VIA MEDICA

ORIGINAL PAPER / GYNECOLOGY

Ginekologia Polska
2023, vol. 94, no. 8, 587–592
Copyright © 2023 PTGiP
ISSN 0017–0011, e-ISSN 2543–6767

DOI 10.5603/GP.a2022.0041

Learning curve analysis of single-site incision laparoscopic adnexal surgery performed by a single surgeon

Sang Wook Yi

Department of Obstetrics and Gynecology, Gangneung Asan Hospital, University of Ulsan College of Medicine, Republic of Korea

ABSTRACT

Objectives: Due to the development of laparoscopy techniques, single-site incision laparoscopic surgery (SILS) has recently been performed at many institutes using only a single-incision transumbilical port. We aimed to carry out a learning curve analysis for SILS for adnexal surgery and validate the short-term surgical outcomes.

Material and methods: In total, 214 patients were enrolled in this study. The medical records of patients who underwent SILS for adnexal surgery by an expert surgeon from October 2008 to September 2018 were reviewed and analyzed.

Results: The mean age and parity were 33.9 ± 11.5 years and 1.0 ± 1.1, respectively. The mean operation duration was 77.5 ± 22.3 min. In the analysis of the learning curve for single-site incision laparoscopic adnexal surgery, surgical proficiency was defined as the point at which the slope of the learning curve became less steep, which was evident after the 24th operation. No operative complications, conversions to laparotomy or additional trocar insertions were observed.

Conclusions: Single-site incision laparoscopic surgery (SILS) for adnexal surgery is a safe technique and does not increase the risk of peri- or postoperative complications. For safe performance of SILS, a certain training period for learning the technique should be required.

Key words: adnexa; learning curve; operative outcomes; operation duration; single-site incision laparoscopic surgery

Ginekologia Polska 2023; 94, 8: 587–592

INTRODUCTION

Laparoscopy is a minimally invasive surgical technique resulting in a short recovery time and a quick return to daily life. Generally, laparoscopy is a less invasive technique than laparotomy because there is less postoperative scarring, and the recovery time is shorter. Because the abdominal wound scars that develop after laparoscopy are smaller than those that develop after laparotomy, laparoscopy has been proven to be cosmetically effective.

Recently, due to the increasing interest in minimally invasive surgery, single-site incision laparoscopic surgery (SILS) has been performed at many institutes using only a single-incision transumbilical port. Compared with conventional laparoscopy (CL) using multiple trocar sites, SILS may be more cosmetically effective because only one incision through the umbilicus is required. However, some authors have reported that the postoperative incidence of umbilical hernia is higher, and that the operation time is longer with SILS than with CL.

Objectives

We aimed to carry out a learning curve analysis for SILS for adnexal surgery and validate the short-term surgical outcomes. Single-site incision laparoscopic surgery (SILS) is usually performed by a surgeon with experience in conventional laparoscopy. Due to some difficulties in the performance of SILS, the performance of a surgeon who is a beginner with this technique is limited. Therefore, in our hospital, SILS for adnexal surgery was carried out by an expert gynecologist who performed conventional gynecological laparoscopy more than 1,000 times over the last 20 years. This was a retrospective review of the medical records of patients who underwent SILS for adnexal surgery in a university teaching hospital over a period of 10 years from October 2008 to

Corresponding author:
Sang Wook Yi
Department of Obstetrics and Gynecology, Gangneung Asan Hospital, University of Ulsan College of Medicine, 38, Bangdong-gil, Sacheon-myeon, Gangneung-si, Gangwon-do, 25440 Gangneung Republic of Korea
e-mail: buzzmi@chol.com

Received: 7.07.2021 Accepted: 18.09.2021 Early publication date: 3.06.2022

September 2018. The learning curve of SILS for adnexal surgery was analyzed, and postoperative surgical outcomes and peri- and postoperative surgical complications were explored. The learning curve of SILS for adnexal surgery is the suggested actual learning curve for SILS for adnexal surgery even though the learning curve does not represent a beginner performing the surgery.

MATERIAL AND METHODS

Between October 2008 and September 2018, SILS for adnexal surgery was performed in 214 patients in a university teaching hospital. The surgeries were performed by an expert gynecologist who had performed gynecological surgeries, including CL, for more than 20 years.

