OUTCOMES OF TWO-STAGE LAPAROSCOPIC FOWLER-STEPHENS ORCHIOPEXY FOR THE TREATMENT OF INTRA-ABDOMINAL UNDESCENDED TESTES

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Two-stage laparoscopic Fowler-Stephens orchiopexy is the standard treatment for intra-abdominal undescended testes with short 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 two-stage laparoscopic Fowler-Stephens orchiopexy for intra-abdominal undescended testes at the Viet Nam National Children's Hospital from January 2021 to June 2024. A total of 39 patients with 45 testes underwent surgery; the median age was 34 months old (11 - 190). The median interval between the two stages was 6 months (3 - 14). No intraoperative or early postoperative complication was recorded. Twenty-seven patients (31 testes) were followed up, with a mean follow-up duration of 16.7 ± 8.4 months; among them, 27 testes (87.1%) were located in the scrotum, 2 testes (6.45%) remained high, and 2 testes (6.45%) were atrophic. Comparison of testicular volume between the two stages, as well as before and after surgery, showed no statistically significant difference (p > 0.05). No late complication was observed during follow-up. The two-stage Fowler-Stephens laparoscopic orchiopexy is a safe and effective procedure for managing intra-abdominal undescended testes. Further studies with larger sample sizes and appropriate control groups are warranted to comprehensively evaluate the overall efficacy of this technique.

Keywords: Undescended testis, laparoscopy, Fowler-Stephens.

I. INTRODUCTION

Undescended testis (UDT) is one of the most common congenital anomalies in male children, with an incidence ranging from 1 - 4.6% in newborns.[1] Although UDT is typically asymptomatic during childhood, delayed treatment may lead to serious consequences, including torsion of the undescended testis, malignant transformation, infertility, and psychological distress during adolescence.[2,3] Since the first open orchiopexy in 1877, the management of UDT has undergone major advances. While the conventional open technique became the standard approach for inguinal testes, it proved ineffective for high intra-abdominal testes. The main limitation of single-stage surgery in such cases lies in its dependence on the natural length of the spermatic vessels. When the testis is located high in the abdomen, the short vascular pedicle restricts mobilization, and any attempt to bring the testis into the scrotum risks excessive tension, vascular compromise, and subsequent atrophy. A major breakthrough in UDT management came in 1959, when Fowler and Stephens demonstrated that the testis could survive on collateral blood supply and

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Received: 24/10/2025
Accepted: 03/11/2025

introduced a technique involving division of the testicular artery to mobilize and bring the testis into the scrotum.[4] The method was later modified by Ransley (1984) into a two-stage procedure, allowing for the gradual development of collateral circulation and improved testicular perfusion.[4] The advent of laparoscopy in the 1990s marked another significant milestone, as this minimally invasive approach was adapted to the Fowler-Stephens technique. With continued advances in laparoscopic instrumentation and surgical expertise, two-stage laparoscopic Fowler-Stephens orchiopexy has now become a widely adopted procedure for the management of intra-abdominal undescended testes in pediatric surgical centers both in Viet Nam and internationally.[5]

To evaluate the outcomes of laparoscopic Fowler-Stephens orchiopexy in the treatment of intra-abdominal undescended testes in children, we conducted a retrospective study of pediatric patients who underwent laparoscopic surgery at the Viet Nam 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 two-stage laparoscopic Fowler-Stephens 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 two-stage laparoscopic Fowler-Stephens 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 applied, including all patients who met the inclusion criteria and did not meet the exclusion criteria during the study period.

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 conducted at least 6 months after surgery to evaluate testicular position and size using ultrasonography, as well as to identify 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.[6] Surgical success was defined as the testis being located within the scrotum and showing no evidence of atrophy.[5]

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).[7]calculated using the ellipsoid equation $W2 \times L \times \pi/6$, correlate with those obtained by ultrasound (US

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

3. Research ethics

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 39 patients with 45 affected testes were included, comprising 33 cases of unilateral UDT and 6 cases of bilateral UDT. The median age at the time of surgery was 34 months old, ranging from 11 to 190 months old.

