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Original Research

Total laparoscopic hysterectomy: Analysis of the surgical learning curve in benign conditions

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HIGHLIGHTS

- Hysterectomy is the most common gynaecological surgery around the world.
- The learning curve for laparoscopic hysterectomy is necessary for guiding the implementation of this surgery in the education of gynaecologists.
- Education and training reduce complications.
- The learning curve is correlated with a decrease in operating time for total laparoscopic hysterectomy.

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ABSTRACT

Objective: To assess the learning curve for total laparoscopic hysterectomy.
Methods: This study was a retrospective analysis of the learning curve for two surgeons during their first 257 consecutive cases of total laparoscopic hysterectomy at a teaching hospital. Patients were divided sequentially into groups comprising the first 75 patients, the next 75, and the final 107 patients. Age, body mass index, gestational parity, indications for laparoscopic hysterectomy, previous pelvic surgery, operating time, haemoglobin decline, complications, need for transfusion, and length of hospital stay were evaluated.
Results: The mean operating time for total laparoscopic hysterectomy reduced significantly from 76.2 min to 68.9 min ($p = 0.001$) between the first and second 75-patient groups. Linear regression analysis showed a plateau was reached on the learning curve after 71–80 cases. The rate of all complications started at 8% in the first group of 75 patients, reduced to 6.7% in the next group, and decreased further in the final group to 4.7%. The decline was not statistically significant ($p = 0.6$).
The difference in the need for transfusion was statistically significant between the first 75 patients and the second group of 75 ($p = 0.04$). Conversion from laparoscopy to laparotomy was required in five patients, four in the early group and one in the final group. Age, body mass index, parity, previous pelvic surgery, decline in haemoglobin, and length of hospital stay were similar among the three groups.
Conclusions: A plateau in the learning curve for TLH was reached after the first 75 cases. We can infer that there is a learning curve for TLH as confirmed by the decrease in operating time (accompanied by no change in complications) correlated to gain in experience. On the other hand, one should not disregard the fact that laparoscopy is not a complication-free surgery and achievement of the learning curve does not exclude complications. Gynaecological surgeons can perform TLH securely during the learning curve.

1. Introduction

Hysterectomy is the most common gynaecological surgery around the world, especially for benign conditions such as

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menorrhagia, fibroids, pelvic pain and uterine prolapse [1,2]. The surgical approach includes abdominal, vaginal or laparoscopic routes. The first laparoscopic hysterectomy (LH) was performed in 1989 by Reich et al. [3]. In subsequent years, the first series of laparoscopy-assisted vaginal hysterectomies (LAVH) and laparoscopic subtotal hysterectomies (LASH) were described by Mage et al. [4], Donnez and Nisolle [5], and Lyons [6]. Laparoscopy has several important advantages compared to laparotomy, including less pain, shorter hospitalisation, faster recovery time and fewer infections [7]. The magnification provided by laparoscopic instruments enables easy access to the uterine vessels, ureter, rectum and vagina [8]. During the past 30 years, laparoscopy has advanced rapidly, following improvements in video camera and electrical surgery technology. Conventional laparoscopy, with three or four small incisions, has become the gold standard for many gynaecological diseases, from benign conditions to endometrial cancer [9,10]. Recently, total laparoscopic hysterectomy (TLH) has received wider acceptance in Turkey, as the surgeons have gained experience.

Injury to the urinary tract remains the primary concern in TLH. Johnson et al. [11] showed the rate of urinary tract injuries was higher in LH than it was during abdominal-incision hysterectomy (AH), in a 2006 meta-analysis that covered 3643 patients in 27 trials, but found no significant difference in the rate of the injury when LH was compared to vaginal hysterectomy (VH). The meta-analysis concluded that VH was preferable to AH, and suggested LH as an alternative when VH was not possible, for example, in cases of enlarged uterus or narrow pelvic arch. Garry et al. [12] encountered ureter and bladder damage as high as 11.1% during LH. However, other researchers reported that LH was not associated with high rates of major complications, especially in experienced hands [7,8,13,14].

