Clinical and Experimental Obstetrics & Gynecology

Clin. Exp. Obstet. Gynecol. **2024**; 51(4): 100
https://doi.org/10.31083/j.ceog5104100

Original Research

Improvement of Gasless Laparoscopic Single-Site Lifting and Use in Surgery for Endometrial Carcinoma

Bingbing Zhao[1,2,†], Xinqiu Lu[3,†], Xuli Gan[4], Zhijun Yang[1,2], Li Li[1,2], Jieqing Zhang[1,2,*]

[1]Department of Obstetrics and Gynecology, Guangxi Medical University Cancer Hospital, 530021 Nanning, Guangxi, China
[2]Key Laboratory of Early Prevention and Treatment for Regional High Frequency Tumor (Guangxi Medical University), Ministry of Education, 530022 Nanning, Guangxi, China
[3]Department of Obstetrics and Gynecology, Guangxi Bei Liu People's Hospital, 537499 Bei Liu, Guangxi, China
[4]Department of Obstetrics and Gynecology, Guangxi Maternal and Child Health Hospital, 530005 Nanning, Guangxi, China
*Correspondence: 1583825050@qq.com (Jieqing Zhang)
[†]These authors contributed equally.
Academic Editor: Michael H. Dahan
Submitted: 6 December 2023 Revised: 23 February 2024 Accepted: 15 March 2024 Published: 17 April 2024

Abstract

Background: The operative field in gasless surgery is limited, and it is difficult to adequately expose the operative field when compared to the use of gas surgery. Gasless laparoscopic single-site (GLESS) is difficult to apply to endometrial cancer surgery. The aim of this study is to investigate the improvement in GLESS lifting style for use in surgery for endometrial cancer as well as to compare the outcome of different surgical approaches in endometrial cancer. **Methods**: A tissue retractor is added to the routine step of GLESS to lift the abdominal wall. The lateral umbilical ligament is exposed, a 2-0 buckwheat thread is passed through the lateral umbilical ligament and abdominal wall in order to lift the umbilical ligament. We measured the changes of space length or height in different dimensions of the improved GLESS approach. Also, we measured the vertical height from the upper edge of the umbilical site to the abdominal cavity, the length from the lower edge of the umbilical site to the right Michaelis point, the height from the bottom of the uterus to the peritoneal cavity of the anterior abdominal wall, and the length from the lateral umbilical ligament to the ipsilateral psoas major muscle. We analyzed the differences in procedures in 177 cases of endometrial carcinoma. We collected data on operative time, hemoglobin change, number of lymph nodes removed, postoperative recovery time and postoperative complications for open surgery, multi site laparoscopic surgery, single site laparoscopic surgery and gasless laparoscopic single-site surgery. **Results**: The vertical height from the upper edge of the umbilical foramen to the abdominal cavity (4.395 $\pm$ 1.593 cm *vs*. 7.418 $\pm$ 1.626 cm, $p < 0.001$), the length from the lower edge of the umbilical foramen to the right Michaelis point (9.850 $\pm$ 2.089 cm *vs*. 12.795 $\pm$ 2.094 cm, $p < 0.001$), the height from the bottom of the uterus to the peritoneal cavity of the anterior abdominal wall (6.900 $\pm$ 1.052 cm *vs*. 9.827 $\pm$ 1.366 cm, $p < 0.001$), and the length from the lateral umbilical ligament to the ipsilateral psoas major muscle and iliac vessels were measured (2.345 $\pm$ 0.515 cm *vs*. 4.318 $\pm$ 0.558 cm, $p < 0.001$) and showed improvement with GLESS. Also, the operative visualization increased significantly with GLESS. No significant difference was observed in operative time ($p = 0.670$), hemoglobin change ($p = 0.065$), number of lymph nodes removed ($p = 0.179$), postoperative recovery time ($p = 0.331$), or postoperative complications ($p = 0.442$) in cases of endometrial cancer utilizing GLESS. **Conclusions**: The use of GLESS can increase surgical exposure. This method of suspending the umbilical ligament through abdominal silk thread can increase exposure of the anatomical structure of the obturator position. The application of GLESS as the procedure for endometrial cancer is safe and feasible.

