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The learning curve of laparoscopic single-site salpingectomy with conventional laparoscopic instruments

A retrospective cohort study

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Abstract

Tubal pregnancy is a common cause of maternal mortality in early pregnancy. Transumbilical laparoendoscopic single-site surgery (TU-LESS) has gained popularity due to its safety and aesthetic advantages. However, the lack of affordable disposable entry platforms hinders its widespread adoption. This study aimed to investigate the learning curve of tubal pregnancy removal using single-incision multiport (SIMP) laparoscopy and provide guidance for novice gynecologists. A retrospective analysis was conducted on cases of ectopic pregnancy (EP) diagnosed at Dongguan Songshan Lake Central Hospital from June 2020 to June 2022. The analysis included 50 cases, with 25 undergoing single-port laparoscopy and 25 undergoing conventional laparoscopy (CL). Various indicators, including body mass index (BMI), previous pregnancies, mass size, hemoglobin levels, surgical duration, and complications, were collected. Learning curve analysis using the cumulative sum (CUSUM) technique was performed to assess procedural proficiency. There were no significant differences in patient characteristics or complications between the 2 groups. However, the single-port laparoscopy group exhibited a statistically significant longer average surgical time (41.60 ± 13.38 minutes) compared to the conventional laparotomy group (32.96 ± 7.32 minutes). The CUSUM analysis demonstrated a decline in surgical time after the completion of approximately 11 cases, indicating an improvement in SIMP laparoscopy surgical proficiency. SIMP laparoscopy for tubal pregnancy removal achieved similar safety outcomes as CL. Notably, the CUSUM analysis revealed that proficiency in single-port laparoscopy could be achieved after approximately 11 cases, leading to stable surgical times. These findings serve as valuable guidance for novice gynecologists interested in adopting single-incision laparoscopy.

Abbreviations: BMI = body mass index, CL = conventional laparoscopy, CUSUM = cumulative sum, EP = ectopic pregnancy, SIMP = single-incision multiport, TU-LESS = transumbilical laparoendoscopic single-site surgery, vNOTES = vaginal natural orifice transluminal endoscopic surgery.

Keywords: CUSUM, learning curve, salpingectomy, SIMP, transumbilical laparoendoscopic single-site surgery, tubal pregnancy, TU-LESS

1. Introduction

Tubal pregnancy is the most common cause of maternal mortality in early pregnancy, accounting for more than 90% of ectopic pregnancy (EP).[1] With the advancement of surgical techniques, an increasing number of young women are opting for transumbilical laparoendoscopic single-site surgery (TU-LESS) due to its safety and effectiveness. Moreover, this procedure offers the advantage of minimal postoperative scarring, enhancing aesthetic outcomes.[2,3] However, in some hospitals, the promotion of this technology is hindered due to the lack of expensive disposable commercially dedicated entry platforms. Ricardo et al[4] described the removal of fallopian tubes in EP via the umbilical 3 foramen. This single-incision multiport (SIMP) is safe and secure and can be adapted for various gynecologic surgeries involving hysterectomy and myomectomy, which are complicated procedures.[5] Even experienced laparoscopic surgeons, however, require some time to investigate and master their surgical approaches due to the specific technical constraints and restrictions of operating triangles in TU-LESS. Gynecologists typically begin learning

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single-hole laparoscopic surgery with uncomplicated procedures such as fallopian tube removal and attachment removal. There are currently few papers on the investigation of learning curves using transumbilical single-port laparoscopy. The learning process can be quantified using cumulative sum (CUSUM) analysis. This study retrospectively analyzed the clinical data of 50 cases of tubal pregnancy removal surgery performed by the same chief surgeon and used CUSUM to infer their learning curve, aiming to provide a reference for novice gynecologists in single-incision laparoscopy.