Education and training reduce complications. Studies have pointed out the importance of the learning curve for LH [15–17]. Generally, the handling of a particular number of cases is accepted as indicating that a surgeon is competent in pelvic laparoscopic procedures. The threshold number may be influenced by the previous education of the surgeon or local factors, such as medico-legal issues and the cost of the operations. The pattern and slope of the learning curve may vary by country and institution.

Defining the learning curve for LH is necessary for guiding the implementation of this surgery in the standard education of gynaecologists. For that purpose, we analysed our learning of TLH. Our primary purpose was to determine the number of cases that would express a surgeon's proficiency in TLH. The secondary aim was to investigate the parameters (e.g., operation time and complications) of consecutive cases and compare them against the increasing experience of the surgeon.

2. Materials and methods

This was a retrospective review of demographic data, operating times and complications from TLH for 257 patients between December 2011 and April 2014 at the Derince Training and Research Hospital in Kocaeli, Turkey.

2.1. Patients

The informed consent of patients was obtained.

We retrieved clinical charts, pathology reports, preoperative history, and physical examination findings from the hospital's electronic medical records. Patient demographic data included age, gravidity, gestational parity, body mass index (weight in kilograms divided by the square of the height in meters), type of delivery, and previous pelvic surgeries. Perioperative information included indications for surgery (myoma uteri, abnormal uterine bleeding refractory to treatment, adnexal mass, chronic pelvic pain or abnormal cervical cytology), type of procedure, conversion to laparotomy, total operating time, uterine weight, estimated blood loss, duration of hospital stay and immediate intraoperative and postoperative complications, such as bowel, bladder, or ureter injury and blood transfusion, port site infection, bleeding or hernia. Total operating time began with the first skin incision and ended with the last closure of an incision. The duration of hospital stay was measured from admission to discharge.

2.2. Surgical technique

The two surgeons (A.K. and H.T.) had not received fellowship training and were not previously experienced with TLH, but had previously performed level-two laparoscopic procedures, for example, ectopic pregnancy and cystectomy [18]. The operating room staff had five to six years of experience with laparoscopy, but were new to gynaecological laparoscopic surgery.

All patients received standard prophylactic cephalosporin. General anaesthesia was administered via endotracheal intubation.

The patients were placed in a modified lithotomy position with the hips extended at 180° and the knees flexed at nearly 90°. The table was tilted nearly 45° in the Trendelenburg position. Both of the arms were tucked along the patient's side. The surgeon was located at the left side of the patient and the assistant was positioned on the opposite side.

A 10 mm trocar was inserted through the umbilicus. Pneumoperitoneum was generated until the intra-abdominal pressure was 14 mmHg. Three additional 5 mm ports were inserted. One of these was placed 5 cm left of the umbilicus, and the other two were placed 2 cm medial and superior to the anterior superior iliac crests. If the uterus was larger than the size of 21 cm in any direction, the Lee Huang point (3 cm above the umbilicus) was used for the trocar and the optic camera port [19].

A RUMI© uterine manipulator with a Koh Cup™ colpotomizer (Cooper Surgical; Trumbull, Connecticut, US) was introduced vaginally at the beginning of the procedure. The hysterectomy was performed using a Ligasure™ Blunt Tip grasping and dissection instrument (Covidien; Dublin, Ireland) and monopolar and bipolar energy modalities. All vascular pedicles were ligated by bipolar coagulation and sectioned with the scissors or were ligated and cut by using the Ligasure™. A circular vaginal incision was performed with monopolar coagulation.

The uterus was removed from the abdomen through the vaginal cuff. If uterine morcellation was necessary, it was carried out vaginally by circular wedge resection with a scalpel. The vaginal apex was closed intracorporeally with interrupted single stitches, using absorbable suture (VICRYL® suture #1 [JK-10]; Ethicon). We did not perform routine cystoscopy. The weight of the uterus without ovaries was measured in the operating room, and then the specimen was sent for pathological investigation.

2.3. Calculation of the learning curve and statistical analysis

Patients were divided sequentially into three groups. Group 1 comprised the first 75 patients. Group 2 included the subsequent 75 patients, and Group 3 included the following 107 patients, who we called 'others'.

