition. Over the following century, surgeons such as Max Schüller and Arthur Dean Bevan continued to refine and standardize the open surgical technique, establishing it as the standard treatment for inguinal UDT. However, for intra-abdominal undescended testes, open surgery posed significant limitations. The traditional approach required an inguinal exploration, and if the testis was not found, the incision had to be extended into the abdomen.

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This procedure was not only highly invasive but also unnecessary in cases where the testis was already atrophic. In 1976, a surgical team from Modena, Italy, led by N. Cortesi, first described the successful use of laparoscopy to diagnose bilateral intra-abdominal undescended testes in an 18-year-old male patient.[5]minimally invasive surgery (MIS Following Cortesi's 1976 report, laparoscopy remained primarily a diagnostic tool for more than a decade. In 1992, Gerald H. Jordan and Boyd H. Winslow published the first series of single-stage laparoscopic vessel-sparing orchiopexy (SLSO), introducing a new therapeutic approach.[6] Today, with advances in laparoscopic instruments and techniques, SLSO has been widely applied for the treatment of intra-abdominal UDT in most pediatric surgical centers both nationally and internationally. To evaluate the outcomes of single-stage laparoscopic orchiopexy for intra-abdominal undescended testes in children, we conducted a retrospective study on pediatric patients who underwent laparoscopic orchiopexy at the National Children's Hospital between January 2021 and June 2024.

II. MATERIALS AND METHODS

1. Subjects

This study included pediatric patients diagnosed with intra-abdominal undescended testes who underwent single-stage laparoscopic orchiopexy at the Viet Nam National Children's Hospital between January 1, 2021, and June 30, 2024.

Inclusion criteria

- Male patients under 16 years of age (at the time of surgery) diagnosed with intra-abdominal undescended testis.

- Patients who underwent single-stage laparoscopic orchiopexy at the Viet Nam National Children's Hospital.

Exclusion criteria

- Patients who had previously undergone surgical treatment for undescended testis at other medical institutions.

- Patients with congenital syndromes or disorders affecting genital development, including Prader-Willi syndrome, Klinefelter syndrome, persistent Müllerian duct syndrome, or other disorders of sexual differentiation.

2. Methods

This was a retrospective descriptive case series with longitudinal follow-up. A total sampling method was employed, including all patients who met the inclusion criteria and did not meet the exclusion criteria during the study period.

Clinical data were collected from medical records and follow-up visits, including age, side of the undescended testis, intraoperative testicular position, operative time (minutes), intraoperative and early postoperative complications (bleeding, trocar-site infection), and length of hospital stay (days). Postoperative follow-up was performed at least 6 months after surgery to evaluate testicular position and volume using ultrasonography, and to record any late complications such as inguinal hernia, trocar-site hernia, or postoperative bowel obstruction.

Testicular atrophy was defined as a reduction of more than 50% in volume compared with the preoperative measurement, or when the affected testis measured less than 25% of the volume of the contralateral healthy testis.[7] Surgical success was defined as the testis being located within the scrotum and showing no evidence of atrophy.[8]

Testicular volume was calculated using the modified Lambert formula: $V = L \times W^2 \times 0.71$ (mL), where L represents testicular length (cm) and W represents testicular width

(cm). This formula is based on the rotational ellipsoid model proposed by Prader (1966) and subsequently referenced in the study by Sotos and Tokar (2012).[9]calculated using the ellipsoid equation W2 x L x π/6, correlate with those obtained by ultrasound (US

Data were coded, entered, and analyzed using SPSS software version 20.0.

3. Research ethicals

All patient-identifying information was kept strictly confidential and was not disclosed in any form to ensure patient privacy. The objectives of this study were entirely scientific and humanitarian, aiming to improve the quality of diagnosis and treatment for children with undescended testes.

III. RESULTS

During the study period, a total of 41 patients with 45 affected testes underwent surgery. The median age at operation was 31 months old, ranging from 11 to 137 months old.

