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Original Research Article

A study of the learning curve of total extraperitoneal repair of inguinal hernia among young laparoscopic surgeons in a tertiary care centre in an urban city

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ABSTRACT

Background: Totally extraperitoneal (TEP) repair of inguinal hernia is a technically demanding laparoscopic procedure with a well-recognized steep learning curve. Limited data exist from teaching institutions in developing countries regarding the progression of surgical competence among young laparoscopic surgeons.
Methods: A prospective observational study was conducted over two years in the Department of General Surgery at a tertiary care teaching hospital. Twenty-five young laparoscopic surgeons with 1–5 years of laparoscopic experience were enrolled. Data on operative time, intraoperative complications, need for senior assistance, mesh fixation method, and surgeon confidence were collected sequentially for each TEP procedure performed. Surgeons were categorized into early (≤10 cases) and late (>10 cases) learning phases. Statistical analysis was performed using Student's t-test, Mann–Whitney U test, Chi-square, and Fisher's exact test as appropriate.
Results: The majority of surgeons were aged 30–35 years (44%), with 36% having 1–2 years of laparoscopic experience. Mean operative time decreased significantly from 142±28 minutes in the early phase to 78±18 minutes in the late phase ($p<0.001$). Requirement for senior assistance decreased from 68% to 22% ($p=0.002$), and mean confidence score improved from 2.8±0.9 to 4.1±0.7 ($p<0.001$). A statistically significant association was found between number of TEP procedures performed and operative time reduction ($p=0.003$). Creation of the space of Bogros (24%) and dissection of Cooper's ligament (16%) were identified as the most time-consuming and assistance-requiring steps.
Conclusions: TEP repair has a clearly defined and significant learning curve. Proficiency is progressively achieved with increasing case volume, with substantial improvement observable beyond 10 cases in this cohort. Structured mentorship, targeted training on critical dissection steps, and adequate case exposure are essential for safe and efficient skill acquisition.

Keywords: Total extraperitoneal repair, Inguinal hernia, Learning curve, Laparoscopic surgery, Surgical training, Preperitoneal space, Young surgeon

INTRODUCTION

Inguinal hernia is among the most common surgical conditions encountered worldwide, with an estimated lifetime risk of approximately 27% in men and 3% in women.[1] Globally, millions of hernia repair surgeries are performed annually, representing a substantial clinical and economic burden. In developing countries such as India, this burden is amplified by late presentation, heavy manual labour, and high prevalence of risk factors including chronic cough, constipation, and occupational strain.[2]

The surgical management of inguinal hernia has undergone remarkable evolution over the past century. Early tissue-based repairs such as the Basini and Shouldice techniques gave way to the tension-free Lichtenstein mesh

repair, which became the gold standard for open repair due to its reproducibility and significantly lower recurrence rates.[4,5] With advances in minimally invasive surgery, the transabdominal preperitoneal (TAPP) and totally extraperitoneal (TEP) laparoscopic approaches emerged, offering advantages of reduced postoperative pain, shorter hospital stay, faster return to activity, and improved cosmetic outcomes.[6]

TEP repair, performed entirely within the preperitoneal space without breaching the peritoneal cavity, avoids intra-abdominal complications associated with TAPP, such as bowel injury and port-site hernias.[7] However, TEP is technically more demanding due to its confined working space, absence of familiar intraperitoneal landmarks, and requirement for precise anatomical orientation.[8] These factors contribute to its well-recognized steep learning curve, making surgeon experience a critical determinant of outcome.[9]

The concept of the learning curve — describing progressive improvement in efficiency and outcome as surgical experience accumulates — is central to evaluating the adoption of any new procedure.[10] For TEP, published studies have reported highly variable thresholds for proficiency, ranging from 30 to over 100 cases, with most data originating from high-volume specialized centres.[11,12] This variability, combined with the paucity of data from teaching hospitals in developing countries, limits the applicability of existing evidence to real-world training environments.