Keywords: lifting; endometrial cancer; gasless laparoscopic single-site

1. Introduction

Laparoscopic surgery is a minimally invasive procedure used in both benign and malignant gynecologic surgery. However, laparoscopic surgery requires the abdomen to be filled with CO_2. Whether CO_2 leads to cancer cell metastasis has been controversial, and the patient's cardiopulmonary function has the potential to be markedly affected. Gasless laparoscopic surgery requires special instruments to suspend the abdominal wall, which can eliminate the effect of CO_2 on cardiopulmonary function and potential cancer metastasis [1–3]. With the continuous development and innovation of minimally invasive surgical technology, laparoendoscopic single-site surgery (LESS) has experienced increased utilization. The surgical incision is in the umbilicus and the scar is smaller, avoiding the possibility of injury caused by pelvic and abdominal organ adhesions [4,5]. In order to reduce the possibility of cancer metastasis caused by CO_2 and the potential impact on cardiopulmonary function, clinicians have applied the combination of gasless surgery and single puncture site to gynecologic tumor patients. Both gasless surgery and LESS have their own shortcomings. The space of gasless surgery is limited, and it is difficult to adequately expose the operative field when compared to the use of gas surgery. All operating instruments of LESS surgery enter through 1 puncture site, and the operative space loses the triangle

Table 1. The clinicopathologic data of patients.

Variables	Group				*p* value
	GLESS (n = 22)	LT (n = 62)	LS (n = 62)	LESS (n = 31)	
Age, years, mean (SD)	52.41 ± 7.620	52.91 ± 7.008	54.18 ± 7.487	50.94 ± 7.602	0.340
BMI, kg/m^2, mean (SD)	23.675 ± 2.964	23.342 ± 3.514	24.512 ± 3.071	23.870 ± 4.023	0.577
FIGO Stage					
IA	16	40	54	24	0.034*
IB	6	22	8	7	
Pathological grade					
G1-G2	22	45	54	29	0.004**
G3	0	17	8	2	

SD, standard deviation; BMI, body mass index; GLESS, gasless laparoscopic single-site; LT, laparotomy; LS, laparoscopic surgery group; LESS, laparoendoscopic single-site surgery; FIGO, International Federation of Gynecology and Obstetrics.

* Comparison between FIGO stage IA and IB.

** Comparison between Pathological grade of G1-2 and G3.

effect. The instruments interfere with each other to form the "chopsticks" effect, which increases the difficulty of the surgery [6,7]. LESS requires that the surgeon complete the procedure utilizing the microscope. There is no surgical assistant to expose the operative field, and the exposure of the visual field is often not clear [8]. The gasless laparoscopic single-site (GLESS) procedure will make the operation more difficult. During the operation for gynecologic malignant tumors, lymph node dissection or extensive parauterine tissue resection are required. The progress of the operation requires sufficient space to visualize and expose the operative field. In general, the application of GLESS in gynecologic malignant tumor surgery has the following problems: (1) The traditional gasless abdominal instrument suspension method does not create the space between the anterior abdominal wall and abdominal organs; (2) The traditional gasless abdominal suspension has limited exposure to the operative field between the lateral abdominal wall and abdominal organs; (3) The GLESS procedure makes it difficult to expose the distance from the internal iliac vessel to the umbilical ligament, which makes pelvic lymph node dissection and extensive parauterine resection difficult to implement. In view of the listed problems, this study intends to improve the suspension mode and study the influence of different suspension modes on the operative space. We also desired to study the safety of open surgery, multi hole laparoscopic surgery, single hole laparoscopic surgery and gasless laparoscopic single-site surgery for endometrial cancer.