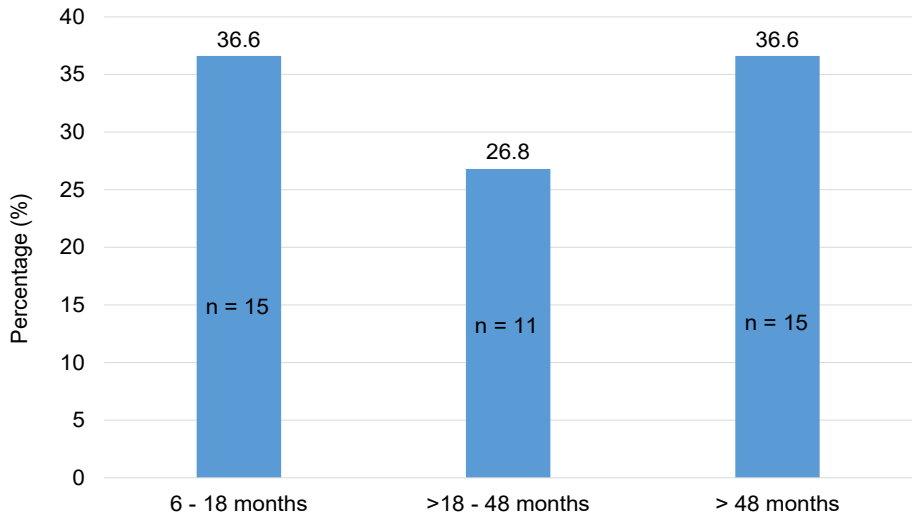

Chart 1. Distribution of patients by age group

Children who underwent surgery at an early age (6 - 18 months old) accounted for 36.6%, equivalent to the group operated on after 4 years of age, while the 18-48-months old group had a lower proportion (26.8%).

Table 1. Intraoperative findings and early postoperative outcomes

Parameter	Result
Operative time per testis (minutes)	42.22 ± 10.39
Intraoperative testicular position	
Low intra-abdominal, n (%)	45 (100)
High intra-abdominal, n (%)	0 (0)
Characteristics of the deep inguinal ring	
Patent, n (%)	35 (77.8)
Closed, n (%)	0 (0)
Not described, n (%)	10 (22.2)

Parameter	Result
Intraoperative complication rate (%)	0
Early postoperative complication rate (%)	0
Length of hospital stay (days)	1.05 ± 0.32

All 45 testes identified intraoperatively were located in the lower abdomen (with a distance to the deep inguinal ring of < 2cm), and the majority were associated with a patent deep inguinal ring (77.8%; 10 cases with no description of the deep inguinal ring).

A total of 26 patients with 30 testes (66.7%) were followed up postoperatively, and the results are presented in Table 2.

Table 2. Postoperative follow-up results

Parameter	Result
Follow-up duration, $\bar{X}$ ± SD (months)	19.6 ± 9.8
Number of testes, n	30
Testes located in the scrotum, n (%)	24 (80)
Testes remaining high, n (%)	5 (16.7)
Atrophic testes, n (%)	1 (3.3)

With a mean follow-up duration of 19.6 months, 24 testes (80%) were located in the scrotum, 5 testes (16.7%) remained in a high position (at the penile base or inguinal canal), and 1 testis (3.3%) was atrophic.

Table 3. Comparison of testicular volume before and after surgery by age group

Age group	n (missing)	Preoperative volume [Median (IQR), mL]	Postoperative volume [Median (IQR), mL]	p[a]
≤ 24 months	14 (6)	0.35 (0.24 - 0.45)	0.41 (0.30 - 0.53)	0.844
> 24 months	16 (2)	0.42 (0.30 - 0.53)	0.51 (0.36 - 0.61)	0.005
Total	30 (8)	0.39 (0.26 - 0.53)	0.49 (0.34 - 0.58)	0.023

Missing: testes with at least one unavailable measurement (pre- or postoperative) were excluded from the analysis; a: Wilcoxon signed-rank test.

After surgery, testicular volume increased significantly in the > 24-months old group and in the overall study population ($p < 0.05$). Although the ≤ 24-months old group also showed an upward trend, the difference did not reach statistical significance, likely due to the small sample size.

IV. DISCUSSION

In our study, all 45 testes were located in the lower abdomen and were associated with a patent deep inguinal ring (with 10 cases lacking retrievable data). This represents an important anatomical factor when applying single-stage laparoscopic vessel-sparing orchiopexy. The

correlation between testicular position and the intraoperative characteristics of the deep inguinal ring is consistent with embryological principles.

The descent of the testis from the abdomen into the scrotum requires the presence of the processus vaginalis, a peritoneal diverticulum that later forms the deep inguinal ring. Therefore, a testis that has naturally descended to a lower intra-abdominal position is often accompanied by a patent deep inguinal ring. Conversely, a closed deep inguinal ring indicates that the process of testicular descent was arrested early during fetal development (resulting in a high intra-abdominal testis) or that an intrauterine vascular insult occurred, leading to testicular atrophy and obliteration of the processus vaginalis.

The success of single-stage laparoscopic orchiopexy depends on the meticulous execution of a series of surgical steps designed to maximize the length of the spermatic vessels. Among these, the most critical maneuver is the incision of the peritoneum lateral to the gonadal vessels followed by their careful dissection proximally, as close as possible to their origin. This step helps to straighten the vascular course and reduce tension on the spermatic pedicle. The magnification provided by laparoscopy is also a key advantage, allowing precise identification and preservation of the small surrounding vessels, thereby minimizing the risk of vascular injury.

