

# Learning Curves in Transabdominal Pre-Peritoneal (TAPP) Herniorrhaphy: Comparison of Transabdominal Extraperitoneal (TEP) Experience and Supervisor-led Learning

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## ABSTRACT

**Objective:** Inguinal hernia (IH) is one of the common diseases encountered in general surgery. Laparoscopic techniques are recommended and preferred surgical methods for inguinal hernia today due to their advantages. There are various published studies regarding the learning curve (LC) of the TAPP technique, one of the laparoscopic methods. In our study, we aimed to compare the LC of TAPP herniorrhaphy performed by a surgeon without supervisor support after TEP experience with that of a surgeon without laparoscopic hernia experience under supervision.

**Methods:** In our study, patients who underwent laparoscopic inguinal hernia repair at our clinic between 2011 and 2024 were analyzed. Patients operated on by a surgeon who transitioned to TAPP herniorrhaphy without supervision after gaining experience in TEP were designated as Group-I, while patients operated on by a surgeon performing TAPP herniorrhaphy under supervision were designated as Group 2. In both groups, the first 100 patients who underwent primary TAPP herniorrhaphy were retrospectively evaluated for operative times, conversion rates to open surgery, and complications, with learning curve data generated.

**Results:** In this study, a total of 128 patients (64 patients in each group) who underwent TAPP herniorrhaphy for primary unilateral inguinal hernia were evaluated. There was no significant difference between the two groups in demographic features ( $p>0.05$ ). No significant difference was found between the groups according to the Nyhus classification ( $p>0.05$ ). No difference was observed between the groups in terms of postoperative complications ( $p>0.05$ ). In the analyses performed for the LC, it was seen that the ideal number of surgeries for Group-I was 19, and for Group-2 it was 26, and it was not statistically significant ( $p>0.05$ ).

**Conclusion:** The learning curve in TAPP surgeries performed under supervision showing similar results to those of surgeons experienced in TEP indicates the potential importance of supervisory support in the learning process.

## INTRODUCTION

IH affect approximately 220 million people worldwide, and each year, 20 million individuals undergo surgery due to hernia in the groin area. IH, which account for more than 75% of abdominal hernias, have a lifetime prevalence of 27% to 32.9% in men, while this rate remains lower in women, ranging from 3% to 12.9%.<sup>[1,2]</sup>

Today, various surgical techniques are available for the repair of IH, including open and laparoscopic approaches. In laparoscopic surgery, particularly advancements recorded in the last 30 years have enabled the development of techniques such as TAPP and TEP repair.<sup>[3,4]</sup> The European Hernia Society (EHS) guidelines recommend open Lichtenstein and laparoscopic inguinal hernia techniques (TEP and TAPP) as the best evidence-based treatment options for the repair of primary unilateral groin hernia, provided

that the surgeon has sufficient experience and the necessary resources for the specific procedure.<sup>[5]</sup>

According to guidelines from the EHS and the International Endohernia Society (IEHS), both new techniques are advantageous in terms of all parameters related to pain when compared to open surgery. Accordingly, the guidelines suggest that laparoscopic hernia repair should be the first-line treatment, especially in patients where quick postoperative recovery is particularly important (grade A). Furthermore, the guidelines propose that an endoscopic procedure should be recommended for the working population, particularly for bilateral hernias, from a socioeconomic perspective (grade A).

There is ongoing debate about which method is preferable. Despite numerous peer-reviewed studies showing the advantages of low postoperative complication rates, short hospital stays, low costs, reduced recurrence rates and postoperative pain, early return to work, and improvements in quality of life and demonstrating that these techniques can be safely performed by surgeons worldwide, the adoption of laparoscopic techniques has remained limited until recently.<sup>[6,7]</sup> Despite the proven benefits of this new, revolutionary technique, its clinical application remains insufficient in many countries.<sup>[8-10]</sup> It raises the question of why so many surgeons do not prefer or adopt laparoscopic inguinal hernia repair. Among the discussed reasons are the technical difficulty of laparoscopic surgery and challenges related to the LC.