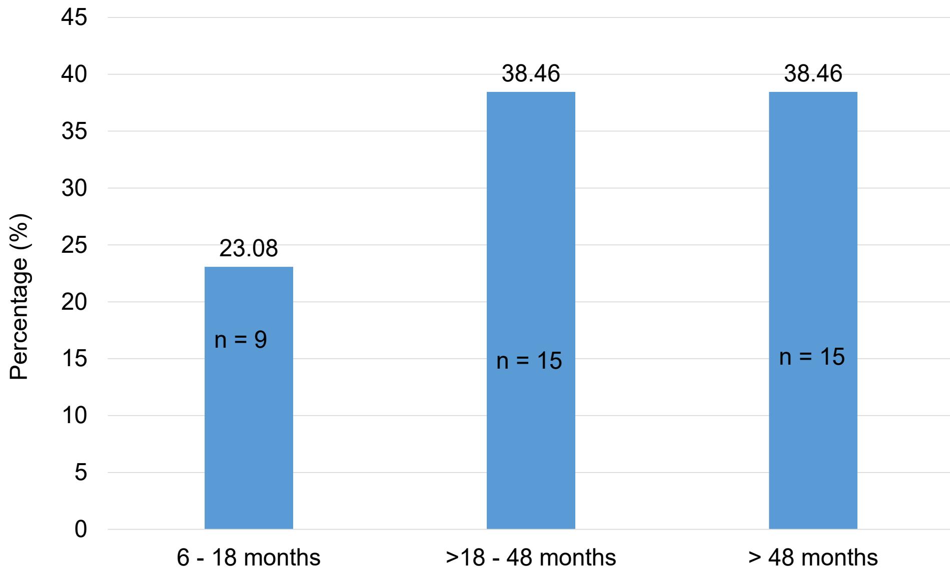

Chart 1. Distribution of patients by age group

Only 23.08% of patients underwent early surgery between 6 - 18 months old, while the majority were operated on after 18 months of age, with both the >18 - 48 months old and > 48 months old groups showing high and equal proportions of 38.46%.

Table 1. Intraoperative findings and early postoperative outcomes

Parameter	Result
Operative time per testis (minutes)	
Stage I	27.24 ± 5.23
Stage II	40.39 ± 9.73
Interval between two stages [Median (min-max), months]	6 (3-14)
Number of testes atrophied between stages (n)	0
Intraoperative complication rate (%)	0
Early postoperative complication rate (%)	0
Length of hospital stay (days)	1.07 ± 0.41

We compared testicular volume between the two stages of the Fowler-Stephens procedure based on intraoperative testicular measurements. Data for three testes were incomplete and therefore classified as missing.

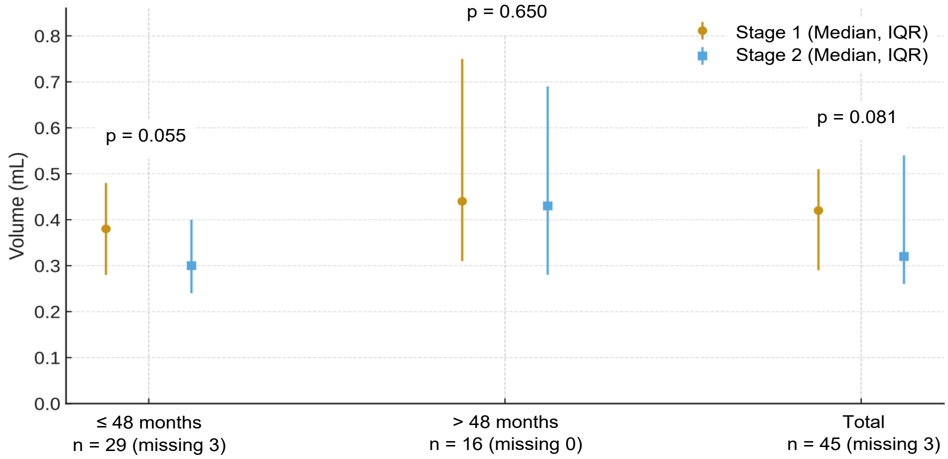

Chart 2. Comparison of testicular volume between Stage I and Stage II of the Fowler-Stephens procedure

Testicular volume between the two stages of Fowler-Stephens orchiopexy showed no statistically significant difference across age groups ($p > 0.05$).