The Institutional Review Board reviewed and approved this study. This retrospective cohort study was performed via a review of the medical records and radiological findings of patients who underwent SILS for adnexal surgery at a teaching hospital between October 2008 and September 2018, which reflects the first 10 years after SILS was introduced. During the study period, 214 patients underwent SILS for adnexal surgery. All the patients were enrolled in this study, and no patients were excluded due to performance failure. In our institution, SILS was not attempted for patients with predicted severe adhesion, inflammation or malignancy as CL was not attempted. Therefore, there were no cases of conversions to laparotomy due to performance failure.

Preoperative preparation

The patients were admitted the day before surgery, excluding emergent situations, and consent for treatment was obtained from all patients and their families. We explained to the patients the possibility of conversion to laparotomy because of severe adhesion, malignancy, or inadequate visualization of the operative field. The SILS procedure was performed under general anesthesia with endotracheal intubation. Most patients were placed in the lithotomy position; younger patients without a history of coitus were placed in the supine position. One dose of prophylactic antibiotics was administered before anesthesia was induced. A uterine manipulator (Panpac Medical Corp, Taipei, Taiwan) was inserted into the uterine cavity in all patients except young patients without a history of coitus.

Port preparation in single-port laparoscopic adnexal surgery

A 1-cm longitudinal skin incision was made in the umbilicus, pulling the abdominal wall upward using two towel clamps, and a Veress needle was inserted to establish pneumoperitoneum. A 10-mm trocar was then placed in the umbilical area, and a 10-mm 0° laparoscope was inserted through the trocar. We determined whether to continue SILS or convert to laparotomy after the pelvic anatomy was carefully inspected.

After the umbilical trocar was removed, the skin incision was extended to approximately 1.5 cm, which was wide enough to allow the passage of one finger. The skin incision was extended to the upper and lower margins of the umbilicus to minimize abdominal scarring. An Alexis® wound retractor XS (Applied Medical, Rancho Santa Margarita, CA, USA) was placed in the umbilicus through the previous incision site. Three trocars (two 12-mm trocars and one 5-mm trocar) were inserted into separate fingers of a $6^1/_2$ surgical rubber glove and secured with rubber bands (Fig. 1). The wrist portion of the glove covered the wound retractor, and three Babcock clamps were placed on the edges of the retractor to prevent carbon dioxide leakage [1]. A 10-mm laparoscope and atraumatic forceps were inserted through the umbilical multichannel glove port.

Adnexal surgery procedure

The pelvic masses of the enrolled cases were primarily ovarian cysts and tumors. The procedures performed included adnexectomy, cystectomy, and myomectomy, which was performed in a case of a pedunculated subserosal myoma initially diagnosed as an adnexal mass. After cystectomy was performed, ovarian tissue suturing was not performed, and hemostatic materials were applied to the surface of the dissected ovary.

Outcome measurements

Following a review of the medical records and radiological findings, the clinicopathological characteristics of the patients, including age, parity, height, weight, body mass index (BMI), adnexal mass size, tumor marker (CA 125) presence/absence and previous medical and surgical histories, and operative outcomes, such as the operation time, change in the hemoglobin (Hb) level, interval of the first passage of gas, postoperative hospital stay, and postoperative complications, were investigated.

Statistical analysis

The results were analyzed using IBM SPSS® version 24 statistical software (IBM, Armonk, NY, USA). Continuous variable comparisons were performed using Student's t-test. Categorical variables were compared with the chi-square or Kruskal-Wallis test. All tests were two-sided, and p values of ≤ 0.05 were regarded as significant. We generated a power-law curve model of the abstracted learning rate. The patient series were chronologically arranged according to their operation dates and were then divided into four groups according to when the operations were performed. The learning curve evaluation of SILS for adnexal surgery was performed using locally weighted regression (LWR).