Various studies have assessed the LC in laparoscopic inguinal hernia repair, indicating that it can vary between 20 and 250 cases.<sup>[11-15]</sup> However, there is no general consensus on the exact number of cases that a surgeon must perform to achieve proficiency in the LC.<sup>[12]</sup> The assessment of the LC is generally evaluated through parameters such as operative time, postoperative complications, and technical difficulties.<sup>[16]</sup>

The purpose of this study is to evaluate and compare the TAPP technique LC in two different parameters, with supervision and TEP technique experience.

## MATERIALS AND METHODS

Patients who presented to our clinic with a hernia diagnosis between April 2011–December 2011 and November 2022–June 2024 and underwent elective surgery using the TAPP method by two different surgeons were retrospectively evaluated.

### Inclusion criteria

- Unilateral hernias
- Age between 18–75 years
- BMI < 35 kg/m<sup>2</sup>

### Exclusion criteria

- Bilateral hernias
- Recurrent hernias

- Patients with giant hernias
- Patients transitioning from TEP to TAPP during surgery
- Emergency patients (irreducible, incarcerated)
- Patients using anticoagulants
- Patients with a history of midline inferior surgery

The patients were divided into two groups: Group 1 consisted of a surgeon experienced in TEP without the presence of a supervisor, during the period of April–December 2011, while Group 2 comprised of a surgeon performing TAPP herniorrhaphy with a supervisor during the November 2022–June 2024 period.

In Group 2, 22 patients who did not meet the inclusion criteria were excluded from 86 patients undergoing TAPP herniorrhaphy, leaving 64 patients included in the study. Of those excluded, 15 had bilateral hernias, 4 were recurrent cases, and 3 were transferred to the supervisor.

For Group 1, 100 patients were initially included to match the number of cases with 64 patients in Group 2 from the start of TAPP. Of these, 36 patients were excluded (3 reverted from TEP to TAPP, 20 were bilateral, and 13 were recurrent cases), resulting in 64 patients in Group 1.

Learning curve (LC) evaluation parameters included the duration of surgery, the conversion to a different method (open) from TAPP, and intraoperative and postoperative complications.

Patients' demographic characteristics, hernia type, duration of surgery, intraoperative complications (vascular and organ injury, hemorrhage), conversion to a different method, the use and duration of drains, postoperative outcomes, length of stay, hemorrhage, hematoma, seroma, cord edema, wound infection, mesh infection, and early recurrence by the 1st month were evaluated. The Nyhus classification was used for hernia classification.<sup>[17]</sup>

Surgery duration was defined as the time from the first skin incision to the removal of the camera port. Intraoperative complications were defined as major vascular injury (testicular or epigastric artery), ductus deferens, and organ damage. Postoperative complications like hematoma or seroma were defined as the accumulation of blood or fluid in any subcutaneous tissue area down to the scrotal region. Recurrence occurring within the first 4 weeks was defined as early recurrence.

Group 1: The surgeon acting as a supervisor had laparoscopy experience in the LC process, performed more than 200 Total Extraperitoneal (TEP) procedures, over 300 laparoscopic cholecystectomies, and more than 400 Lichtenstein inguinal hernia repairs, but had no experience with laparoscopic TAPP herniorrhaphy and operated without a mentor, performed by a single surgeon.

Group 2: Performed by a single surgeon without experience in laparoscopic TEP and TAPP, having performed more than 300 Laparoscopic Sleeve Gastrectomies, over 350 laparoscopic cholecystectomies, and more than 200 Lichtenstein inguinal hernia repairs, but without experi-

ence in laparoscopic TAPP herniorrhaphy, operated under the guidance of an experienced TAPP supervisor.

All procedures were conducted according to the principles of the 1964 Helsinki Declaration and its later amendments, with informed consent obtained from all patients who were included in the study. Ethical Committee approval was obtained with the number 2024/109 on 18.07.2024.

### Surgical technique

All surgeries were performed using the generally described (3 trocar-laparoscopic) TAPP method [18–20]. Differently, a standard mesh size of 15\*15 was used in all cases, and the peritoneal opening was closed with tacks.