Among 39 patients in the study cohort, 27 patients with 31 affected testes were followed up. The mean follow-up duration (calculated from the second-stage surgery) was 16.7 ± 8.4 months. Of these, 27 testes (87.1%) were located in the scrotum, 2 testes (6.45%) remained high, and 2 testes (6.45%) were atrophic.

Table 2. Comparison of testicular volume before and after surgery

Age group	n (missing)	Preoperative volume [Median (IQR), mL]	Postoperative volume [Median (IQR), mL]	p[a]
≤ 24 months	10 (0)	0.35 (0.29 - 0.41)	0.34 (0.30 - 0.46)	0.432
> 24 months	21 (2)	0.43 (0.28 - 0.67)	0.34 (0.25 - 0.57)	0.441
Total	31 (2)	0.37 (0.28 - 0.55)	0.34 (0.28 - 0.46)	0.670

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

Postoperative testicular volume in both age groups showed no significant change compared with preoperative values ($p > 0.05$). In the ≤ 24-months old group, the median volume remained nearly unchanged, while in the > 24-monthd old group, a slight decrease was observed but did not reach statistical significance.

No late postoperative complication such as inguinal hernia, trocar-site hernia, or adhesive bowel obstruction was recorded.

IV. DISCUSSION

In 1959, R. Fowler and F. D. Stephens published a landmark study on the vascular anatomy of the testis.[4] They demonstrated that the testis possesses a rich collateral blood supply, and even if the main testicular artery is divided high in the retroperitoneum, testicular viability can be maintained through the deferential artery (a branch of the inferior vesical artery) and the cremasteric artery (a branch of the inferior epigastric artery). This discovery was revolutionary, as it enabled the descent of testes previously considered non-viable for surgical correction due to a short spermatic pedicle. However, the original Fowler-Stephens procedure was a single-stage open operation, involving division of the testicular vessels followed by immediate orchiopexy. The limitation of this approach lay in the insufficient collateral circulation to sustain the testis immediately after vessel division, which often led to ischemic atrophy. In 1984, Ransley et al. introduced a key modification to the Fowler-Stephens procedure by dividing it into two stages, allowing time for the collateral vessels to develop adequately before testicular descent.[4] This two-stage concept was further supported by experimental work by Pascual (1989) in a rat model. Using xenon perfusion studies, Pascual demonstrated that one hour after ligation of the testicular artery, blood flow to the testis decreased by approximately 80%, but by 30 days, perfusion had recovered to pre-ligation levels. In 1991, David Bloom was the first to report the use of laparoscopy to perform the first stage of the Fowler-Stephens procedure, laying the foundation for modern two-stage laparoscopic Fowler-Stephens orchiopexy, a minimally invasive evolution of this time-tested technique.

Two-stage laparoscopic Fowler-Stephens orchiopexy is now widely recognized worldwide as the standard treatment for high intra-abdominal undescended testes, particularly when the spermatic vessels are too short to allow single-stage descent. The interval between the two stages plays a crucial role, as it provides time for collateral circulation to form and strengthen sufficiently to sustain the testis after the primary testicular vessels have been divided in the first stage. The objective of this interval is to maximize testicular viability and preserve testicular volume while minimizing the risk of ischemia and parenchymal atrophy before the second-stage descent.