2. Materials and methods

A retrospective analysis was conducted on EP cases diagnosed at Dongguan Songshan Lake Central Hospital from June 2020 to June 2022. Among them, 25 cases were treated with single-port laparoscopy, and 25 cases underwent conventional laparoscopy (CL). All surgeries were performed by the same surgeon, and a unilateral salpingectomy was performed in all cases. The collected indicators included body mass index (BMI), number of previous pregnancies, parity, size of adnexal masses under ultrasound, hemoglobin level, HCG level, surgical duration, intra-abdominal blood volume, length of hospital stay, and postoperative complications. Inclusion criteria were as follows: patients in generally good condition with stable vital signs; confirmed tubal pregnancy that met the surgical indications and required surgical removal of the affected fallopian tube; no contraindications for laparoscopic surgery; all cases excluded shock and rescue.

The Ethics Committee of Dongguan Songshan Lake Central Hospital has approved the study. Written informed consent for treatment was obtained from the patients.

2.1. Surgical procedures

Surgery was performed with the patient under general endotracheal anesthesia and in a lithotomy position.

SIMP laparoscopy: Using the natural skin fold within the umbilicus as a guide, a 1.5 to 2.0 cm longitudinal incision was created at the base of the umbilicus. Through a single 1.5 to 2.0 cm umbilical transcutaneous incision, 3 trocars—the left and right conventional 5mm laparoscopic trocars as working ports and the central 10mm trocar for the laparoscopy 30-degree scope camera—were individually put into the peritoneum (Fig. 1). During the procedure, the fallopian tubes were removed using an endoscopic bag. Postoperative umbilical wound (Fig. 2).

Figure 1. Positions of the trocars.

2.2. Data analysis

The data were analyzed using SPSS 25.0 statistical software. The normality test and homogeneity of variance test were performed for continuous variables. Normally distributed variables with homogeneous variances were presented as mean ± standard deviation (x ± s) and analyzed using a t-test. A non-parametric Wilcoxon rank-sum test was used to assess data that was not normally distributed or had heterogeneous variances. These data were provided as the median (M) and interquartile range (IQR). For categorical data, chi-square tests or Fisher exact tests were employed. A P value < .05 was considered statistically significant for detecting differences. Utilize the CUSUM to assess the learning curve approach. The calculation formula is: $\mathrm{CUSUM} = \sum_{i=1}^{n} (\mathrm{Ti} - \mathrm{Tm})$, where n represents the number of surgical cases, Ti represents the time of each surgical case, and Tm represents the average surgical time.

3. Results

A total of 50 patients participated in this study (Table 1): 25 female patients underwent single-incision laparoscopic salpingectomy, and 25 female patients underwent conventional laparoscopic salpingectomy. There were no statistically significant differences between the 2 groups in terms of average age, parity, gravidity, BMI, history of abdominal surgery, preoperative hCG levels, and mass size on ultrasound examination ($P > .05$). There was no statistically significant difference between the 2 groups in terms of intra-abdominal hemorrhage ($P > .05$). The comparison of pre- and postoperative hemoglobin changes showed no statistically significant difference between the 2 groups ($P > .05$). The average surgical time for the single-incision group was 41.60 ± 13.38 minutes, while for the conventional group it was 32.96 ± 7.32 minutes, and the difference in surgical time between the 2 groups was statistically significant ($P < .05$). There were no intraoperative complications, and no complications such as umbilical hernia were found during the 6-month follow-up. A scatter plot of surgical time versus the number of cases was plotted according to the sequence of surgeries (Fig. 3). The CUSUM curves are shown in Figure 4. When $R^2 = 0.930$, the curve-fitting effect is good. The fitted curve equation is $Y = 0.0174X^3 - 1.4188X^2 + 25.5112X - 26.8183$. As the number of cases increased, the surgical time gradually decreased, and after the 11th case, the surgical time stabilized.