2. Materials and Methods

2.1 Patient Information

A retrospective study was carried out on women with endometrial cancer who underwent primary surgical treatment at Department of Obstetrics and Gynecology, Guangxi Medical University Cancer Hospital, from March 2018 through March 2022. We selected 177 patients (Table 1) with endometrial cancer which included 22 cases in the gasless laparoscopic single site (GLESS) group, 62 cases in the laparotomy group (LT), 62 cases in the multi hole laparoscopic surgery group (LS), and 31 cases in the laparoscopic single site surgery group (LESS). The inclusion criteria in the study were as follows: patients undergoing primary surgical treatment for endometrial cancer at our hospital after having been diagnosed by preoperative endometrial sampling; patient age $\geq$18 years; and histologic subtype of endometrioid adenocarcinoma according to the International Federation of Gynecology and Obstetrics (FIGO) 2009 classification. The study was reviewed and approved by our ethics committee.

The data were extracted from the medical records, including age, histologic type and tumor grade, FIGO stage I, operative time, hemoglobin change, number of lymph nodes removed, postoperative recovery time and postoperative complications. We analyzed the differences in operative time, hemoglobin change, number of lymph nodes removed, postoperative recovery time and postoperative complications for the different groups. Postoperative complications included intestinal obstruction, intestinal fistula, double-J tube insertion, poor healing of the abdominal wound, lymphatic fistula, urinary fistula, urinary tract infection, incisional hernia, reoperation for postoperative bleeding, injury of blood vessels, thrombosis, and injury of bladder or bowel. Table 1 demonstrates that there are statistical differences in clinical stage and pathological grade of the cases reviewed.

2.2 Methods of Improved the Lifting

Routine suspension of GLESS requires making a longitudinal incision in the middle of the umbilicus, 3–4 cm long, and placing a protective sleeve on the incision. A Kirschner wire is used to penetrate subcutaneously along the abdominal white line. The suspension rod of the gas-