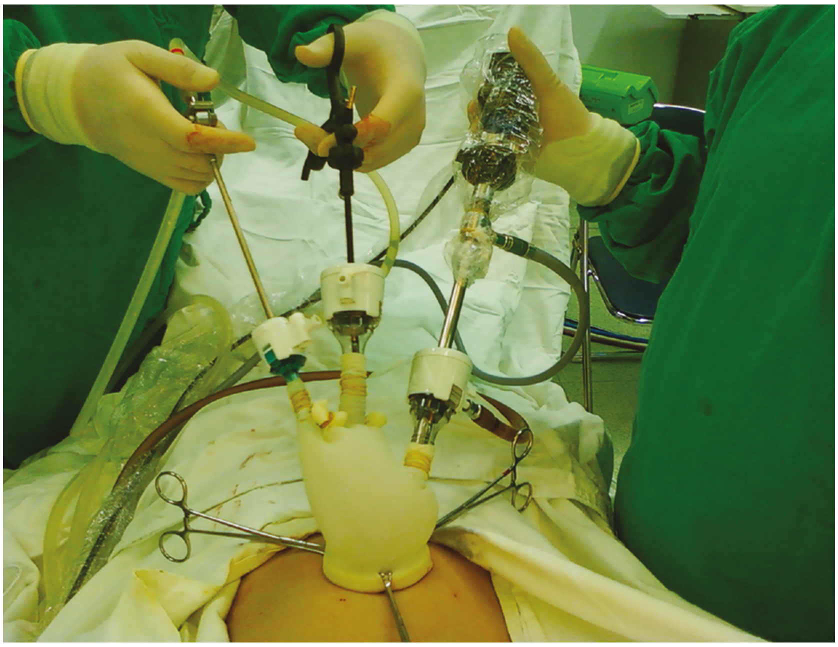

Figure 1. Port preparation in single-port laparoscopic adnexal surgery. After the skin incision was extended to approximately 1.5 cm, an Alexis® wound retractor XS (Applied Medical, Rancho Santa Margarita, CA, USA) was placed in the umbilicus through the previous incision site. Three trocars (two 12-mm trocars and one 5-mm trocar) were inserted into separate fingers of a $6^{1}/_{2}$ surgical rubber glove and secured with rubber bands. The wrist portion of the glove covered the wound retractor, and three Babcock clamps were placed on the edges of the retractor to prevent carbon dioxide leakage

Locally weighted regression (LWR) is a method in which a regression surface is fit to data through multivariate smoothing [2].

RESULTS

In total, 214 enrolled patients who underwent SILS for adnexal surgery by an expert surgeon were included. The mean age was 33.9 ± 11.5 years. The mean parity and BMI were 1.0 ± 1.1 and 23.2 ± 4.3 kg/m^2, respectively. The mean operation duration was 77.5 ± 22.3 min.

The operations consisted of cystectomy (n = 115), salpingo-oophorectomy (n = 52), salpingectomy (n = 44), tubal ligation (n = 8), ovarian drilling and cauterization (n = 5), tuboplasty (n = 5), myomectomy (n = 4), diagnostic laparoscopy (n = 4), appendectomy (n = 1), ovarian wedge resection (n = 1), and rudimentary horn resection (n = 1). Most of operations were performed with more than one procedure. Myomectomies were performed in the case of simple subserosal myoma or myoma mistaken for adnexal mass combined with the main operation of adnexal surgery. The mean size of the adnexal mass was 6.3 ± 5.0 cm.

No operative complications, conversions to laparotomy or additional trocar insertions were observed. The mean length of postoperative hospital stay was 3.9 ± 0.7 days. The mean change in hemoglobin level from preoperative to postoperative day 2 was 1.7 ± 0.8 g/dL. The mean interval to the first passage of gas after the operation was 41.8 ± 16.5 hours.

The enrolled cases were divided into four groups according to when the operations were performed (chronological order). Groups 1–4 included 54, 53, 54, and 53 patients, respectively. The clinical characteristics of the four patient groups were not significantly different (Tab. 1). The operation durations of the four groups, which were established according to when the operations were performed, were compared (Fig. 2). No statistically significant differences were observed.

The operative outcomes, such as the operation duration and interval to the passage of gas after operation, did not show a difference among the four patient groups (Tab. 2). The changes in hemoglobin level from preoperative to postoperative day two in groups 1–4 were 2.0 ± 0.7, 1.6 ± 0.8, 1.8 ± 0.9 and 1.5 ± 0.9, respectively, and the difference among groups was significant ($p < 0.05$). The mean change in the level of hemoglobin was the largest in group 1 and smallest in group 4. Thus, the difference in hemoglobin level tended to decrease as more operations were performed.

The mean lengths of postoperative hospital stay in groups 1–4 were 4.1 ± 0.9, 3.7 ± 0.5, 3.9 ± 0.6, and 3.6 ± 0.5 days, respectively, and the differences among groups were significant ($p < 0.05$). The mean postoperative hospital stay was longest in group 1 and shortest in group 4. Because the postoperative hospital stay did not increase due to postoperative complications in this study group, the differences between the groups were considered nonsignificant.