The average operating time was determined for each group. Outcome measures, such as estimated blood loss, postoperative hospital stay and conversion to laparotomy were recorded and evaluated for statistical significance.

Student's t-test was used for continuous data, and a p value of less than 0.05 was considered statistically significant. Continuous data were expressed as means ± standard deviation.

3. Results

Among the 257 patients, 74 (28,7%) had a history of abdominopelvic surgery. An additional 41 (15,9%) had a previous caesarean section.

Mean patient age across all groups was 48.9 years (min 37; max 70). Mean BMI was 28.1 ± 4.7 kg/m2. Mean uterine weight was 378.4 ± 194.8 g (min 145; max 1740). The average gestational parity was 3.3 ± 0.1 pregnancies.

The most frequent indication for surgery was abnormal uterine bleeding, followed by myoma uteri (Table 1).

Laparoscopic operations were completed successfully for 252 patients. For five patients, conversion to laparotomy was needed. The reasons for conversion were bleeding (three cases), a large pelvic mass (one case), and a large uterine myoma (one case). Four of the laparotomies were in the early group of surgeries, and one laparotomy was in the last group.

We have evaluated the duration of surgery among cases. We have observed a distinct decrease in operation time somewhere between 50th and 100th cases (Fig. 1). The linear regression analysis for the duration of operation in first 100 cases demonstrated a trend of decreasing, $p < 0.05$ (Fig. 2). Therefore, we have evaluated the first 100 cases ten by ten. With this approach we have located the point of significant change in the shortening of the operation time in series of cases 71–80 (Fig. 3). The average operation time was 73 min for cases 61–70, then 66 min for cases 71–80, and 62 min for cases 81–90 ($p < 0.05$). The average operation time was steady after the cases 71–80, indicating that a learning curve plateau in terms of operation time was reached after this point and continues through the rest of the cases. According to this finding, we divided the cases in mainly 3 groups; first 75 cases, second 75 cases, and the rest. The rest of the cases comprised 107 patients.

There was no difference between the groups in age, BMI, parity, previous pelvic surgery, decline in haemoglobin level, complications, or length of hospital stay (Table 2). The operative results, including the mean operation time and need for transfusion, are shown in Table 2. Between Group 1 and Group 2, the decline in operation time and need for transfusion was statistically significant ($p = 0.001$ and 0.04, respectively).

The total complication rate was 6.2%. Complications were classified as major (3.1%) and minor (3.1%). Major complications were bowel injury (2 cases), bladder injury (2 cases), port site hernia (one case), ureter injury (one case), ureterovaginal fistula (one case), and vesicovaginal fistula (one case). Minor complications were subileus (2 cases), port site infection (3 cases) and port site bleeding (3 cases). The rate of 'any complications' was found to be 8% ($n = 6$), 6.7% ($n = 5$), 4.7% ($n = 5$) in the first 75 cases, second 75 cases, and the rest, respectively ($p = 0.6$). We have also listed the major complications as follows; bowel injuries (case 12 and 199), bladder injuries (case 17 and 87), port site herniation (case 209), vesicovaginal fistula (case 111), ureterovaginal fistula (case 31), and ureteric injury (case 91). These complications indicated that achievement of the learning curve does not exclude complications. However, the total weight of the uterus was found to be increased throughout the cases; 318 g vs. 414 g in group 1 and group 3, respectively ($p < 0.05$) indicating the complexity of the cases increased throughout the time in our series.

For further analysis, the original three groups of patients were re-divided into five sequential blocks of 50 patients (the last group held 57 patients). The decline in operation time compared to the surgeons' increasing experience is shown in Fig. 1. The average operation time was 78 min in the earliest group, then 68 min in the second group. The difference was significant ($p < 0.05$).

4. Discussion

Laparoscopic surgery has several important advantages over laparotomy, and has become a mainstay of gynaecological surgery during the past 30 years [7,8]. Rapid technological innovations have allowed conventional laparoscopy, with three or four small incisions, to be supplanted by single-port surgery and robotic surgery. Initially, laparoscopic surgery was performed for minor gynaecological procedures, such as tubal ligation. Now, it is used for many benign and malignant uterine conditions [9,10].