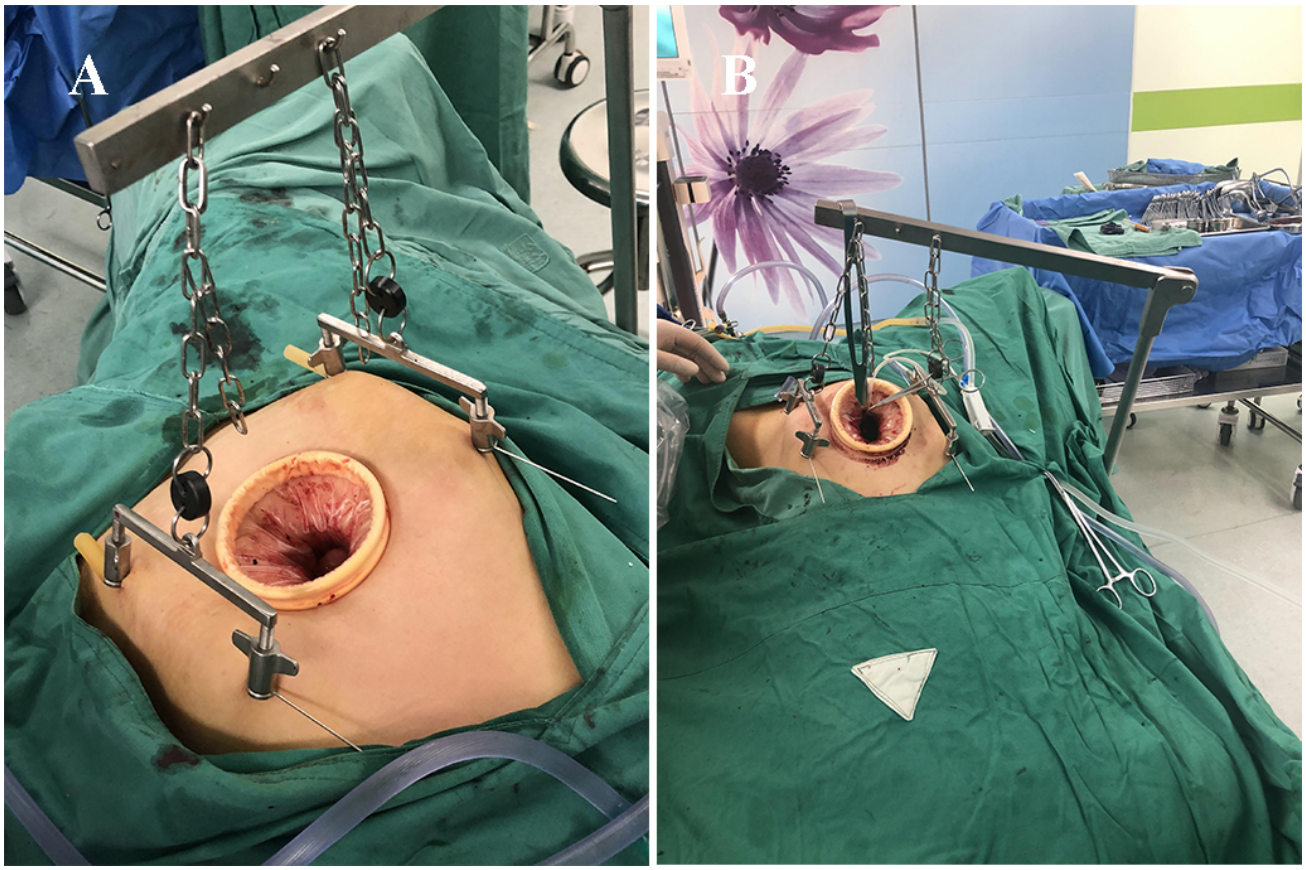

Fig. 1. Use the Kirschner wire to penetrate subcutaneously along the abdominal white line, fix the suspension rod of the gasless suspension equipment on the right side of the patient, and fix the steel needle on the steel needle grip. (A) Cross the lifting rod across the white line, hang the steel needle grab chain on the cross bar of the suspension rod, with the suspension height of the abdominal wall being adjusted by the chain. (B) Improved suspension of GLESS: add a tissue retractor to the step of routine suspension of GLESS and pull the abdominal wall upward.

less suspension equipment is fixed on the right side of the patient and the steel needle is fixed on the steel needle grip. The lifting rod is crossed across the white line, the steel needle grab chain is hung on the cross bar of the suspension rod, and the suspension height of the abdominal wall is adjusted by the chain. Improved suspension of GLESS requires adding a tissue retractor to the step of routine suspension and pulling the abdominal wall upward (Fig. 1B). This is followed by opening the lateral peritoneum with an ultrasonic scalpel, exposing the right umbilical ligament, passing a 2-0 buckwheat thread through the umbilical ligament, passing it through the abdominal wall, and lifting the umbilical ligament to the left.

We measured the vertical height from the upper edge of the umbilical foramen to the abdominal cavity, the length from the lower edge of the umbilical foramen to the right Michaelis point, the height from the bottom of the uterus to the peritoneal cavity of the anterior abdominal wall, and the length from the lateral umbilical ligament to the ipsilateral psoas major muscle and iliac vessels. The LT group, LS group, and LESS group were performed in the conventional way.

2.3 Statistical Analysis

SPSS 26 (IBM Corp., Armonk, NY, USA) was used to analyze the data. Prior to statistical analysis, measurement data were tested for normal distribution and variance homogeneity. Rand sum test and ANOVA analysis of variance (F-test) were evaluated for significant differences between clinicopathologic data. Chi-square test and *t*-test analyses were used to evaluate the improvement of gasless laparoscopic single-site lifting and the effects of different surgical methods. $p < 0.05$ in this study was statistically significant.

3. Results

Routine suspension of GLESS is showed in Fig. 1A and Fig. 2. Improved suspension of GLESS is showed in Fig. 1B.

Different surgical fields are presented in routine suspension of GLESS and improved suspension of GLESS. It can be seen that after the change, the operative space is significantly increased (Fig. 3).