4. Discussion

The surgical treatment for tubal pregnancy includes salpingotomy or salpingectomy, with laparoscopy being the preferred approach. With the development of technology and improvements in surgical skills, an increasing number of gynecological procedures can now be performed using single-incision laparoscopy, advancing in more challenging directions.[6] It is even possible to perform extensive total hysterectomy and lymph node dissection using single-incision laparoscopy.[7–10] Evidence has proven that the application of single-incision laparoscopy in gynecology is a safe and feasible surgical method.[2,11] For beginners, performing malignant tumor surgery using single-incision laparoscopy may seem unattainable, like the distance between the Earth and the Moon. Beginners usually start learning single-incision laparoscopy with relatively simple procedures such as salpingectomy and accessory removal,[12] gradually gaining experience and confidence before progressing to more difficult surgeries. As the

saying goes, "A journey of a thousand miles begins with a single step." In 1981, Tarasconi[13] reported on the transabdominal single-port laparoscopic salpingectomy. In 2005, Ghezzi et al[14] reported a single-port laparoscopic salpingectomy for EP. Keziban et al[15] reported a spontaneous heterotopic pregnancy presenting as an acute abdomen, which was successfully treated using vaginal natural orifice transluminal endoscopic surgery (vNOTES). vNOTES has shown promise in treating various adnexal lesions.[16] However, some young patients may refuse this approach due to concerns about future pregnancy and sexual dysfunction.[17] Cihan Kaya et al[18] used conventional surgical equipment and added an additional 10 mm trocar 3 cm above the midline of the pubic symphysis to perform surgery for EP, achieving favorable outcomes. This technique less invasive and less costly but leaving postoperative abdominal scarring. In our study, we performed single-incision laparoscopic surgery using conventional laparoscopic instruments, resulting in a completely invisible scar after the procedure. There were no statistically significant differences between the single-incision group and the traditional multiport group in terms of age, parity, gravidity, BMI, history of abdominal surgery, preoperative hCG levels, mass size on ultrasound examination, or changes in hemoglobin levels before and after surgery. The single-incision group had no surgical failures or conversions to multiport surgery, and no complications such as umbilical wound infection or umbilical hernia occurred postoperatively. There was a statistically significant difference in surgical time between the 2 groups. The average surgical time in our single-incision group was 42 minutes, which is shorter than the reported average of 53 to 55 minutes.[19,20] This may be attributed to the simpler technique of using a single-incision with 3 channels for suturing the umbilical incision. And we used a uterine manipulator during the surgery to help expose the fallopian tubes, making the surgery easier.

Figure 2. Display after suturing the umbilical wound after surgery.

Due to factors such as the loss of the surgical triangle, mutual interference of surgical instruments, and limited field of view, mastering this surgical technique requires a special learning curve. For beginners, the implementation of single-incision laparoscopy can start with the treatment of tubal pregnancy, progressing from simple to complex, gradually improving the operational proficiency of gynecological surgeons and accumulating experience. The CUSUM analysis method, which quantifies the learning process, aids in progressively completing and mastering specific surgical skills through continuous learning.[21] It is commonly assessed based on the number of surgical cases required to attain relative surgical proficiency.[22,23] Single-incision laparoscopic surgery exhibits varying learning curves for different surgical techniques and procedures within the field of gynecology. Proficiency in transumbilical single-incision laparoscopic salpingo-oophorectomy is typically achieved after 10 to 15 cases,[24] single-port laparoscopic myomectomy requires 45 cases to cross the learning curve,[25] while single-incision laparoscopic-assisted total laparoscopic hysterectomy and comprehensive staging surgery for endometrial cancer require approximately 24 and 20 cases.[26,27] Our study indicates that single-incision laparoscopic salpingectomy can be mastered after only 11 cases, with subsequent notable reduction in operating time. Accumulating experience through simpler LESS procedures, like salpingectomy, can boost surgeons' confidence and readiness for more complex myomectomy and hysterectomy procedures. However, it should be noted that in cases where factors like intra-abdominal adhesions increase the difficulty of the surgery, it may be necessary to switch to traditional multiport surgery. One research limitation is that the chief surgeon performs every surgery. In order to confirm the method practicality, more medical facilities and physicians will be required in the future.

Table 1

Comparison between 2 groups of patients.

