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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Learning curve for unilateral endoscopic totally extraperitoneal (TEP) inguinal hernioplasty

H. Lau, N. G. Patil, W. K. Yuen, F. Lee

Department of Surgery, University of Hong Kong Medical Center, Tung Wah Hospital, 12 Po Yan Street, Sheung Wan, Hong Kong

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Abstract
Background: Performance of endoscopic totally extraperitoneal inguinal hernioplasty (TEP) requires specialized anatomical knowledge and surgical dexterity. The present study was undertaken to evaluate the learning curve for a general surgeon to master the technique of TEP in the absence of an experienced supervisor.
Methods: A retrospective analysis of the first 120 consecutive unilateral TEPs was performed. Medical records were reviewed to evaluate demographic features, perioperative outcome, and follow-up results. The study population was divided into six consecutive groups of 20 patients. Clinical data were compared among the groups to evaluate the impact of operative experience on perioperative outcome.
Results: Operative time was the only clinical parameter that showed significant improvement with experience; it reached a plateau value of < 1 h after the fourth group. Conversions to transabdominal and open approaches were required in only one patient in groups 1 and 6, respectively. Comparison of demographic features, hernia types, postoperative morbidity rates, length of hospital stay, and number of days to resume normal activities showed no significant differences among the groups. All complications were minor and resolved uneventfully. No recurrence was detected during follow-up.
Conclusions: The learning curve for unilateral TEP by a general surgeon peaked after performing 80 procedures. In most cases, unilateral TEP can be accomplished safely within 1 h. Even during the learning process, TEP carries a low morbidity and conversion rate.

Key words: Laparoscopy — Inguinal herniorrhaphy — Inguinal hernia — Hernia — Totally extraperitoneal hernioplasty — Learning curve

Endoscopic totally extraperitoneal inguinal hernioplasty (TEP) was first introduced by Ferzli et al. [4] and McKernan and Laws [9] in 1992. TEP has been gaining in popularity in recent years, but the acceptance and implementation of endoscopic hernioplasty by general surgeons has been slow compared to the adoption of laparoscopic cholecystectomy [2]. During both open and laparoscopic cholecystectomies, the operative field and surgical anatomy are identical. In contrast, the performance of endoscopic hernioplasty requires a novel perspective of the pelvic anatomy compared to conventional open repair of inguinal hernia. Furthermore, endoscopic hernioplasty frequently requires two-hand manipulation for the reduction of the hernial sac and for mesh placement within a limited working space. TEP therefore requires specialized anatomical knowledge and technical dexterity.

Few studies have been conducted to evaluate the learning curve for TEP [7]. The present study was undertaken to determine the learning curve for a general surgeon to master the technique of unilateral TEP at a university-affiliated hospital in the absence of supervision from an experienced laparoscopic hernia surgeon. The aim was to establish the number of operations required to stabilize the operative time and complication rate during the learning process.

Materials and methods

After attending a training course on laparoscopic hernioplasty with a hands-on animal workshop, one of us (H.L.) performed 14 transabdominal preperitoneal (TAPP) inguinal hernioplasties on 10 patients before switching his operative approach to TEP. Following the adoption of TEP, the surgeon performed this surgery regularly over a period of 10 months. A retrospective analysis of the first 120 consecutive patients who underwent unilateral TEP was then performed. The study population was divided into six chronologically consecutive

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Correspondence to: H. Lau

Table 1. Comparison of demographic features and hernia types among the six groups of patients

	I	II	III	IV	V	VI	*p* value
Age (mean ± SD)	68 ± 11.3	61 ± 13.1	65 ± 9.9	65 ± 13.5	55 ± 19.2	62 ± 12.4	ns[a]
Male:female	19:1	19:1	20:0	20:0	19:1	19:1	ns[b]
Hernia anatomy[c]							ns[b]
II	9	9	7	9	13	10	
IIIA	8	4	3	3	3	6	
IIIB	1	4	6	5	3	3	
IIIC	0	1	0	0	0	1	
IVA	1	0	2	2	0	0	
IVB	0	1	2	1	1	0	
IVC	0	1	0	0	0	0	
IVD	1	0	0	0	0	0	

[a] Student's *t*-test
[b] Chi-square test
[c] Nyhus classification [10]

groups, each comprising 20 patients. All the medical records were reviewed to document demographic features, hernia types, operative time, perioperative morbidity, postoperative pain scores, length of hospital stay, and number of days to resume normal activities. Clinical parameters and outcome data were compared among the groups.

Surgical technique

Patients were operated on a supine Trendelenburg position under general anesthesia. Urinary catheterization was not employed.