Young surgeons in tertiary care teaching hospitals gradually transition from supervised to independent TEP practice, but this progression has been poorly characterized. Understanding the specific challenges encountered at each stage- both objective (operative time, complications) and subjective (confidence, perceived difficulty) is essential for designing effective, competency-based training programs.

This study was therefore undertaken to prospectively evaluate the learning curve of TEP inguinal hernia repair among young laparoscopic surgeons in a tertiary care teaching hospital, with the aim of identifying proficiency thresholds, critical procedural challenges, and factors influencing skill acquisition.

METHODS

Study design and setting

This prospective observational study was conducted over two years in the Department of General Surgery at a tertiary care teaching hospital equipped with full laparoscopic infrastructure, including high-definition imaging systems and standard instruments for TEP repair. The institution follows a structured surgical training model with supervised progression toward independent practice.

Study population and eligibility

Twenty-five young laparoscopic surgeons were enrolled using universal sampling. Inclusion required 1–5 years of laparoscopic surgical experience and a minimum of 20 previously performed laparoscopic procedures (cholecystectomy or appendectomy). Participants included Senior Residents, Post-MS Senior Residents, and Assistant Professors actively performing TEP repair during the study period, either under supervision or independently. Surgeons with more than 5 years of laparoscopic experience, those already independently proficient in TEP, or those with fewer than 20 prior laparoscopic procedures were excluded. Participation was voluntary, with written informed consent obtained from all participants.

Data collection

A predesigned case record form was used to collect data prospectively. Baseline surgeon characteristics recorded included age, gender, designation, handedness, years of experience, and case volumes in laparoscopic cholecystectomy, laparoscopic appendectomy, open hernia repair, TAPP, and TEP. For each TEP procedure, sequential case numbers were assigned per surgeon. Variables documented included operative time, hernia type, intraoperative complications (peritoneal breach, bleeding), need for senior assistance, procedural steps requiring most time or assistance, mesh fixation method and time, and surgeon confidence (Likert scale 1–5). Comparison was made between the early learning phase (subsequently generalized as ≤10 cases) and late learning phase (>10 cases).

Outcome measures and definition of proficiency

The primary outcome was assessment of the learning curve through change in operative performance with increasing case numbers. Proficiency was defined as consistent reduction and stabilization of operative time, decrease in intraoperative complications, ability to complete the procedure independently, and reduction in perceived technical difficulty across critical procedural steps. Secondary outcomes included determination of procedures required for proficiency, step-wise difficulty analysis, and assessment of factors influencing learning.

Statistical analysis

Data were entered in Microsoft Excel and analysed using statistical package for the social sciences (SPSS) version 25. Continuous variables were expressed as mean ± standard deviation; categorical variables as frequencies and percentages. Comparison between early and late learning phases used Student's t-test or Mann–Whitney U test for continuous data and Chi-square or Fisher's exact test for categorical data. A p value <0.05 was considered statistically significant (two-tailed, 95% confidence interval). The study was approved by the Institutional

Ethics Committee and conducted in accordance with the Declaration of Helsinki.

RESULTS

Demographic and background characteristics

The cohort comprised 25 surgeons, predominantly male (64%) and aged 30–35 years (44%), with the remainder below 30 years (32%) or above 35 years (24%). By designation, 40% were Senior Residents, 36% Assistant Professors, and 24% Post-MS Senior Residents. Most surgeons (68%) had 1–3 years of laparoscopic experience (Tables 1-3).

Table 1: Demographic profile.

Parameters	N (%)
Age (years)	
<30	8 (32)
30–35	11 (44)
>35	6 (24)
Gender	
Male	16 (64)
Female	9 (36)
Designation	
Senior Resident	10 (40)
Assistant Professor	9 (36)
Post-MS SR	6 (24)
Experience in laparoscopic procedures (years)	
1–2	9 (36)
2–3	8 (32)
3–5	8 (32)

Prior laparoscopic surgical experience

Most surgeons (84%) had performed more than 20 laparoscopic cholecystectomies, and 32% had performed more than 60. Current operative time for cholecystectomy was under 30 minutes in 36% and 30 minutes to 1 hour in 48%, reflecting substantial progression from first-case performance. Confidence in cholecystectomy was high (score 4–5) in 68% of surgeons. Similarly, moderate to high exposure to laparoscopic appendectomy was noted, with 44% performing 10–30 cases. Confidence in appendectomy was score 4–5 in 60% of participants.