### Statistical Analysis

Descriptive statistics of the data used median, mean, standard deviation, frequency, and ratio values. The distribution of variables was measured with Kolmogorov-Smirnov and Shapiro-Wilk tests. The Mann-Whitney U test was used to analyze quantitative independent data with abnormal distribution. The chi-square test was used to analyze qualitative independent data, and the Fisher test was used when chi-square test conditions were not met. SPSS 27.0 software was used for analysis.

## RESULTS

Out of a sample of 186 individuals, a total of 128 patients who met the study criteria were included, with 64 patients

in Group 1 and 64 in Group 2. When patients in both groups were compared, no significant differences were found in terms of age, gender, ASA score, hernia side, and hernia types ( $p>0.05$ ). Only the BMI values of Group 2 patients were significantly higher (24.03 vs. 25.78,  $p<0.05$ ).

In both groups, no patients required hospital stay longer than 2 days. The average length of stay in Group 1 was found to be longer and statistically significant compared to Group 2 (1.13 vs. 1.03,  $p<0.05$ ). The average surgery duration was significantly longer in Group 2 compared to Group 1 (38.56 vs. 35.34,  $p<0.05$ ).

The detailed demographic information of all patients is shown in Table 1. The distribution of patients based on surgery duration is presented in Figures 1-2.

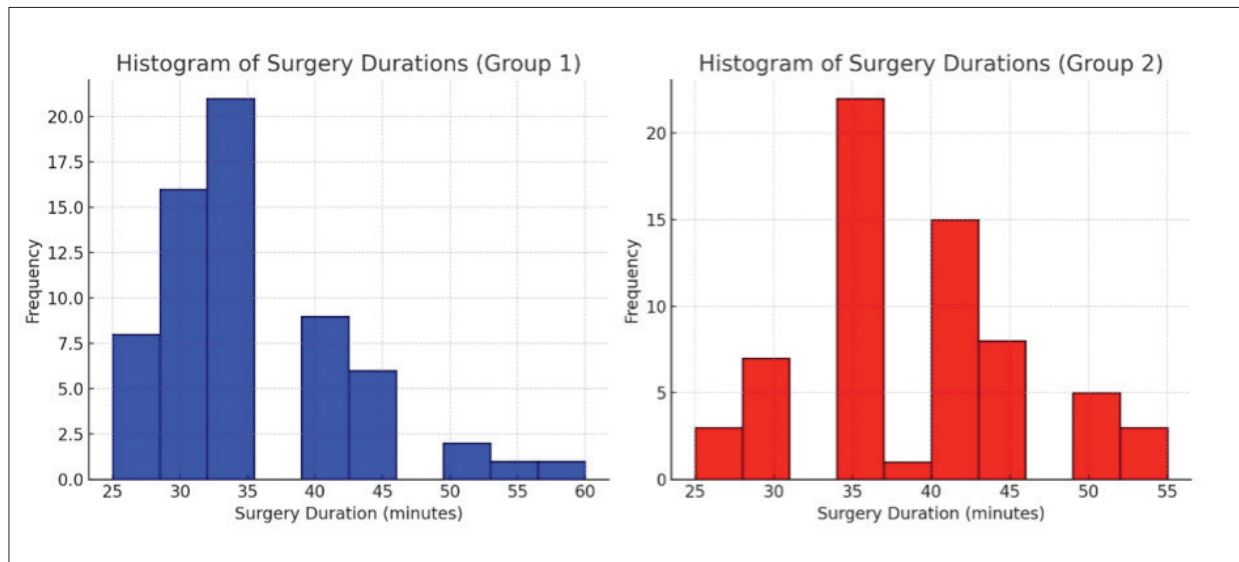
### Complications

When all patients were evaluated, a complication rate of 22.66% was observed. In the second group, the rate of seroma was found to be higher compared to the first group (1 vs. 7), although this was not statistically significant ( $p>0.05$ ). In Group 2, out of 7 patients with seroma, 6 resolved spontaneously, and 1 required aspiration as there was no improvement at the 6-week check-up, with no need for additional surgery. In Group 1, there was 1 hematoma that did not require interventional treatment, while no hematoma was observed in Group 2. Cord edema was seen in a total of 20 patients, with 11 cases (1.19%) in Group 1 and 9 cases (13.73%) in Group 2, mak-