A transverse subumbilical incision was made to expose the anterior rectus sheath on the side of inguinal hernia. Division of the anterior rectus sheath exposed the rectus muscle, which was retracted laterally. A 10-mm blunt-end trocar was then inserted into the preperitoneal space and insufflated with carbon dioxide (CO_2) to a pressure of 10 mmHg. Another 10- or 13-mm reusable trocar port was placed over the midline ~8 cm from the pubis. Extraperitoneal space was dissected and created by endo-scissors with diathermy. Balloon dissection was not utilized.

A 5-mm reusable trocar was inserted at the anterior axillary line, 4 cm proximal to the ipsilateral anterior superior iliac spine. The hernial sac was then dissected and reduced. For direct inguinal hernia, the attenuated transversalis fascia was usually inverted and stapled to the rectus muscle. It was followed by parietalization of the spermatic cord for a distance of 4 cm. A Prolene mesh of 10 × 14 cm^2 (Ethicon., Somerville, NJ, USA) was introduced and anchored in place with an endo-stapler (Multifire Endo Hernia 0°; US Surgical Corporation, Norwalk, CT, USA). Operative time was recorded from skin incision until skin closure.

Postoperative assessment

Patients were allowed to resume normal diet and normal activities immediately after the operation. All patients were given oral propoxyphene 50 mg and paracetamol 325 mg 4 times daily upon request. Linear analogue pain scores on a scale from 0 to 10 at rest and on coughing were assessed daily. "Length of hospital stay" refers to the total number of nights spent in hospital after operation. Patients were followed up at our Hernia Clinic by the operating surgeon 1 week after discharge. All complications were recorded and any clinical recurrence was documented.

Statistical analysis

Comparisons of data among the six groups were performed by chi-square test and one-way analysis of variance (ANOVA) where appropriate. Statistical analysis was performed with the help of computer software (SPSS/PC+ 7.0; SPSS, Chicago, IL, USA). Values were expressed as mean ± standard deviation (SD). A *p* value of < 0.05 was regarded as significant.

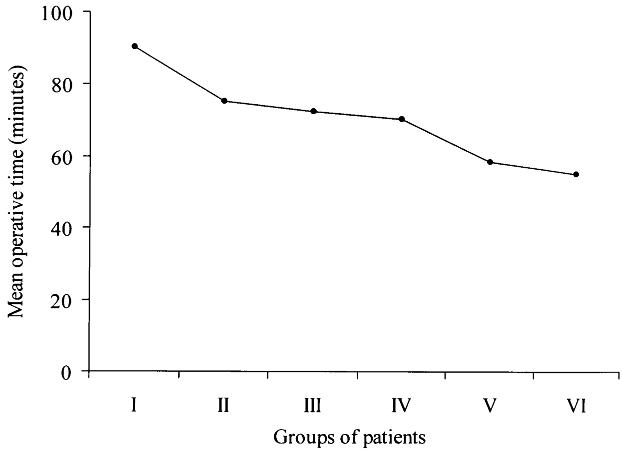

Fig. 1. Comparison of mean operative times among the six groups of patients ($p < 0.05$).

Results

The ages of the study population ranged from 22 to 84 years, with a mean age of 63 ± 13.9 (SD) years. There were 116 men and four women. The demographic features and types of hernia of the two groups were comparable among the six groups (Table 1). The numbers of primary direct and indirect inguinal hernias were 27 (22.5%) and 79 (66%), respectively. In addition, there were two femoral hernias and 12 recurrent hernias. Of the 12 recurrent inguinal hernias, all patients had undergone previous repair of the inguinal hernia once. Three patients were documented to have mesh hernioplasties; the rest were likely to have undergone sutured herniorrhaphies at other institutions. A total of 32 patients had undergone previous repair of inguinal hernia on the contralateral side.

Comparison of the mean operative times showed significant differences among the six groups of patients ($p < 0.05$) (Fig. 1). The mean operative time reached a plateau value of < 1 h after the surgeon had completed 80 procedures. Conversions to TAPP and open approaches were required in only one patient of groups 1 and 6, respectively, due to adhesions (n = 1) and a sliding inguinal hernia (n = 1). There were no visceral or vascular injuries.