Presence of senior assistance significantly reduced operative time for both index laparoscopic procedures: with assistance, the majority completed cholecystectomy in 1–2 hours, whereas without assistance, most required more than 2 hours, underscoring the critical role of mentorship during early skill acquisition.

Open hernia repair experience

All 25 surgeons had performed unilateral open hernia repair; 18 had bilateral experience and 10 had managed recurrent hernias. The majority (56%) had performed more than 50 open repairs. A clear reduction in operative time was observed compared to initial surgeries, and confidence was score 4–5 in 68% of participants, indicating a strong foundation in groin anatomy.

TAPP learning curve

Most surgeons were in the early-to-intermediate TAPP phase, with 56% having performed fewer than 10 cases. Operative time for unilateral TAPP improved markedly — cases requiring more than 6 hours decreased from 4 (initial) to 0 (current), while cases completed within 2 hours increased from 2 to 9. The most time-consuming step was peritoneal dissection (24%), followed by identification of anatomical landmarks (20%). These steps also most frequently required senior assistance (28% and 16%, respectively). Confidence was score 4–5 in 56% of surgeons.

TEP learning curve

The majority of surgeons were in the early TEP phase: 28% had performed fewer than 5 cases and 32% had performed 5–10. Only 16% had performed more than 15 cases.

Operative time reduction

The shift is striking: initially, 60% required more than 4 hours; currently, 84% complete the procedure within 4 hours, with 40% completing within 2 hours.

Table 2: Operative time reduction.

Time category	First TEP (N)	Current TEP (N)
<2 hours	1	10
2–4 hours	9	11
4–6 hours	10	4
>6 hours	5	0

Step-wise difficulty analysis

Creation of the Space of Bogros and Cooper's ligament dissection consistently emerged as the most demanding and mentor-dependent steps (Figure 1).

Mesh fixation

Tacker fixation was used in 48% of cases, suture in 36%, and no fixation in 16%. The majority (64%) completed fixation within 10–20 minutes.

Confidence in TEP

Score 4–5 was reported by 52% of surgeons, score 3 by 32%, and score 1–2 by 16%, reflecting ongoing skill development in most participants.

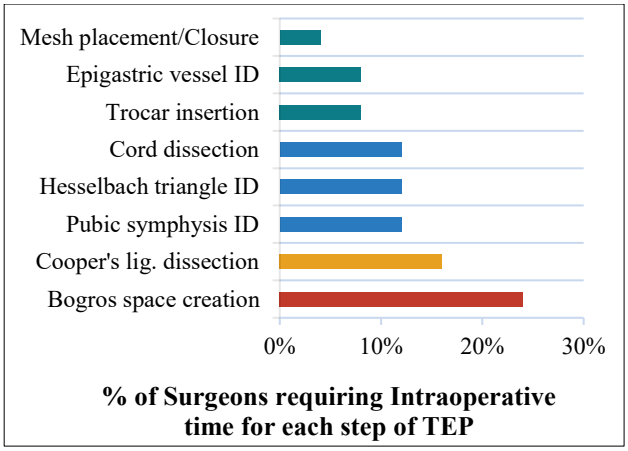

Figure 1: Step-wise difficulty analysis.

Analytical results: learning curve validation

A statistically significant association was found between number of TEP procedures performed and operative time improvement ($p = 0.003$). Among surgeons with more than 10 TEP cases, 9 of 10 showed improved operative time, compared with 6 of 15 surgeons with 10 or fewer cases (Table 3).

Table 3: Early versus late learning phase comparison.