Table 1. Characteristics of the patients in groups established according to when the operation was performed

	Total (n = 214)	Group 1 (n = 54)	Group 2 (n = 53)	Group 3 (n = 54)	Group 4 (n = 53)	p value
Age [y]	33.9 ± 11.5	32.9 ± 10.1	34.5 ± 11.3	35.6 ± 13.6	32.7 ± 10.9	0.51
Parity	1.0 ± 1.1	1.1 ± 1.1	1.1 ± 1.2	1.0 ± 1.2	0.9 ± 0.9	0.61
Height [cm]	159.8 ± 5.9	159.6 ± 4.8	159.2 ± 6.0	159.7 ± 6.7	160.8 ± 6.2	0.52
Weight [kg]	59.3 ± 11.7	57.7 ± 9.2	58.9 ± 12.3	59.7 ± 13.6	61.0 ± 11.4	0.52
BMI [kg/m^2]	23.2 ± 4.3	22.7 ± 3.6	23.2 ± 4.3	23.4 ± 4.8	23.6 ± 4.4	0.70
Mass size [cm]	6.3 ± 5.0	6.3 ± 4.5	6.5 ± 6.6	6.4 ± 3.7	6.1 ± 5.0	0.98
CA 125 (U/mL]	15.1 ± 18.1 (n = 174)	20.7 ± 18.1 (n = 43)	12.4 ± 10.9 (n = 40)	12.6 ± 12.1 (n = 45)	14.5 ± 25.7 (n = 46)	0.12

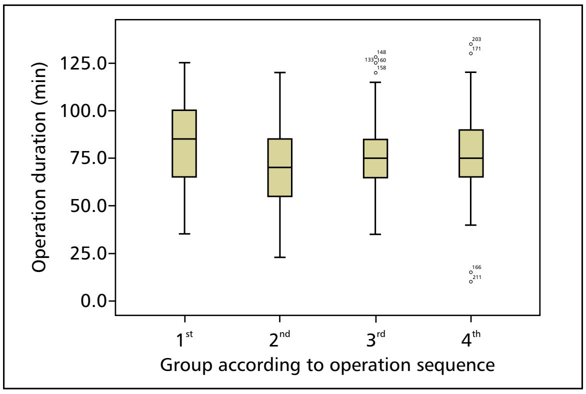

Figure 2. Comparison of the operation durations among the four groups established according to when the operation was performed

Table 2. Surgical outcomes of the patients in groups established according to when the operation was performed

	Total (n = 214)	Group 1 (n = 54)	Group 2 (n = 53)	Group 3 (n = 54)	Group 4 (n = 53)	p value
Operation duration [min]	77.5 ± 22.3	81.9 ± 21.9	71.6 ± 20.3	79.3 ± 21.0	76.9 ± 25.0	0.10
Hb change [g/dL]	1.7 ± 0.8	2.0 ± 0.7	1.6 ± 0.8	1.8 ± 0.9	1.5 ± 0.9	0.01
Interval to the passage of gas after operation [hours]	41.8 ± 16.5	38.8 ± 14.9	39.7 ± 15.1	44.1 ± 17.5	44.5 ± 17.9	0.17
Postoperative hospital stay [days]	3.9 ± 0.7	4.1 ± 0.9	3.7 ± 0.5	3.9 ± 0.6	3.6 ± 0.5	0.01
Conversion to multiport	None	None	None	None	None	
Postoperative complication	None	None	None	None	None	

The learning curve for SILS for adnexal surgery was assessed by the change in operation time as more operations were performed (Fig. 3). Locally weighted regression (LWR) analysis indicated that the operation time decreased significantly as more operations were performed, and surgical proficiency, which was defined as the point at which the slope of the learning curve abruptly became less steep after the segment with the steepest slope, was achieved after approximately 24 operations.

DISCUSSION

Due to the increasing interest in minimally invasive surgery, SILS has been used in gynecologic surgeries in many hospitals. SILS has some limitations in performance because the surgical instruments require the use of the same umbilical port at the same time. Thus, surgeons need time to learn how to adequately perform SILS. In many studies, SILS is suggested to be a safe surgical procedure and yield superior cosmetic effects than conventional laparoscopic surgery. However, although SILS is difficult to perform, little is known about its learning curve assessment and the factors associated with operative outcomes during the learning period [3].