Several reports have shown that, for most patients, TLH was safe and effective, with a low rate of complications [7,14,16]. Donnez et al. [8] studied 3190 laparoscopic hysterectomies in 2008, and observed the rates of major complications for LAVH and TLH as 0.37% and 0.52%, respectively. Karaman et al. [14] examined 1120 patients who underwent LH and LAVH, and found the overall major complication rate was 1%. Kim et al. [7] compared 936 cases of AH, single-port TLH, and multi-port TLH; the complication rates were 2.5%, 5.5% and 0.7%, respectively.

These studies were in line with the current study, where the total rate of complications was 6.2% and the rate of major complications was 3.1%, but contrasted with the 11.1% complication rate found in the Garry et al. [12] study mentioned in the introduction. Donnes et al. [20] reviewed the Garry et al. [12] study, and determined that the proficiency of the 43 gynaecologists varied from centre to centre, and the inexperience of some of the gynaecologists was not considered. Therefore, Donnes et al. [20] asserted that the method in the Garry et al. [12] study created a bias.

For laparoscopic surgery to be advantageous, the surgeon must be proficient. Every surgeon follows a learning curve, which refers to the relationship between operating time and patient outcomes, including surgical complications. In the literature, a decrease in mean operating time and perioperative complications has been used most frequently to evaluate the learning curve [21–25]. Twijnstra et al. [26] investigated whether a mentorship program was effective for implementing a new surgical procedure at a

Table 1
Indications for TLH.

	Group 1 (first 75 cases), n(%)	Group 2 (second 75 cases), n(%)	Group 3 (the others), n(%)	Total, n(%)
AUB	43 (57.3)	17 (22.7)	29 (27.1)	89 (34.6)
Myoma uteri	9 (12)	20 (26.7)	36 (33.6)	65 (25.3)
AUB + myomauteri	12 (16)	13 (17.3)	23 (21.5)	48 (18.7)
PMB	4 (5.3)	9 (12)	3 (2.8)	16 (6.2)
EH	1 (1.3)	7 (9.3)	8 (7.5)	16 (6.2)
Pelvic mass	1 (1.3)	6 (8)	6 (5.6)	13 (5.1)
Prolpsus uteri	2 (2.7)	1 (1.3)	1 (0.9)	4 (1.6)

Data was presented as n (%), AUB = Abnormal uterine bleeding, PMB = postmenapozal bleeding, EH = endometrial hyperplasia.