Characteristics	SIMP laparoscopy (n = 25)	Conventional laparoscopy (n = 25)	*P* value
Age, mean (SD)	32.84 ± 6.99	30.28 ± 5.83	.166
Gravidity	3.88 ± 1.53	3.28 ± 1.56	.178
Parity	1.80 ± 0.913	1.44 ± 1.19	.237
Body mass index, mean (SD), kg/m^2	23.13 ± 3.57	21.97 ± 2.78	.207
History of abdominal surgery	6 (24%)	8 (32%)	.529
Mass size on ultrasonography (cm)	2.98 ± 1.11	3.11 ± 1.59	.735
Preoperative serum HCG level (mIU/mL)	7479.04 ± 9553.13	5349.00 ± 10293.50	.452
Operative time (min)	41.60 ± 13.38	32.96 ± 7.32	.007*
Hemoperitoneum (mL)	152.00 ± 118.57	146.00 ± 123.25	.861
Hemoglobin change, Mean (SD), g/L	14.00 ± 11.88	13.28 ± 8.52	.807

SIMP = single-incision multiport.

*Indicating $P < .05$.

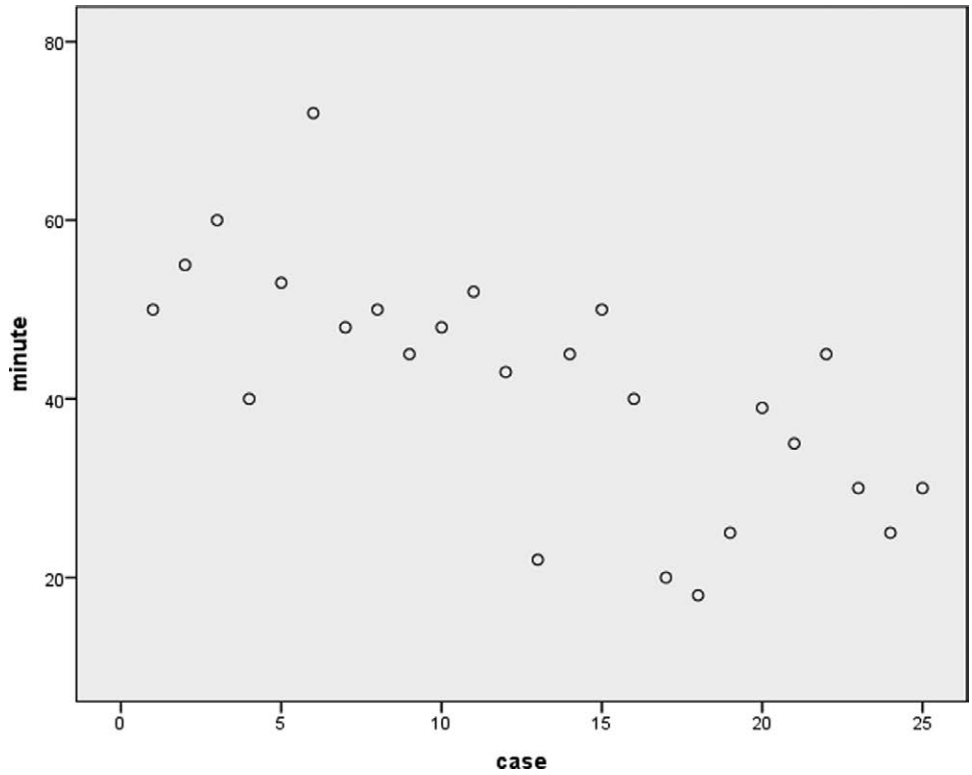

Figure 3. Scatter plot of surgical time for each salpingectomy case.