Single-site incision laparoscopic surgery [SILS] involves a limited surgical space around the umbilical single-site incision, which often results in instruments interfering with

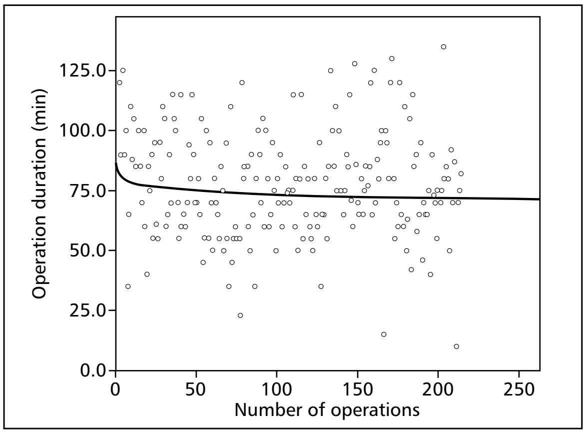

Figure 3. Learning curve for SILS for adnexal surgery. Surgical proficiency was defined as the point at which the slope of the learning curve became less steep and was evident after 24 operations

each other in a single port site, colloquially referred to as sword fighting. To prevent sword fighting, Fukomoto et al. [3] suggested that one-handed maneuvers are performed in the early phase of laparoscopic adrenalectomy, and the crossover technique is then performed. With this technique, the instruments are crossed at the platform (SILS^{TM} port). Thus, the instrument in the surgeon's left hand is seen on the right side of the monitor, and that in the surgeon's right hand is seen on the left side of the monitor. Although the crossover technique can initially confuse the surgeon, performing the technique with bent instruments creates an appropriate operative angle and adequate surgical space after the surgeon has mastered the technique. For SILS, many variations of the surgical technique have been used to overcome the limited surgical field and interference with surgical instruments. However, a standard method has not been developed, and each surgeon has different challenges in learning to perform SILS.

In this study, a case series of patients who underwent SILS for adnexal surgery was assessed, and the learning curve of an expert surgeon was analyzed. The decrease in operation time was not significant after 24 cases. Lee et al. [4] found that SILS was performed relatively safely after analyzing the surgical outcomes and learning curve of SILS for myomectomy and that the operation was performed efficiently in terms of the operative time after approximately 45 surgeries were performed. We suggest that the operation can be performed efficiently after fewer cases because SILS for adnexal surgery is a relatively simple surgical procedure compared with myomectomy.

In our study, the mean postoperative hospital stays significantly differed across groups. The mean postoperative hospital stay was longest in group 1 and shortest in group 4. In Korea, patients tend to want to stay in the hospital for more than four days after an operation. The reasons for this tendency are considered the relatively low medical expenses in Korea and patient anxiety regarding short hospital stays. Consequently, most patients were not discharged if they did not want to leave. In this study, because the length of hospital stay did not increase due to postoperative complications, the prolonged postoperative hospital stay was considered nonsignificant.

Learning curve assessments in many types of operations have gained increasing attention in the recent literature [5]. The prominent approach to learning curve analysis is to discretize experience — that is, divide the cases into groups with surgeons either acting as their own control group or being compared with experienced surgeons [6–7].

This approach allows standard statistical analyses that compare means or medians of the groups and multivariable analyses to be performed with any other grouped variable. The main weakness of this approach is that discretizing a continuous variable leads to the loss of information; in this case, the specific time at which the learning curve changes can be approximated only by the group size, and subtle trends may be lost.

Another approach involves considering the case number as a continuous variable and applying regression modeling to define the relationship between the case number and raw outcome [8]. Cumulative sum (CUSUM) modeling, a method that has recently gained interest, also describes the outcome as a function of the case number as a continuous variable [9]. The learning curves generated in reports are intuitive, but it is difficult to apply multivariable analyses to control for known confounders that can exert large effects.

The learning curve associated with an operation reflects the complexity of the surgical procedures. Song et al advocated that proficiency in performing SILS for cystectomy was achieved after 33 operations [10]. Paek et al. [11] also proved that 40 cases of SILS for hysterectomy needed to be performed for surgeons to become proficient. In our study, the learning curve for SILS for adnexal surgery was assessed by the change in operation time as more operations were performed. Locally weighted regression (LWR) analysis indicated that the operation time decreased significantly as more operations were performed, and surgical proficiency, which was defined as the point at which the slope of the learning curve abruptly became less steep after the segment with the steepest slope, was achieved after approximately 24 operations.

The strengths of the present study include a case volume larger than 200 and the involvement of a single surgeon and institution to reduce confounders. The deflection point for each curve was accurate because it was determined with a statistical test rather than a visual estimate. For this reason, despite the small sizes of the study groups, bias resulting from the surgeon or medical treatment patterns can be excluded.