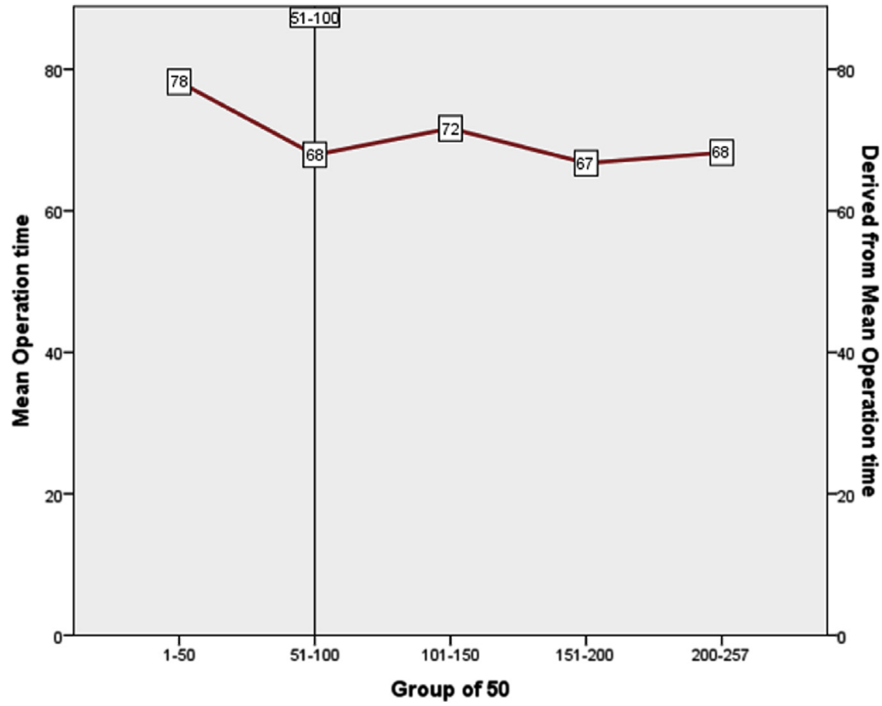

Fig. 1. The relationship between the total operation time and increasing experience (50-point zones in case).

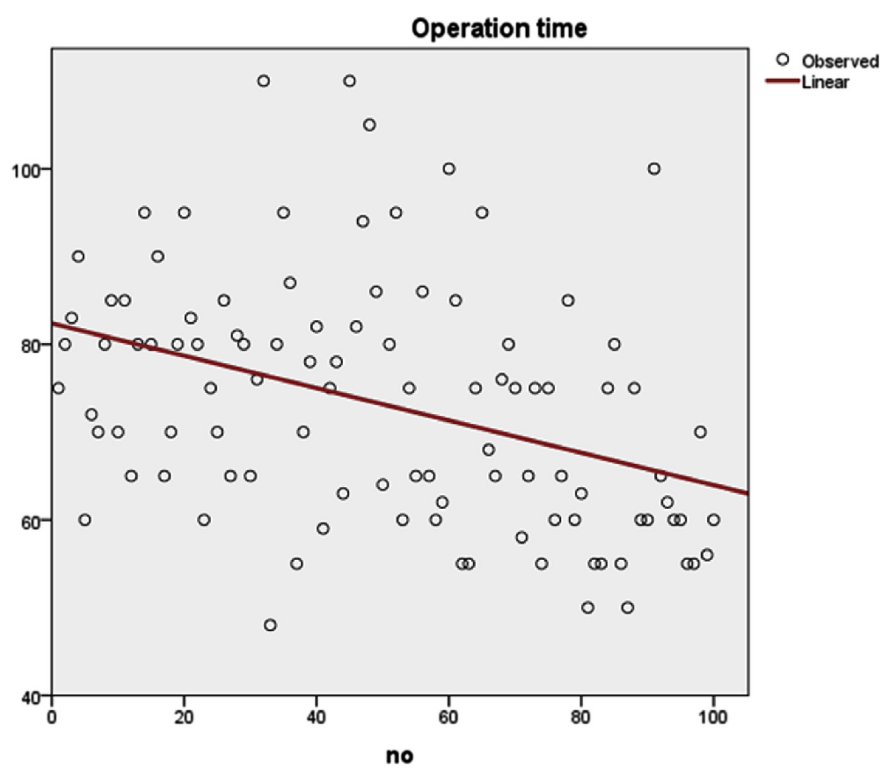

Fig. 2. The linear regression analysis for the duration of operation in first 100 cases ($p < 0.05$).

teaching hospital. They concluded that 22–25 LHs are needed to reach a plateau in the learning curve. The evaluate study performed by Garry at al [12]. suggested that surgeons need to perform 25 cases to complete the learning curve.

In our analysis, the learning curve was measured by a reduction in operating time. The most significant reduction was detected between cases 50–100. The operation time did not decrease after this group. Therefore, we performed linear regression analysis of the first 100 cases, to show the relationship between the duration of the operation and the estimated curve. According to this analysis,