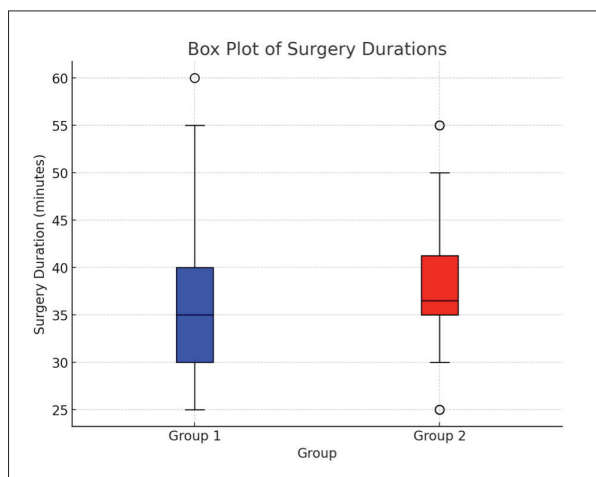
**Table 1.** Demographic characteristics of the patients

	Total n=128	Group 1 n=64 (50%)	Group 2 n=64 (50%)	p-value
Age, Mean±SD	43.73±11	43.98±11.69	42.75±10.33	0.53 t
Gender, n(%)				
Male	118 (92.19)	60 (93.75)	58 (90.63)	0.74 X <sup>2</sup>
Female	10 (7.81)	4 (6.25)	6 (9.38)	
ASA, n(%)				
ASA I	65 (50.78)	29 (45.31)	36 (56.25)	0.21 X <sup>2</sup>
ASA II	59 (46.9)	34 (53.13)	25 (39.06)	
ASA III	4 (3.13)	1 (1.56)	3 (4.69)	
BMI, Mean±SD	24.91±3.17	24.03±2.44	25.78±3.57	<b>0.0016<sup>t</sup></b>
Duration of surgery (min), Mean±SD	36.95±7.43	35.34±7.47	38.56±7.10	<b>0.0137<sup>m</sup></b>
Hospitalization time (day), Mean±SD	1.08±0.27	1.13±0.33	1.03±0.18	<b>0.048<sup>t</sup></b>
Hernia site N (%)				
Right	73(57.03)	38(59.37)	35(54.69)	0.72 X <sup>2</sup>
Left	55(42.97)	26(40.63)	29(45.31)	
Hernia type				0.85 X <sup>2</sup>
Direct herni (D)	37(28.91)	19(29.69)	16(25.0)	
Indirect herni (ID)	73(57.03)	36(56.25)	37(57.81)	
D-ID	20(17.19)	9(14.06)	11(17.19)	
Femoral	3(2.34)	1(1.56)	2(3.12)	

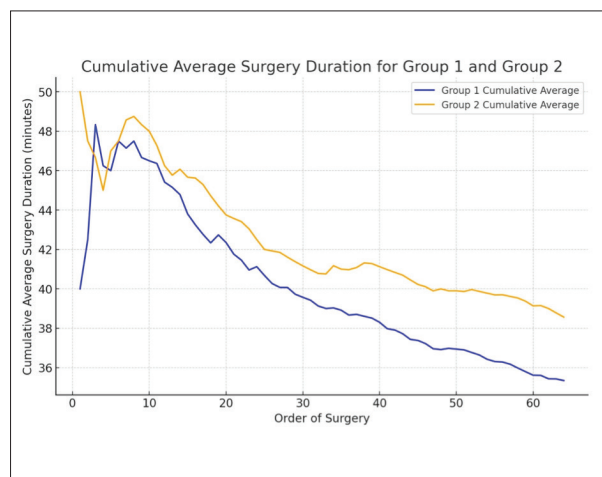
<sup>m</sup>Mann-whitney u test; X<sup>2</sup>:Chi-square test; Fisher's Exact test/t t-Test ; SD: Standard deviation; ASA: American Society of Anesthesiologist; BMI: Body Mass Index; D: direct; ID: Indirect.