Parameter	Early phase	Late phase	P value
Mean operative time (min)	142±28	78±18	<0.001
Senior assistance required	68%	22%	0.002
Mean confidence score	2.8±0.9	4.1±0.7	<0.001

All three primary parameters showed highly significant improvement from early to late phase, confirming a clear, measurable learning curve.

DISCUSSION

Interpretation of demographic profile and surgical experience

The cohort, predominantly aged 30–35 years (44%) with 1–3 years of laparoscopic experience (68%), represents an ideal baseline population for evaluating the learning curve of an advanced minimally invasive procedure. This demography reflects real-world surgical training programs where residents and young faculty transition from basic to complex procedures. Bittner et al emphasized that surgical learning curves are most accurately analysed during active residency or fellowship training phases, where skill acquisition is steepest.[12] Furthermore, Ferzli et al demonstrated that younger surgeons in formal academic environments show rapid initial proficiency progression when exposed to structured case volumes.[7]

Prior foundational experience in basic laparoscopic surgery (cholecystectomy and appendectomy) played a vital role in accelerating early TEP competence in our study. Basic laparoscopy establishes essential psychomotor skills, including instrument triangulation, dynamic depth perception, and non-dominant hand manipulation.[11] In our cohort, 84% had performed >20 laparoscopic cholecystectomies. This pre-existing baseline facilitated easier adaptation to TEP. Furthermore, 100% of participants had extensive open hernia repair experience (56% having performed >50 cases). Stoppa et al and Simons et al demonstrated that prior open preperitoneal hernia experience reduces intraoperative complications during early laparoscopic attempts, as intuitive anatomical orientation within the retropubic space relies heavily on prior open exposure.[13,14]

Operative time reduction and proficiency thresholds

Operative time serves as a primary surrogate marker for technical proficiency in laparoscopic surgery. In our study, mean operative time decreased significantly from 142±28 minutes in the early phase (≤10 cases) to 78±18 minutes in the late phase (>10 cases) ($p<0.001$). Initial cases were prolonged, with 60% requiring >4 hours and 20% exceeding 6 hours; however, in current practice, 84% were completed within 4 hours, and 40% within 2 hours.

These results directly mirror previous literature while highlighting the benefit of direct supervision. Lal et al evaluated TEP learning dynamics and reported a sharp drop in operative time after 30 cases, reaching a steady plateau between 30–50 cases.[15] Choi et al similarly reported that operative times stabilized only after 50–60 cases.[16] However, in our cohort, a statistically significant reduction in operative time was observed earlier, past the 10-case threshold ($p=0.003$). This faster curve aligns with observations by Lau et al who noted that in dedicated teaching hospitals with continuous senior supervision, the steep early phase of the learning curve can be significantly shortened.[17] While comprehensive mastery and low recurrence rates typically require 50–100 cases as recommended by the Hernia Surge Group guidelines, early technical fluency and operative safety are rapidly achieved within the first 10–15 mentored cases.[18]

Analysis of procedural difficulty and critical dissection steps

Evaluating procedural steps independently demonstrated that TEP difficulty is non-uniform. Creation of the Space of Bogros (24%) and dissection of Cooper's ligament (16%) were identified as the most time-consuming and assistance-demanding steps.

This parameter directly reflects the unique anatomical challenge of TEP: operating within a restricted, non-insufflated extraperitoneal space without standard intraperitoneal landmarks. Developing the space of Bogros requires delicate blunted dissection to avoid tearing the

flimsy underlying peritoneum or causing venous hemorrhage from the retropubic venous plexus (parieto-vesical fascia). Ferzli et al and Phillips et al similarly reported that peritoneal tears and loss of working space occurred predominantly during Space of Bogros creation and Cooper's ligament clearing in a surgeon's first 20 cases.[7,19] Conversely, mesh placement, unrolling, and fixation were completed quickly (within 10–20 minutes in 64% of cases), with only 4% requiring senior intervention. This indicates that once the preperitoneal space is dissected correctly, terminal steps are rapidly mastered.