In our study, the median interval between the two stages of the Fowler-Stephens procedure was 6 months (ranging from 3 to 14 months), and no case of testicular atrophy was observed during intraoperative inspection at the second stage. Our findings are consistent with the recommendations of the EAU (2025) and align with the time frame adopted by most authors.[1] However, international studies indicate that there is no absolute consensus regarding the optimal interval between stages. Some authors consider 3 months to be the shortest but still sufficient duration to promote neovascularization, particularly in cases where shortening the total treatment time is desired. Others prefer an interval of 4 months as a balanced approach that allows additional time for the development of collateral circulation while minimizing the duration of intra-abdominal testicular placement.[8] Meanwhile, several studies have advocated waiting 6 months or longer, reflecting a more cautious strategy aimed at maximizing the development of collateral blood supply, especially in cases involving high intra-abdominal testes or poorly developed collateral vessels. Roy et al. (2020) reported on 279 patients with a median interval of 7 months (IQR 6-8) between stages.[9] Niedzielski (2022) performed two-stage laparoscopic Fowler-Stephens orchiopexy with the second stage scheduled after 9 - 12 months, achieving a 93.1% success rate and a trend toward increased testicular volume over time.[10] These findings suggest that extending the interval to approximately 9 - 12 months remains acceptable in selected clinical settings, provided that patients are closely monitored. Determining the timing of the second stage should not adhere rigidly to a fixed interval; instead, it should be individualized, taking into account a combination of clinical and anatomical factors related to the testis and its vascular pedicle, along with the surgeon's judgment, to achieve the ultimate goal of preserving testicular structure and function.

Our results showed no statistically significant difference in testicular volume measured between Stage 1 and Stage 2 of the Fowler-Stephens procedure, across both age groups as well as in the overall cohort (median 0.42mL vs. 0.32mL, $p = 0.081$). This finding indicates that division of the testicular vessels during Stage 1 does not alter testicular volume. Furthermore, when comparing preoperative and postoperative volumes, no statistically significant change was observed. In comparison with international studies, Abdelhalim et al. (2019) measured testicular volume intraoperatively at both stages and reported that among 36 testes with complete data, only 2 (5.6%) showed a reduction of more than 20% immediately after Stage 1, whereas 16 (45.7%) exhibited an increase of more than 20% during the interval between stages, with a median increase of up to 70.2%.[11] The authors concluded that volume reduction tended to occur after Stage 2 (22.2% during postoperative assessment), while vessel division during Stage 1 rarely caused a significant decrease; most testes that remained small at follow-up were already small preoperatively, suggesting that congenital testicular underdevelopment rather than ischemia was the underlying cause. These findings reinforce that Stage 1 is not the direct factor leading to decreased testicular size, whereas Stage 2 requires meticulous handling to preserve collateral circulation. Niedzielski et al. (2022) reported a series of 29 testes measured at six time points, notably at 3 months and 9-12 months after Stage 1 (the interval before Stage 2). The median volume remained 0.28 mL at both time points and subsequently increased with age at later follow-ups; the atrophy index also declined over time.[10] Taken together, the evidence indicates that testicular vessel division during Stage 1 of the Fowler-Stephens procedure does not cause a reduction in testicular volume. The risk of postoperative volume loss or atrophy primarily arises after Stage 2. Therefore, surgical strategy should focus on maximizing preservation of arterial collaterals, minimizing the use of electrocautery (favoring laparoscopic scissors or bipolar instruments), avoiding injury to the periductal collateral vessels, and maintaining an adequate interval between stages to allow full maturation of the collateral blood supply.

In our series of 45 testes treated with two-stage Fowler-Stephens orchiopexy, 31 testes were successfully followed up. Among these, 27 of 31 testes were located in the scrotum, 2 of 31 remained in a high position, and 2 of 31 were atrophic, corresponding to a success rate of 87.1% and an atrophy rate of 6.45%.

Table 3. Comparison of outcomes of two-stage laparoscopic Fowler-Stephens orchiopexy across studies

Study	Number of testes (n)	Mean follow-up (months)	Success rate (%)	Atrophy rate (%)
Present study	31	16.7	87.1	6.45
Stedman (2014)[12]	67	12.0	86.4	10.4
Roy (2020)[9]	96	12.5	85.0	8.3
Yu (2018)[13*]	1991	(-)	89.0	8.0

**Systematic review including multiple studies, without a specific follow-up period.*

When compared with previously published studies, our success rate was higher and the atrophy rate was lower than those reported in the single-center studies by Stedman (2014) and Roy (2020).[9,12] In comparison with the multicenter study by Yu (2018), our success rate was slightly lower (87.1% vs. 89.0%), while the atrophy rate was also lower (6.45% vs. 8.0%).[13] However, given the relatively small sample size, further studies with larger cohorts and longer follow-up durations are needed to validate these findings and provide stronger evidence for clinical recommendations.