**Figure 1.** Comparison of surgery duration between Group 1 and Group 2 in a histogram.



**Figure 2.** Boxplot of surgery duration for Group 1 and Group 2.



**Figure 3.** Comparison of cumulative mean surgery times of Group 1 and Group 2.

**Table 2.** Complications in 2 groups

	Total n=128	Group I n=64 (50)	Group2 n=64 (50)	p-value
Postoperative complications N (%)	29 (22.66)	13 (20.31)	16 (25.00)	0.67 X <sup>2</sup>
Scrotal hematoma	1 (0.78)	1 (1.56)	0 (0)	1 X <sup>2</sup>
Seroma	8 (6.25)	1 (1.56)	7 (10.68)	0.067 X <sup>2</sup>
Cord edema	20 (15.63)	11 (17.19)	9 (13.73)	0.8 X <sup>2</sup>

X<sup>2</sup> Chi-square test / Fisher's Exact test

ing up 15.63% overall. There were no cases of cord or organ injury, major vascular injury, or severe bleeding that required transfusion. Re-operation was not performed. Detailed information is summarized in Table 2.

When the effects of patients' age, gender, BMI, and type of

hernia on surgery duration were analyzed, it was observed that age, gender, and BMI did not affect surgery duration ( $p>0.05$ ). When the effects of hernia types on surgery duration were compared according to Nyhus, Nyhus type 3a had the shortest duration at 30.61 minutes, while Ny-

**Table 3.** Mean surgery durations according to Nyhus classification

Nyhus Classification	Surgery Duration mean $\pm$ std)	Number of Patients
2	36.84 $\pm$ 5.83 minutes	56
3a	30.61 $\pm$ 4.80 minutes	33
3b	45.59 $\pm$ 6.59 minutes	17
3a+2	38.47 $\pm$ 4.58 minutes	15
3a+3b	48.75 $\pm$ 8.54 minutes	4
3a+3c	37.50 $\pm$ 3.54 minutes	2
2+3c	35.00 $\pm$ N/A minutes	1

Std: Standard deviation.

**Table 4.** Regression analysis results showing the effects of Nyhus classification and other variables on surgery duration

Variable	Coefficient	p-value
Nyhus Complex	8.2744	0.0
Age	-0.0656	0.2306
Gender (Male/Female)	2.1221	0.3256
BMI	0.1163	0.5293

BMI Body mass index.

hus type 3a+3b was found to have the longest duration at 48.75 minutes (Table 3). When we categorized Nyhus classification into simple (uncomplicated 3a and 2) and complicated (other groups), a significant difference was observed between the two groups, with times of 30.61 $\pm$ 4.8 minutes vs. 42.49 $\pm$ 7.05 minutes ( $p<0.005$ ) (Table 4).

### Learning Curve

We aimed to identify the point where the ideal LC stabilizes. "The LC was defined as the period during which the surgery duration stabilized."

This was done by analyzing how surgery times change over time using moving averages or cumulative averages, and by detecting the point where cumulative average times stabilize. In Group 1, the point where the cumulative average surgery time fell below a certain threshold and stabilized was the 19th surgery. In Group 2, it was identified as the 26th surgery. When the two groups were compared, no statistically significant difference was observed in the LC between Group 1 and Group 2, whereas the surgery time in Group 1 was statistically significantly shorter than in Group 2 ( $p<0.005$ ) (Fig. 3).

## DISCUSSION

The concept of the 'LC' was first defined in 1936 by T.P. Wright in the aircraft manufacturing sector.<sup>[12]</sup> Initially used in various fields outside of healthcare, the term began to be applied in medicine following the emergence of minimally invasive surgery in the 1980s. Traditionally, in surgical

branches, resident training is based on a master-apprentice relationship and is supervised by a supervisor according to the basic training principles of the branches. In surgery, the term 'LC' is used to describe the process of acquiring surgical skills necessary to perform a procedure safely, adequately, and effectively.<sup>[21]</sup>

The guidelines of the EHS advocate for open Lichtenstein and laparoscopic inguinal hernia techniques (TEP and TAPP) as the best evidence-based treatment options for the repair of primary unilateral groin hernias, provided that the surgeon is adequately experienced and that the necessary resources for the procedure are available.<sup>[5]</sup>