Our study has several limitations. First, all surgical procedures were performed by an expert surgeon in CL, who performed over 1,000 of these surgeries. For this reason, the learning curve only shows the learning process for adnexal surgical procedures performed with SILS by an expert in CL but not by novice surgeons. Consequently, a multicenter study involving numerous surgeons, including every level of experience, is required to prove the validity of the procedure among other surgeons.

Second, the adnexal surgical procedures were not classified as operative procedures, such as oophorectomy or cystectomy. Although the series of surgeries used for analysis was adnexal surgery, the surgical procedure was not purified from the same surgical procedure. With this, the analysis had some limitations considering pure surgical procedure learning curves, such as simple ovarian cystectomy, salpingectomy or oophorectomy. Therefore, the learning curve analysis may not reflect the learning process for each procedure type in adnexal surgeries. For the validation of each adnexal surgical procedure, a more well-designed multicenter study is needed.

CONCLUSIONS

In conclusion, SILS for adnexal surgery is a reasonably safe and alternative surgical procedure to CL that does not increase the risk of perioperative or postoperative complications. However, to safely perform SILS, a certain training period for learning the surgical procedure should be required.

Article information and declarations

Conflict of interest

All authors declare no conflict of interest.

REFERENCES

1. Yi SW, Ju DaH, Lee SS, et al. Transumbilical retrieval of surgical specimens through a multichannel port. JSLS. 2014; 18(4): e2014.00178, doi: 10.4293/JSLS.2014.00178, indexed in Pubmed: 25408603.
2. Centner V, Massart DL. Optimization in locally weighted regression. Anal Chem. 1998; 70(19): 4206–4211, doi: 10.1021/ac980208r , indexed in Pubmed: 21651257.
3. Fukumoto K, Miyajima A, Hattori S, et al. The learning curve of laparoendoscopic single-site adrenalectomy: an analysis of over 100 cases. Surg Endosc. 2017; 31(1): 170–177, doi: 10.1007/s00464-016-4950-6, indexed in Pubmed: 27194254.
4. Lee HJ, Kim JuY, Kim SKi, et al. Learning Curve Analysis and Surgical Outcomes of Single-port Laparoscopic Myomectomy. J Minim Invasive Gynecol. 2015; 22(4): 607–611, doi: 10.1016/j.jmig.2015.01.009, indexed in Pubmed: 25614346.
5. Lin JF, Frey M, Huang JQ. Learning curve analysis of the first 100 robotic-assisted laparoscopic hysterectomies performed by a single surgeon. Int J Gynaecol Obstet. 2014; 124(1): 88–91, doi: 10.1016/j.ijgo.2013.06.036, indexed in Pubmed: 24182553.
6. Lenihan JP, Kovanda C, Seshadri-Kreaden U. What is the learning curve for robotic assisted gynecologic surgery? J Minim Invasive Gynecol. 2008; 15(5): 589–594, doi: 10.1016/j.jmig.2008.06.015, indexed in Pubmed: 18722971.
7. Lim PC, Kang E, Park DoH. Learning curve and surgical outcome for robotic-assisted hysterectomy with lymphadenectomy: case-matched controlled comparison with laparoscopy and laparotomy for treatment of endometrial cancer. J Minim Invasive Gynecol. 2010; 17(6): 739–748, doi: 10.1016/j.jmig.2010.07.008, indexed in Pubmed: 20955983.
8. Payne TN, Dauterive FR. A comparison of total laparoscopic hysterectomy to robotically assisted hysterectomy: surgical outcomes in a community practice. J Minim Invasive Gynecol. 2008; 15(3): 286–291, doi: 10.1016/j.jmig.2008.01.008, indexed in Pubmed: 18439499.
9. Lee HH, Song KY, Park CH, et al. Training of surgical endoscopists in Korea: assessment of the learning curve using a cumulative sum model. J Surg Educ. 2012; 69(4): 559–563, doi: 10.1016/j.jsurg.2012.03.002, indexed in Pubmed: 22677598.
10. Song T, Kim TJ, Lee YY, et al. Learning curves for single-site laparoscopic ovarian surgery. J Minim Invasive Gynecol. 2012; 19(3): 344–349, doi: 10.1016/j.jmig.2012.01.003, indexed in Pubmed: 22322155.
11. Paek J, Kim SW, Lee SH, et al. Learning curve and surgical outcome for single-port access total laparoscopic hysterectomy in 100 consecutive cases. Gynecol Obstet Invest. 2011; 72(4): 227–233, doi: 10.1159/000324384, indexed in Pubmed: 22067204.