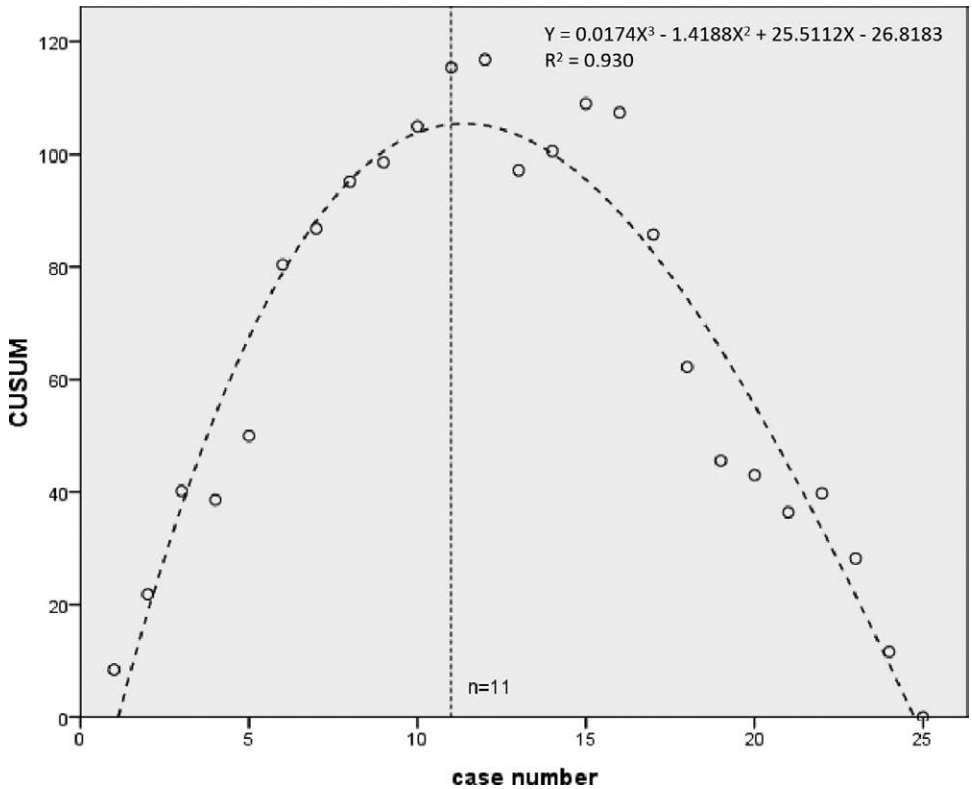

Figure 4. Learning curve of operational time for salpingectomy.

5. Conclusion

SIMP laparoscopy does not require additional special instruments or equipment. SIMP laparoscopy for tubal pregnancy removal achieved similar safety outcomes as CL. Notably, the CUSUM analysis revealed that proficiency in single-port laparoscopy could be achieved after approximately 11 cases, leading to stable surgical times. These findings serve as

valuable guidance for novice gynecologists interested in adopting single-incision laparoscopy.