The LCs and complication rates of surgeons who frequently perform the procedure will differ from those who operate occasionally, such as residents and surgical assistants.<sup>[22]</sup> There is evidence indicating that even after 400 cases, the operation time, conversion rate, and short-term complication rate continue to decrease.<sup>[23]</sup>

Many factors can affect the LC in surgery, including previously acquired individual and institutional experiences, especially in laparoscopic operations. Patient selection for laparoscopy, details of the technique, the number of annual surgeries performed, and training can also be significant. In this context, there may be differences in the LC between experienced surgeons learning a new technique and younger surgeons working in a hospital where TAPP has already been fully standardized and applied as a routine procedure.<sup>[11]</sup>

Numerous studies can be found in the literature describing the LC in laparoscopic inguinal hernia repair. Studies include variable data from 20 to 250 cases.<sup>[12-15]</sup> However, there is no general consensus regarding the exact number of cases a surgeon must perform to achieve the LC. Some publications indicate that the operation times for experienced surgeons are longer than those for seasoned surgeons and that a reduction occurs after around 50 cases.<sup>[11]</sup>

In our study, the average number of cases required for the LC was found to be 19 for Group 1 surgeons with TEP experience, while it was determined to be 26 for Group 2 surgeons who had no prior TAPP experience. Although no statistical difference was observed between the two



groups, it shows that TEP experience is beneficial in the learning of laparoscopic hernia repair. Compared to the literature, the LC with supervisor assistance appears to be superior to that of many studies. Maybe watching the operation outside the team by the experienced surgeon could be safe before starting.

The average operation time for TAPP in the literature is highly variable, ranging from 20 to 64 minutes across different studies.<sup>[3,11,24]</sup> Another study reported that the operation time was longer due to the closure of the peritoneum with sutures (54-65 minutes).<sup>[12]</sup> There are publications indicating significantly long learning phases, stating that it takes about 30 minutes to close the opened peritoneum with sutures, as required by the surgical technique.<sup>[11]</sup>

In our study, the operation times were observed to be shorter than those reported in the literature, at 35.34 minutes for Group 1 and 38.56 minutes for Group 2. We believe the shorter operation times compared to other publications may be due to TEP and laparoscopic experience, the surgery being performed under supervisor assistance, and the effective closure of the peritoneal incision with tacker (Fig. 1, Table 1).

The literature includes reports that large inguinal defects and advanced scrotal hernias contribute to prolonged operation times.<sup>[5,19,25,26]</sup> In our study, the operation times for direct hernia type 3a and indirect type II according to the Nyhus classification were statistically significantly shorter than those of other hernia types ( $p < 0.05$ ).

Selecting cases primarily categorized as type 3a and type 2 during the learning phase may be more suitable and motivating for new surgeons.

For a surgeon experienced in laparoscopy but without laparoscopic hernia experience, it has been determined that after 26 repetitions of TAPP herniorrhaphy, the average operation time shows a decrease and stabilizes, similar to what is achieved by someone with TEP experience after 19 cases, with no extra difference found in terms of complications.

## Conclusion

Surgeons who have adequate laparoscopic experience but lack laparoscopic hernia repair experience can quickly learn TAPP herniorrhaphy under supervisor assistance. Surgeons with TEP experience may prefer to transition to TAPP herniorrhaphy without supervisor assistance. Selecting patients with uncomplicated hernias (Type 2) or direct hernias (Type 3A) can positively affect the surgeon's LC process.

## Limitations

The study was conducted retrospectively. In this study, peritoneal flaps were closed with clips in all cases. Intracorporeal sutures require a separate learning process concerning operation time. Therefore, it is important to note that surgical skill may vary among surgeons. To provide a more comprehensive and accurate analysis of the

development of the LC, multicenter studies comparing a large number of surgeons and socioeconomically heterogeneous populations should be conducted.

## Ethics Committee Approval

The study was approved by the Dogus University Hospital Ethics Committee (Date: 18.07.2024, Decision No: 2024/109).