Table 2. Comparison of postoperative morbidities among the six groups of patients

	I	II	III	IV	V	VI	*p* value[a]
Morbidity rate (%)	15	15	25	20	20	20	ns
Complications							
Wound bruising	3	0	2	0	1	0	
Groin collection	0	3	0	0	2	2	
Retention or urine	0	0	3	1	0	0	
Atelectasis	0	0	0	2	0	0	
Preperitoneal collection	0	0	0	0	0	1	
Skin blisters	0	0	0	0	0	1	
Gouty arthritis	0	0	0	0	1	0	
Inguinoscrotal hematoma	0	0	0	1	0	0	

ns, not significant
[a] Chi-square test

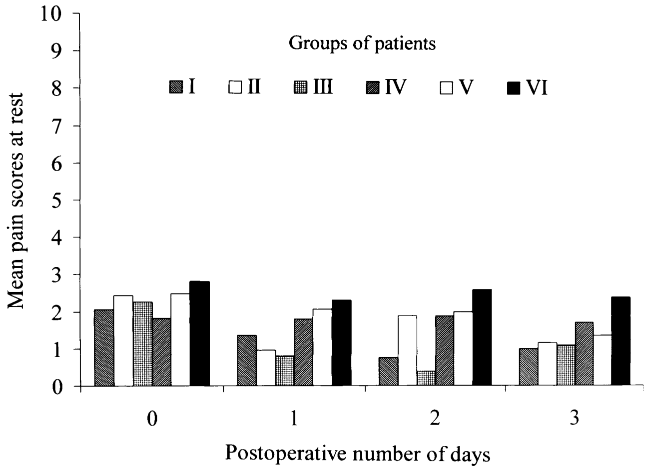

Fig. 2. Comparison of daily postoperative pain scores at rest among the six groups of patients.

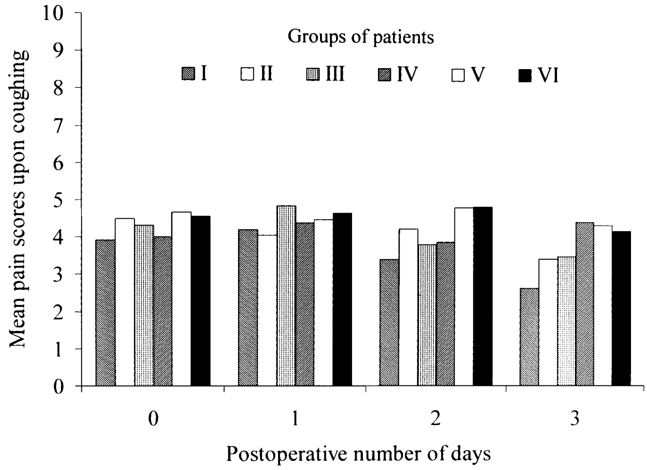

Fig. 3. Comparison of daily postoperative pain scores on coughing among the six groups of patients (p = ns).

The overall postoperative morbidity rate was 19.2% (n = 23). All complications were minor and resolved without intervention. Table 2 compares the postoperative morbidities among the six groups of patients. The morbidity rates showed no significant improvement with increasing experience, but a gradual reduction in the incidence of wound bruising was observed. Of the six patients who developed bruising, two developed extensive ecchymosis over the ipsilateral flank of the abdomen after discharge from the hospital. Computed tomography (CT) scan of the abdomen was performed on one patient and showed no evidence of hematoma formation. Both incidences were probably secondary to bleeding from injured vessels upon the insertion of the lateral trocar port. Asymptomatic groin collection occurred in seven patients; all resolved without aspiration.

A comparison of postoperative pain scores at rest showed no significant differences among the six groups on postoperative days 0 and 3 (Fig. 2). Pain scores upon coughing during the whole postoperative period were comparable among the six groups (Fig. 3).

The overall mean length of hospital stay was 2 ± 1.5 days. Patients resumed normal activities in 3.8 ± 2.2 days. Comparison of these two outcome measures among the six groups showed no significant differences (Fig. 4, Fig. 5). Length of follow-up ranged from 1 week to 2 years, with a mean follow-up of 3 months. No recurrence was detected up to the date of review.

Discussion

The learning curve has been defined as the number of operations required for the stabilization of operating times and complication rates [14]. Our study demonstrated that the mean operative time of unilateral TEPs reached a plateau value of < 1 h after an experience of 80 procedures. The morbidity rates remained fairly constant during and after the learning process. Similar findings were also reported by Aeberhard et al. [1], who demonstrated a significant association between operative time and operator experience. In that study, which included > 1000 patients, the operative time dropped significantly to < 1 h after an experience of 100 repairs. Voitk [14] reported that the learning curve for TAPP hernioplasty for a general surgeon in community practice was ≥50 operations. Because TEP is technically more demanding than TAPP, a steeper learning curve was therefore anticipated.