The vertical height from the upper edge of the umbilical foramen to the abdominal cavity, the length from the

Fig. 2. Surgical incision protective sleeve. This is an elastic device with the shape being easy to match with surgical incision.

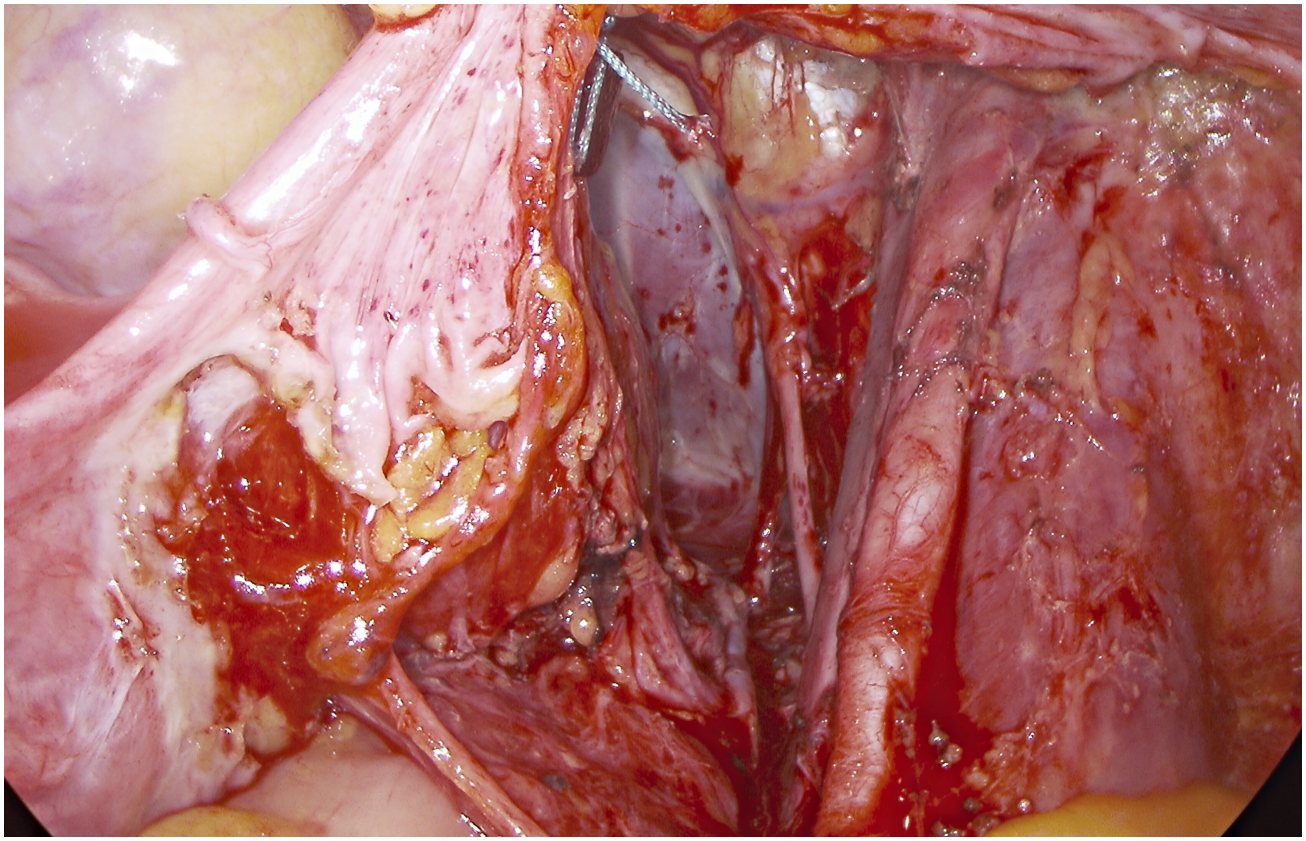

Fig. 3. Surgical fields after improved suspension of GLESS. Expose the right umbilical ligament, pass 2-0 buckwheat thread through the umbilical ligament, pass it through the abdominal wall, and lift the umbilical ligament to the left.

lower edge of the umbilical foramen to the right Michaelis point, the height from the bottom of the uterus to the peritoneal cavity of the anterior abdominal wall, and the length from the lateral umbilical ligament to the ipsilateral psoas major muscle and iliac vessels were measured (Table 2).