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References

[1] Committee on Practice Bulletins—Gynecology. Obstet Gynecol. 2018;131:e65–77.
[2] Fader AN, Rojas-Espaillat L, Ibeanu O, et a`l. Laparoendoscopic single-site surgery (LESS) in gynecology: a multi-institutional evaluation. Am J Obstet Gynecol. 2010;203:501.e1–6.
[3] Jung YW, Kim YT, Lee DW, et al. The feasibility of scarless single-port transumbilical total laparoscopic hysterectomy: initial clinical experience. Surg Endosc. 2010;24:1686–92.
[4] Savaris RF, Cavazzola LT. Ectopic pregnancy: laparoendoscopic single-site surgery--laparoscopic surgery through a single cutaneous incision. Fertil Steril. 2009;92:1170.e5–7.
[5] Ichikawa M, Akira S, Mine K, et al. Evaluation of laparoendoscopic single-site gynecologic surgery with a multitrocar access system. J Nippon Med Sch. 2011;78:235–40.
[6] Yang YS, Kim SH, Jin CH, et al. Solo surgeon single-port laparoscopic surgery with a homemade laparoscope-anchored instrument system in benign gynecologic diseases. J Minim Invasive Gynecol. 2014;21:695–701.
[7] Fader AN, Escobar PF. Laparoendoscopic single-site surgery (LESS) in gynecologic oncology: technique and initial report. Gynecol Oncol. 2009;114:157–61.
[8] Garrett LA, Boruta DM, 2nd. Laparoendoscopic single-site radical hysterectomy: the first report of LESS type III hysterectomy involves a woman with cervical cancer. Am J Obstet Gynecol. 2012;207:518.e1–2.
[9] Fagotti A, Ghezzi F, Boruta DM, et al. Minilaparoscopic radical hysterectomy (mLPS-RH) vs laparoendoscopic single-site radical hysterectomy (LESS-RH) in early stage cervical cancer: a multicenter retrospective study. J Minim Invasive Gynecol. 2014;21:1005–9.
[10] Boruta DM, Fagotti A, Bradford LS, et al. Laparoendoscopic single-site radical hysterectomy with pelvic lymphadenectomy: initial multi-institutional experience for treatment of invasive cervical cancer. J Minim Invasive Gynecol. 2014;21:394–8.
[11] Park HS, Kim TJ, Song T, et al. Single-port access (SPA) laparoscopic surgery in gynecology: a surgeon's experience with an initial 200 cases. Eur J Obstet Gynecol Reprod Biol. 2011;154:81–4.
[12] Zhao M, Zhao J, Hua K, et al. Single-incision multiport laparoscopy versus multichannel-tipped single port laparoscopy in gynecologic surgery: outcomes and benefits. Int J Clin Exp Med. 2015;8:14992–8.
[13] Tarasconi JC. Endoscopic salpingectomy. J Reprod Med. 1981;26:541–5.
[14] Ghezzi F, Cromi A, Fasola M, et al. One-trocar salpingectomy for the treatment of tubal pregnancy: a "marionette-like" technique. BJOG. 2005;112:1417–9.
[15] Doğan K, Kaya C, Ilıman DE, et al. A spontaneous heterotopic pregnancy presenting with acute abdomen treated with natural orifice transluminal endoscopic surgery procedure: Case report. Turk J Obstet Gynecol. 2019;16:271–3.
[16] Kaya C, Alay I, Cengiz H, et al. Conventional laparoscopy or vaginally assisted natural orifice transluminal endoscopic surgery for adnexal pathologies: a paired sample cross-sectional study. J Invest Surg. 2021;34:1185–90.
[17] Benhidjeb T, Benhidjeb I, Stark M, et al. Women's perception of transgastric and transvaginal natural orifice transluminal endoscopic surgery (NOTES) - impact of medical education, stage of life and cross-cultural aspects. Int J Womens Health. 2022;14:1881–95.
[18] Kaya C, Alay I, Eren E, et al. Laparoscopy-assisted suprapubic salpingectomy "Kaya technic" - a low-cost treatment of ectopic pregnancy. J Obstet Gynaecol. 2019;39:1164–8.
[19] Yoon BS, Park H, Seong SJ, et al. Single-port versus conventional laparoscopic salpingectomy in tubal pregnancy: a comparison of surgical outcomes. Eur J Obstet Gynecol Reprod Biol. 2011;159:190–3.
[20] Yoon BS, Park H, Seong SJ, et al. Single-port laparoscopic salpingectomy for the surgical treatment of ectopic pregnancy. J Minim Invasive Gynecol. 2010;17:26–9.
[21] Wohl H. The cusum plot: its utility in the analysis of clinical data. N Engl J Med. 1977;296:1044–5.
[22] Dou Y, Wang Y, Tang S, et al. Learning curve for laparoendoscopic single-site radical hysterectomy using the "chopstick" technique: a retrospective cohort study. Ann Transl Med. 2022;10:1165–1165.
[23] Tahmasbi Rad M, Wallwiener M, Rom J, et al. Learning curve for laparoscopic staging of early and locally advanced cervical and endometrial cancer. Arch Gynecol Obstet. 2013;288:635–42.
[24] Escobar PF, Starks DC, Fader AN, et al. Single-port risk-reducing salpingo-oophorectomy with and without hysterectomy: surgical outcomes and learning curve analysis. Gynecol Oncol. 2010;119:43–7.
[25] Lee HJ, Kim JY, Kim SK, et al. Learning curve analysis and surgical outcomes of single-port laparoscopic myomectomy. J Minim Invasive Gynecol. 2015;22:607–11.
[26] Koyanagi T, Motomura S. Single-incision laparoscopically assisted vaginal hysterectomy: operative outcomes and its learning curve. Exp Ther Med. 2011;2:867–71.
[27] Barnes H, Harrison R, Huffman L, et al. The adoption of single-port laparoscopy for full staging of endometrial cancer: surgical and oncology outcomes and evaluation of the learning curve. J Minim Invasive Gynecol. 2017;24:1029–36.