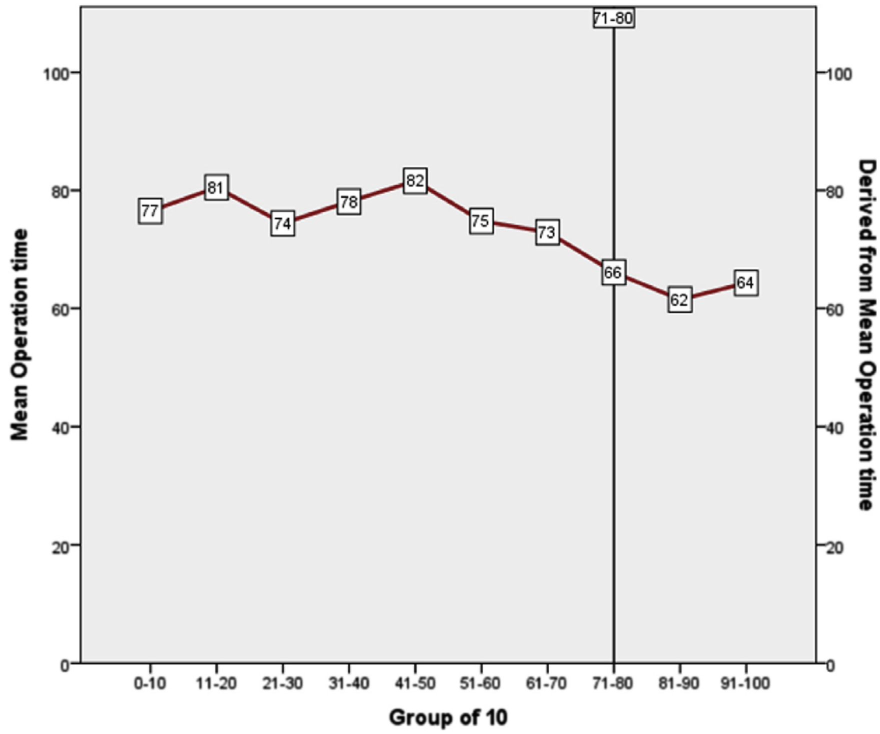

Fig. 3. The linear regression analysis for the duration of operation in first 100 cases (10-point zones in case).

Table 2
The demographic and operation features of patients.

	Total	Group 1 (first 75 cases)	Group 2 (second 75 cases)	Group 3 (the others)	*p value*
Age (year)	48.9 ± 5.9	48.4 ± 5.5	50.1 ± 6.9	48.3 ± 5.3	0.1
Body mass index	28.1 ± 4.7	27.6 ± 4.5	28.0 ± 4.4	28.5 ± 5.1	0.3
Parity	3.3 ± 0.1	3.3 ± 0.2	3.4 ± (0.2	3.1 ± 0.1	0.6
Previous pelvic surgery, n (%)	74 (%28.7)	18 (% 7.0)	26 (% 10.1)	30 (% 11.6)	0.3
Operation time (minute)	70.4 ± 15.4	76.2 ± 13.3	68.9 ± 14.5	67.5 ± 16.5	**0.001**
Decline in hemoglobin (g/dl)	1.2 ± 0.8	1.3 ± 0.8	1.1 ± 0.7	1.2 ± 0.8	0.2
Stay in hospital (day)	3.4 ± 1.2	3.2 ± 1.2	3.4 ± 1.3	3.4 ± 1.2	0.3
Complication, n(%)	16 (% 6.2)	6 (%8)	5 (%6.7))	5 (%4.7)	0.6
Need for transfusion, n(%)	11 (%4.3)	7 (%9.3)	2 (%2.7)	2 (%1.9)	**0.04**

Data are presented as number, mean ± standard deviation or n (%).

the most significant shortening of operating time and the plateau on the learning curve occurred during cases 71–80. In other words, the significant reduction in operation time in this study was achieved after the first 75 cases with seem to be an important parameter for other junior surgeons.

Our learning curve cut-off values did not match previous studies, possibly because we included patients with factors that affected the difficulty of the surgery, such as high BMI, large uterine size, and previous pelvic surgery. Another possible explanation might be that we were not in a mentorship program.

However, in a prospective study [27] that showed similar results to ours, the surgeon carried out 156 laparoscopic hysterectomies under the direct control of an overseer. At the end of the training period, the complication rate for TLH was 1.59%.