## Informed Consent

Retrospective study.

## Peer-review

Externally peer-reviewed.

## Authorship Contributions

Concept: Y.Ö.; Design: Y.Ö., Y.B.K.; Supervision: Y.Ö., Y.B.K.; Data collection &/or processing: Y.Ö.; Analysis and/or interpretation: Y.Ö., Y.B.K.; Literature search: Y.Ö., Y.B.K.; Writing: Y.Ö.; Critical review: Y.Ö., Y.B.K.

## Conflict of Interest

None declared.

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## Transabdominal Pre-peritoneal (TAPP) Öğrenme Eğrisinde: Transeksraperitoneal (TEP) Deneyimi ile Supervisor Eşliğinde Öğrenimin Karşılaştırılması

**Amaç:** İnguinal herni, tedavisinde açık ve laparoskopik gibi farklı cerrahi tekniklerin kullanıldığı, genel cerrahinin sık karşılaşılan hastalıklarından biridir. Laparoskopik yöntemler, sahip olduğu avantajları nedeniyle kasık fıtığı için günümüzde önerilen ve tercih edilen ameliyat tekniklerindendir. Laparoskopik yöntemlerden biri olan TAPP tekniği öğrenme eğrisi ile ilgili yayınlanmış değişik çalışmalar vardır. Çalışmamızda, TEP deneyiminden sonra süpervizör desteği olmayan cerrah ile laparoskopik fıtık deneyimi olmayan bir cerrahın süpervizör eşliğinde TAPP herniorafinin öğrenme eğrisini karşılaştırmayı amaçladık.

**Gereç ve Yöntem:** Çalışmamızda, kliniğimizde 2011–2024 tarihleri arasında laparoskopik kasık fıtığı ameliyatı olan hastalar incelendi. TEP deneyimine sahip olup, süpervizör olmadan TAPP herniorafisine geçen cerrahın hastaları Grup 1 olarak, süpervizör eşliğinde TAPP herniorafisi uygulayan cerrahın hastaları ise Grup 2 olarak tanımlandı. Her iki grupta primer TAPP herniorafisi uygulanan ilk 100 hastanın ameliyat süreleri, açık cerrahiye geçiş oranları ve komplikasyonlar retrospektif olarak değerlendirildi ve öğrenme eğrisi verileri oluşturuldu. Bilateral veya nöks fıtık vakaları çalışma kapsamı dışında tutuldu.

**Bulgular:** Bu çalışmada, her iki grupta da tek taraflı kasık fıtığı nedeniyle TAPP herniorafisi uygulanan toplam 128 hasta (her grupta 64 hasta) değerlendirildi. Her iki grupta da hastaların yaş, cinsiyet dağılımı, ASA skoru, yatış süresi ve fıtık tarafı açısından anlamlı bir fark saptanmadı ( $p>0.05$ ). Direk (D), İndirekt (ID), D-ID ve Femoral (F) ayrımı ile Nyhus sınıflamasına göre gruplar arasında anlamlı bir farklılık bulunmadı. Grup 2'de vücut kitle indeksi (VKİ) istatistiksel olarak anlamlı derecede yüksek bulundu ( $p<0.005$ ). Postoperatif komplikasyonlar açısından gruplar arasında farklılık gözlenmedi ( $p>0.05$ ). Öğrenme eğrisi karşılaştırıldığında, Grup 1'de öğrenme eğrisinin 19 ameliyatta, Grup 2'de ise 26 ameliyatta tamamlandığı görüldü. Grup 2'de ameliyat sayısı sayısal olarak daha yüksek olmasına rağmen, istatistiksel olarak anlamlı bir fark izlenmedi ( $p>0.05$ ).

**Sonuç:** Süpervizör eşliğinde yapılan TAPP ameliyatlarında öğrenme eğrisinin, TEP deneyimli cerrahlarla benzer sonuçlar göstermesi, öğrenme sürecinde süpervizör desteğinin potansiyel önemini işaret etmektedir.

**Anahtar Sözcükler:** Laparoskopik inguinal herni onarımı; öğrenme eğrisi; TAPP; TEP.