There were no differences in the 177 cases of endometrial carcinoma in operative time, hemoglobin change, number of lymph nodes removed, postoperative recovery time and postoperative complications (Table 3).

Table 2. The effects of different surgical methods on the space in endometrial cancer.

Measuring method	Group		*p*
	Routine-GLESS (n = 22)	Improved-GLESS (n = 22)	
The vertical height from the upper edge of the umbilical foramen to the abdominal cavity (cm)	4.395 ± 1.593	7.418 ± 1.626	<0.001
The length from the lower edge of the umbilical foramen to the right Michaelis point (cm)	9.850 ± 2.089	12.795 ± 2.094	<0.001
The height from the bottom of the uterus to the peritoneal cavity of the anterior abdominal wall (cm)	6.900 ± 1.052	9.827 ± 1.366	<0.001
The length from the lateral umbilical ligament to the ipsilateral psoas major muscle and iliac vessels were measured (cm)	2.345 ± 0.515	4.318 ± 0.558	<0.001

Table 3. The effects of different surgical methods on endometrial cancer patients.

Classification	Groups				*p* value
	GLESS (n = 22)	LT (n = 62)	LS (n = 62)	LESS (n = 30)	
Operative time	201.41 ± 55.13	219.44 ± 64.70	204.40 ± 42.95	210.16 ± 27.06	0.670
Hemoglobin change	14.41 ± 7.33	16.13 ± 13.15	15.53 ± 9.42	12.65 ± 7.31	0.065
Number of lymph nodes removed	12.68 ± 8.48	15.87 ± 5.18	14.05 ± 7.64	13.84 ± 6.99	0.179
Postoperative recovery time	2.05 ± 0.58	2.18 ± 0.98	2.05 ± 1.43	2.10 ± 0.65	0.331
Postoperative complications	1/22	10/62	7/62	3/31	0.442

4. Discussion

Gynecologic minimally invasive surgery has the benefits of less trauma and rapid recovery. Studies have demonstrated that the application of LESS in endometrial cancer is safe and feasible, but previous reports are single site laparoscopic surgery with pneumoperitoneum [9,10]. The use of CO_2 pneumoperitoneum during the operation is the key step in laparoscopic surgery. Previous studies have shown that the use of laparoscopic CO_2 may have a potential impact on cardiopulmonary function and may also lead to cancer cell metastasis [11]. In 2018, Ramirez *et al.* [12] published the results of a prospective randomized controlled clinical trial in the New England Journal of Medicine. They believed that among patients with early cervical cancer, open surgery has higher disease-free survival (DFS) and overall survival (OS) than minimally invasive radical hysterectomy, with a low mortality and recurrence rate. Significant hemodynamic changes occur during minimally invasive staging surgery for endometrial cancer [13]. Whether pneumoperitoneum leads to poor prognosis in patients with intrauterine cancer is still inconclusive. Currently, gasless laparoscopy is increasingly applied in gynecological laparoscopy. It decreases the complications associated with CO_2 pneumoperitoneum, and reduces the operation difficulty and cost [14,15]. Gynecologic malignant tumor surgery involves pelvic lymph node dissection or extensive parauterine tissue resection. Based on the limited application of the single site gasless laparoscopy technology, it is generally used in benign diseases, such as in patients with ovarian tumors during pregnancy [16], and its application in malignant tumors is still limited [17].

The exposure of laparoscopic operative field and space in gynecologic malignant tumor surgery includes several important dimensions, including the vertical height between the anterior abdominal wall and abdominal organs (intestinal tube surface, etc.), the length from the single hole puncture site to the lateral abdominal wall, and the vertical height from the anterior abdominal wall peritoneum to the bottom of the uterus. During lymph node dissection, it is necessary to expose and measure the gap between the umbilical ligament, psoas major muscle and external iliac vessels as well as expanding the operative space to avoid damage to the intestines and blood vessels.