In our study, the total complication rates in Groups 1, 2 and 3 were 8%, 6.7% and 4.7%, respectively, but the decrease was not statistically significant. Howbeit, we also observed that the total weight of the uterus was increased throughout the cases. This indicated that the complexity and the difficulty of the cases increased through time in this study. Others found a significant decrease in the complications of LH as the learning curve was acquired [13,21,28]. These complications directed us to discuss that achievement of the learning curve does not exclude complications. Our results were likely related to the increasing complexity of the cases as much as to the growing number of cases. Early in training, minor complications were encountered, but during the later cases, we began to encounter major complications in more difficult cases. Therefore, we speculate that the complication rate after the achievement of learning curve is related with the complexity of the cases and we predict that if the surgeon operates more difficult cases, he/she would have to deal with new complications. Moreover, this kind of patient selection may result in a plateau for the decreasing complication rates. However, further unbiased prospective studies are needed to understand how this affects the morbidity and mortality of the cases.

Jones [28] analysed the complications of LHs performed by a single surgeon, by comparing the first 250 cases with the second 250. In that study, complications decreased from 9.5% to 4.3% after 200 cases. The high second number was explained by the undertaking of more difficult procedures. Wattiez et al. [21] compared the rates of complications in 1647 TLHs performed for benign pathology among 695 women, between the years 1989–1995, and a second group of 952 women, between the years 1996–1999. The rate of major complications declined significantly, from 5.6% to 1.3%, respectively. Although the complication rate did not decrease significantly in our study, it started low, and ended at 3.1%. These results seem consistent with previous studies and plainly show that TLH can be securely performed by experienced hands during the learning period for the technique.

In the literature, the rates varied for conversion from laparoscopy to laparotomy, from 6.6% to 0.03% [8,16,17,29]. Conversion to laparotomy generally occurred more frequently in the early learning phase [29], but in the Garrett et al. [16] study, six of eight patients whose surgery was changed to laparotomy were handled by surgeons who had completed the learning curve. The complications were not related to laparoscopy, but rather, for example, to advanced disease and broad adhesions. Our rate of conversion to laparotomy was 1.9% (n = 5) and resulted from bleeding (n = 3), large pelvic mass (n = 1), and large fibroid (n = 1). In the cases of the large pelvic mass and the large fibroid, laparotomy was performed due to insufficient space for movement of the laparoscopic instruments, even with entry through the Lee Huang point. These results matched earlier studies.

The inadequacy of surgical instruments is a possible factor affecting the learning curve. However, our study did not address the adequacy of the surgical instruments. During two cases, we observed it as the most violent. It would be useful to examine this factor in future studies.

There were some limitations to our study. The major limitation of our study was the retrospective design. The other limitation was that all procedures were performed by the same two surgeons at one institution. Their experience may not be reproducible by other surgeons. Therefore, the external validity of this study may be limited. Surgeon proficiency is an unsolved bias in similar studies.

5. Conclusions

We documented that the first 75 cases have an important value in the learning curve of TLH. A plateau in the learning curve for TLH was reached after this point. We can infer that there is a learning curve for TLH as confirmed by the decrease in operating time (accompanied by no change in complications) correlated to gain in experience. On the other hand, TLH is not a complication-free surgery and achievement of the learning curve does not exclude complications. The complications encountered after the initial period of experience may be related with the complexity of the cases as much as to the growing number of cases. Therefore, a surgeon experienced on TLH is not the one without any complications but is the one who is able to recognize and manage these complications timely. TLH can be performed securely during the learning curve by gynaecological surgeons equipped with basic skills in endoscopic surgery.

Conflicts of interest

Authors declare that there is no financial support or relationships that may pose potential conflict of interest.

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Ethical approval

Ethical approval was not obtained since it was a retrospective observational study. All patients gave informed written consent to the study conforming to the Declaration of Helsinki.

Author contribution

Hasan Terzi: Study design, concept, data collection, analysis and interpretation of data.

Alper Biler: Study design, concept, analysis and interpretation of data, writing, corresponding author.

Omer Demirtas: Data collection, data analysis, writing.

Omer Tolga Guler: Data analysis, statistical analysis.

Nuri Peker: Study design, concept.

Ahmet Kale: Revised article critically.

Guarantor

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