Liem et al. [7] examined the learning experience of four surgeons, each with 30 consecutive TEPs. Although a significant reduction in operating time was observed

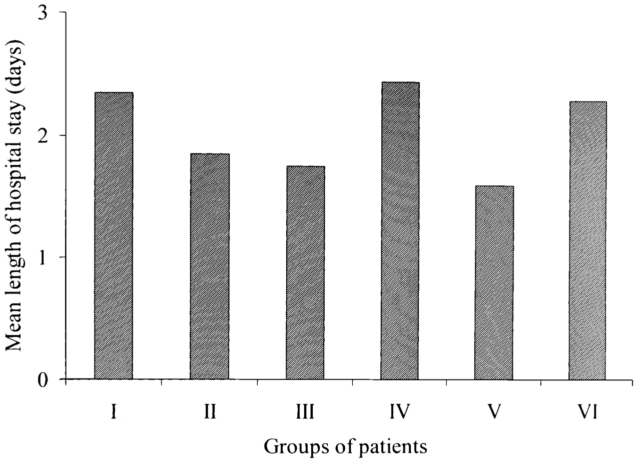

Fig. 4. Comparison of the mean length of hospital stay among the six groups of patients (p = ns).

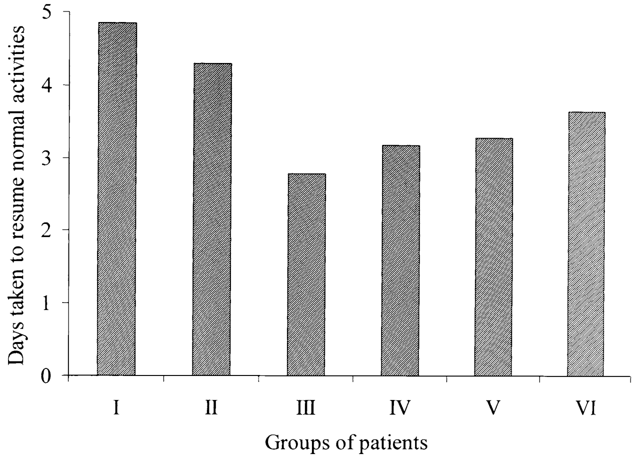

Fig. 5. Comparison of days to resume normal activities among the six groups of patients (p = ns).

with increasing experience, high conversion and recurrence rates were reported in their study. Above all, no conclusion was drawn on the exact length of the learning curve for TEP. Perceived pressure by the surgeons to complete the procedures expediently might have led to the high conversion rate. It is also possible that poor judgment or technical errors led to early recurrence of hernia [12]. In our experience, conversion of TEP to other approaches was, in fact, uncommon. Shorter operative times should not be obtained at the expense of patient safety and optimal outcome. We believe that an experience of 30 procedures would be inadequate for most surgeons to reach the peak of the learning curve of TEP. Factors that may influence the learning curve include the surgeon's experience with laparoscopic procedures, a sound knowledge of the pelvic anatomy, and the ability to use a two-handed technique [3]. Previous experience of TAPP may also facilitate the transition to TEP.

No serious morbidity was observed in the present series. Appropriate patient selection for TEP cannot be overemphasized. Patients who had previous lower midline surgeries or irreducible inguinal hernias were excluded from this TEP series since most visceral injuries have been reported to occur in this cohort [5]. To reduce the risk of visceral and vascular injuries during the procedures, all trocars were placed by open dissection and the railroad technique [6]. No sharp instruments were used during the procedures.

No early recurrence was documented in the present study, but the long-term outcome remains to be established. Recurrence after TEP has been attributed to inadequate dissection of extraperitoneal space, insufficient mesh size, insufficient prosthesis overlap of the defect, improper fixation, and folding of the prosthesis [8, 11, 13]. An undersized mesh patch has been reported as the most common reason for recurrence. Our preferred dimensions for the Prolene mesh are 10×14 cm^2 because this size fits the preperitoneal space exactly in the majority of our patients. To ensure full deployment of the mesh, lateral extraperitoneal space should be dissected beyond the ipsilateral anterior superior iliac spine and the cord structures should be parietalized for a distance of 4 cm. Anchoring the mesh in place by stapling can help to prevent migration or invagination of the mesh into a large direct hernial defect. During deflation of the extraperitoneal space, it is important to ascertain that the returned peritoneum does not displace or fold the inferior edge of the mesh. The success of endoscopic hernioplasty depends on the adequate overlap of all edges of the musculo-aponeurotic defect by the mesh.

In summary, the learning curve doing unilateral endoscopic TEP inguinal hernioplasty peaked for a general surgeon after 80 procedures. TEP carried a low morbidity and conversion rate even during the learning process. Based on our results, we conclude that most unilateral TEPs can be accomplished within 1 h after a surgeon has attained sufficient proficiency in surgical skills and knowledge.

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