V. CONCLUSION

The two-stage Fowler-Stephens 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.

REFERENCES

1. Radmayr C, Bogaert G, Doğan HS, et al. *EAU Pocket on Paediatric Urology (Limited Text Update April 2025)*. European Association of Urology Guidelines Office; 2025.

2. Ergül RB, Bayramoğlu Z, Keçeli AM. Risk for testicular germ cell tumors and spermatogenesis failure in post-pubertal undescended testes. *Int Urol Nephrol*. 2024;56(7):2269-2274. doi:10.1007/s11255-024-03963-4

3. Chen P, Yang Z, Chen N, et al. Diagnosis and treatment of cryptorchid testicular torsion in children: A 12-year retrospective study. *Front Pediatr*. 2022;10. doi:10.3389/fped.2022.968997

4. Naycı A, Bahadır GB, Erdoğan C. Laparoscopic one-stage Fowler-Stephens orchiopexy preserving gubernaculum. *Turk J Urol*. 2017;43(1):75-78. doi:10.5152/tud.2016.32392

5. Varga A, Kardos D, Radványi Á. Medium-Term Results of Staged Laparoscopic Traction Orchiopexy for Intra-abdominal Testes: A Multicenter Analysis. *Journal of Pediatric Surgery*. 2023;58(10):2020-2026. doi:10.1016/j.jpedsurg.2023.04.013

6. Durell J, Johal N, Burge D, et al. Testicular atrophy following paediatric primary orchidopexy: A prospective study. *J Pediatr Urol*. 2016;12(4):243.e1-4. doi:10.1016/j.jpurol.2016.05.023

7. Sotos JF, Tokar NJ. Testicular volumes revisited: A proposal for a simple clinical method that can closely match the volumes obtained by ultrasound and its clinical application. *International Journal of Pediatric Endocrinology*. 2012;2012(1):17. doi:10.1186/1687-9856-

2012-17

8. Elzeneini WM, Mostafa MS, Dahab MM. How far can one-stage laparoscopic Fowler-Stephens orchiopexy be implemented in intra-abdominal testes with short spermatic vessels? *J Pediatr Urol*. 2020;16(2):197.e1-197.e7. doi:10.1016/j.jpurol.2020.01.003

9. Roy C, Cullis PS, Clark C. Retrospective analysis of testicular outcomes following laparoscopic two-stage Fowler Stephens orchidopexy. *Journal of Pediatric Surgery*. 2020;55(2):300-303. doi:10.1016/j.jpedsurg.2019.10.030

10. Niedzielski J, Balinska K, Wilk D. The effect of the two-stage laparoscopic Fowler-Stevens operation on testicular growth and risk of atrophy in boys with intra-abdominal testes. *Arch Med Sci*. 2022;18(3):666-671. doi:10.5114/aoms.2019.86596

11. Abdelhalim A, Chamberlin JD, Young I, et al. Testicular Volume Changes in Laparoscopic Staged Fowler-Stephens Orchiopexy: Studying the Impact of Testicular Vessel Division. *Urology*. 2019;127:113-118. doi:10.1016/j.urology.2019.01.030

12. Stedman F, Bradshaw CJ, Kufeji D. Current Practice and Outcomes in the Management of Intra-abdominal Testes. *European Journal of Pediatric Surgery*. 2014;25:409-413. doi:10.1055/s-0034-1383854

13. Yu C, Long C, Wei Y, et al. Evaluation of Fowler-Stephens orchiopexy for high-level intra-abdominal cryptorchidism: A systematic review and meta-analysis. *Int J Surg*. 2018;60:74-87. doi:10.1016/j.ijsu.2018.10.046