Table 4. Comparison of outcomes of single-stage laparoscopic vessel-sparing orchiopexy among studies

Study	Number of testes (n)	Mean follow-up (months)	Success rate (%)	Atrophy rate (%)
Present study	30	19.6	80	3.3
Alzahem (2013)[10]	35	12	88	3
Alam (2017)[11]	50	17.3	80	8
Tian-Qu He (2022)[12]	41	12	90.2	0

In this study, the success rate (defined as testes located in the scrotum without atrophy) was 80%, comparable to Alam (2017) and slightly lower than Alzahem (2013) with 88%.[10,11] The testicular atrophy rate was 3.3%, within the 3 - 8% range reported in the above studies, indicating that this technique is safe and provides good preservation of testicular perfusion. Preservation of the spermatic vessels is the key factor in minimizing the risk of postoperative atrophy; however, this very preservation limits testicular mobility, leading to a proportion of testes that cannot be placed in the desired scrotal position. This represents the characteristic trade-off between single-stage laparoscopic vessel-sparing orchiopexy and the two-stage Fowler-Stephens approach. Alam et al. (2017) observed that the two-stage Fowler-Stephens procedure achieved a 0% rate of high-positioned testes but was associated with a higher atrophy rate. Therefore, selecting the single-stage approach for low intra-abdominal testes is reasonable, as the spermatic vessels are typically long enough to allow a tension-free descent into the scrotum. Our results confirm that this method provides an optimal balance between achieving the desired anatomical position and maintaining adequate vascular

supply to the testis.

In addition to vessel-sparing single-stage orchiopexy, several authors have explored methods to shorten the course of the spermatic cord to improve postoperative testicular position. Tian-Qu He (2022) reported remarkable results with a success rate of 90.2% (testes positioned at the scrotal base) and no testicular atrophy during a 12-month follow-up.[12] In that study, the author compared laparoscopic orchiopexy combined with a modified Prentiss maneuver versus the traditional inguinal route. The Prentiss group achieved a significantly higher rate of low-scrotal testicular position (90.2% vs. 71.9%; p = 0.026), while operative time, postoperative pain, and early complications were not significantly different between groups. After 12 months, no case of atrophy, hydrocele, or inguinal hernia were reported, confirming the safety and feasibility of the technique. The main advantage of the Prentiss maneuver lies in its ability to straighten the spermatic cord by creating a new tunnel medial to the inferior epigastric vessels, eliminating the angulation at the deep inguinal ring and thereby shortening the effective distance while preserving the vascular supply. This allows the testis to reach an optimal scrotal position with good perfusion and minimal cord tension. However, the procedure requires high precision, as any deviation during tunnel creation may damage the inferior epigastric vessels or bladder, or cause cord torsion. Moreover, this technique only partially increases the effective cord length and therefore cannot replace the two-stage Fowler-Stephens procedure for high intra-abdominal testes.

A notable finding in this study was the postoperative increase in testicular volume. Across the entire cohort, the median testicular volume increased significantly (p = 0.023), with a particularly marked improvement in children aged > 24 months old (p = 0.005). This result is consistent with the well-established physiological mechanism whereby relocation of the testis into the cooler scrotal environment promotes catch-up growth, partially compensating for the developmental delay caused by prolonged intra-abdominal retention. The study by Ajiki et al. (2023) supports this observation.[13] The authors evaluated 93 patients (127 testes) and compared the testicular volume ratio (TVR), calculated as affected-to-normal side × 100%, before and after surgery. In patients with preoperative testicular atrophy (TVR < 50%), the median TVR increased from 27% to 58% in the ≤ 24-month group (p < 0.01) and from 32% to 61% in the > 24-month group (p < 0.05). Ajiki concluded that surgical intervention provides measurable recovery of testicular volume, regardless of the patient's age at operation. Our findings demonstrated a similar trend. In the ≤ 24-months old group, postoperative testicular volume showed an increase that did not reach statistical significance (p = 0.844). This lack of significance may be attributed to the small sample size (14 testes, with missing data in 6 cases). Moreover, in this younger group, the testes are typically less affected preoperatively, making volume gain less pronounced in statistical testing. In contrast, the > 24-month group exhibited a more evident "catch-up" effect, likely due to greater preoperative underdevelopment. Numerous large international studies have confirmed the long-term benefit of early surgery in restoring testicular volume. However, both the findings of Ajiki et al. (2023) and our data indicate that surgical intervention remains beneficial even in older children, as it can still promote partial recovery of testicular growth.

This study has several limitations. Because of its retrospective design, data collection depended on the completeness of available medical records, leading to unavoidable data omissions. The sample size was relatively

small, and the absence of a control group limited the ability to compare and generalize the findings. These factors may have affected the robustness of the statistical analysis. Further prospective studies with larger cohorts are needed to validate these results and establish more definitive recommendations.

V. CONCLUSION

The single-stage vessel-sparing laparoscopic orchiopexy is a safe and effective procedure for the treatment of intra-abdominal undescended testes. However, further studies with larger sample sizes and appropriate control groups are required to comprehensively evaluate the overall efficacy of this technique.

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