Senior assistance and mentorship impact

The requirement for senior surgeon intraoperative assistance decreased dramatically from 68% in the early phase to 22% in the late phase (p=0.002). This reduction directly demonstrates the acquisition of technical autonomy.

Mentorship is a key modifier of surgical learning curves. Aggarwal et al demonstrated that unmentored learning curves are characterized by higher complication rates, prolonged operation times, and delayed proficiency stabilization.[11] In contrast, structured intraoperative mentorship allows senior surgeons to intervene specifically during high-risk steps (e.g., separating the hernia sac from cord structures or clearing Bogros space), preventing intraoperative complications such as peritoneal rupture or bleeding. As a result, trainees acquire confidence faster and transition to independent practice safely.

Evolution of surgeon confidence

Surgeon self-confidence, measured on a 5-point Likert scale, increased significantly from 2.8±0.9 in the early phase to 4.1±0.7 in the late phase (p<0.001). Subjective self-efficacy is a vital indicator of procedural familiarity. Ericsson et al highlighted that psychological comfort in high-stress surgical environments correlates strongly with objective motor skill refinement and reduced error rates.[20] In our cohort, the rise in confidence closely paralleled objective reductions in operative time and assistance requirements, validating confidence scores as reliable indicators of trainee progression.

Comparison with published international literature

Comparison with published international literature in given in Table 4.

Table 4: Comparison of present study parameters with existing literature.

Parameter	Present study	Published literature	Comparative interpretation
Initial operative time	142±28 min	120–160 min (Lal et al[15], Choi et al[16])	Consistent with reported initial operative times for novice TEP surgeons.
Proficient operative time	78±18 min	45–75 min (Lau et al[17], Belyansky et al[6])	Comparable operative efficiency achieved in the late learning phase.
Early proficiency threshold	>10 cases	30–50 cases (Lal et al[15], HerniaSurge[18])	Significant early performance gains observed sooner due to active intraoperative mentorship.
Most difficult procedural step	Space of Bogros creation and Cooper's dissection	Peritoneal space creation and sac dissection (Ferzli et al[7], Phillips et al[19])	Identical step-wise technical bottlenecks identified across extraperitoneal approaches.
Assistance reduction rate	68% to 22% (p=0.002)	70% to 15% (Aggarwal et al[11])	Reflects standard transition from supervised to autonomous performance.

Clinical implications for training programs

The findings from this study provide concrete guidelines for optimizing laparoscopic training curricula.

Step-targeted skill acquisition

Training modules, cadaver labs, and virtual reality simulators should specifically focus on extraperitoneal space creation (Space of Bogros) and parietalization of cord structures rather than basic mesh placement.

Structured autonomy milestones

The 10-case mark represents a critical transition threshold where trainees transition from direct step-by-step assistance to primary operator status with passive supervision.

Prerequisite experience

Mandatory thresholds of open hernia repairs and basic laparoscopic procedures should precede TEP training to provide necessary anatomical and motor foundations.

Limitations

This study has limitations. The prospective sample of 25 surgeons from a single tertiary care centre limits external generalizability and subgroup statistical power. Data on long-term outcomes, such as 1-year hernia recurrence rates and chronic groin pain (post-herniorrhaphy neuralgia), were not evaluated within the study timeframe.

Furthermore, potential confounding factors such as hernia complexity (e.g., large scrotal hernias, recurrent hernias, or post-radiation anatomy) were not stratified independently. Multicenter prospective studies with long-term follow-up are recommended to validate these findings.

CONCLUSION

TEP inguinal hernia repair is associated with a well-defined, statistically significant learning curve. In young laparoscopic surgeons working in a tertiary care teaching hospital, progressive improvement in operative time, reduction in senior assistance requirement, and increase in confidence are clearly demonstrable with increasing case exposure. Creation of the Space of Bogros and Cooper's ligament dissection represent the most challenging procedural steps requiring focused mentored training. Structured, competency-based training programs with adequate case volume and step-targeted supervision are essential to safely and efficiently navigate the TEP learning curve, ultimately improving surgical outcomes and patient safety.

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