The traditional gasless abdominal suspension equipment utilized has limitations in exposing the spatial visual field (Fig. 1A). It may lead to prolonged operative time, increased surgical bleeding, increased postoperative complications and other adverse factors, which limits the development of pneumoperitoneum free surgery. We have improved the procedure as shown in Fig. 1B. The results of this study demonstrate that the space of gasless laparoscopic single site surgery is improved by improving the suspension mode. This allows progress in the following aspects of the procedure: Adding a thyroid retractor at the single puncture site on the abdominal wall can lift the abdominal wall upward (4.395 ± 1.593 cm *vs.* 7.418 ± 1.626 cm, $p < 0.001$), increase the distance between the anterior abdominal wall and abdominal organs (6.900 ± 1.052 cm *vs.* 9.827 ± 1.366 cm, $p < 0.001$), and increase the vertical height between the anterior abdominal wall and abdominal organs. The statistical results revealed that after the upward lifting, there was a statistically significant difference between the two groups. Due to the upward lifting effect of the tissue

retractor, the suspension position of the anterior abdominal wall is higher, and the lifting of the steel needles on both sides can also increase the distance upward. Therefore, the midpoint of the whole anterior abdominal wall and the lifting point of the lateral abdominal wall are moved upward at the same time, which increases the vertical height from the puncture site to the abdominal cavity, as well as increasing the vertical height of the lateral abdominal wall. When the lateral abdominal wall is pulled upward, the vertical distance from the lateral abdominal wall to the abdominal organs increases (9.850 ± 2.089 cm *vs*.12.795 ± 2.094 cm, $p < 0.001$), and the length from the puncture site to the lateral abdominal wall increases, which increases the operative space and widens the operative field of vision. Specifically in the lymph node dissection of gynecologic malignant tumors, the wide space of the lateral abdominal wall will make the manual operation easier. During pelvic lymph node dissection, the umbilical ligament can be lifted by a silk thread penetrating the abdominal wall, which can fully expose the anatomical structure of the obturator fossa. In the single puncture site procedure, the operation in the abdominal cavity needs to be completed by one person. After improvement of the device, it can better expose the external iliac artery and vein, obturator nerve, other blood vessels, nerves and adipose tissue. The length from the lateral umbilical ligament to the ipsilateral psoas major muscle and iliac vessels were measured (2.345 ± 0.515 cm *vs*. 4.318 ± 0.558 cm, $p < 0.001$) and were all improved, allowing the pelvic lymph node dissection to be carried out with ease.

After the improvement, we compared the influence of different surgical methods on the operation of early endometrial cancer, and found that there was little difference in the operative time of several surgical methods, minimal change in hemoglobin before and after surgery, and no difference in postoperative complications, indicating that nonpneumoperitoneal laparoscopic surgery is safe and feasible in endometrial cancer.

However, this study has certain limitations. The technique of the operation is different, which may lead to the differences in operative time and blood loss. There is the possibility of data bias in a retrospective analysis. The small sample size may lead to errors in the results [18]. This study may not reflect its advantages due to the small number of cases.

GLESS appears to offer several advantages over conventional laparoscopy, such as elimination of the adverse effects and potential risks associated with CO_2 insufflation. Gasless laparoscopy has recently attracted attention in low-income countries as a cost-effective alternative to conventional laparoscopy [19,20], while potentially reducing the likelihood of tumor metastasis [21–24]. This study demonstrates that the improved device can effectively increase the operative space and visual field of single site gasless abdominal surgery. Other methods to improve the surgical procedure need to be further studied.

5. Conclusions

The improvement of GLESS can increase surgical exposure. This method of suspending the umbilical ligament through abdominal silk thread can increase exposure of the anatomical structure of the obturator position. The application of GLESS in the operation for endometrial cancer is safe and feasible.

Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

JZ and LL designed the research study; XL, XG and BZ analyzed the data and performed research; JZ and BZ were involved in formal analysis; JZ and ZY conducted quality control over the surgical process. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Guangxi Medical University Cancer Hospital (approval number: KYB2023134).

Acknowledgment

Thanks to the medical staff of Guangxi Medical University Cancer Hospital for the surgery and nursing. Thanks to the teachers who helped in the process of writing the paper. Thanks to all the peer reviewers for their opinions and suggestions.

Funding

Guangxi Medical and Health Appropriate Technology and Popularization and Application Project (S2020094).

Conflict of Interest

The authors declare no conflict of interest.

References

[1] Galaal K, Bryant A, Fisher AD, Al-Khaduri M, Kew F, Lopes AD. Laparoscopy versus laparotomy for the management of early stage endometrial cancer. The Cochrane Database of Systematic Reviews. 2012; CD006655.

[2] Wenger FA, Jacobi CA, Kilian M, Dressler H, Guski H, Müller JM. The impact of laparoscopic biopsy of pancreatic lymph nodes with helium and carbon dioxide on port site and liver metastasis in BOP-induced pancreatic cancer in hamster. Clinical & Experimental Metastasis. 2000; 18: 11–14.

[3] Yashwashi T, Kaman L, Kajal K, Dahiya D, Gupta A, Meena SC, *et al*. Effects of low- and high-pressure carbon dioxide pneumoperitoneum on intracranial pressure during laparoscopic cholecystectomy. Surgical Endoscopy. 2020; 34: 4369–4373.
[4] Symeonidis EN, Nasioudis D, Economopoulos KP. Laparoendoscopic single-site surgery (LESS) for major urological procedures in the pediatric population: A systematic review. International Journal of Surgery (London, England). 2016; 29: 53–61.
[5] Chambers LM, Carr C, Freeman L, Jernigan AM, Michener CM. Does surgical platform impact recurrence and survival? A study of utilization of multiport, single-port, and robotic-assisted laparoscopy in endometrial cancer surgery. American Journal of Obstetrics and Gynecology. 2019; 221: 243.e1–243.e11.
[6] Wang Y, Yao Y, Dou Y, Tang S, Chen C, Li Y, *et al*. Chopstick technique used in laparoendoscopic single site radical hysterectomy for early stage cervical cancer. Scientific Reports. 2021; 11: 6882.
[7] Dou Y, Deng L, Tang S, Yao Y, Liang X, Hu Q, *et al*. Chopstick technique versus cross technique in LESS hysterectomy (CCLEH study): a prospective randomized controlled trial. Trials. 2022; 23: 702.
[8] Yang Y, Pan YQ, Lu Q, Bao W, Wang M, Liu W, *et al*. Ergonomic learning curves on gynecological laparoendoscopic single-site (LESS) surgery. BMC Surgery. 2023; 23: 327.
[9] Fagotti A, Boruta DM, 2nd, Scambia G, Fanfani F, Paglia A, Escobar PF. First 100 early endometrial cancer cases treated with laparoendoscopic single-site surgery: a multicentric retrospective study. American Journal of Obstetrics and Gynecology. 2012; 206: 353.e1–353.e6.
[10] Park JY, Kim DY, Suh DS, Kim JH, Nam JH. Laparoendoscopic single-site versus conventional laparoscopic surgical staging for early-stage endometrial cancer. International Journal of Gynecological Cancer. 2014; 24: 358–363
[11] Lin F, Pan L, Li L, Li D, Mo L. Effects of a simulated CO2 pneumoperitoneum environment on the proliferation, apoptosis, and metastasis of cervical cancer cells in vitro. Medical Science Monitor: International Medical Journal of Experimental and Clinical Research. 2014; 20: 2497–2503.
[12] Ramirez PT, Frumovitz M, Pareja R, Lopez A, Vieira M, Ribeiro R, *et al*. Minimally Invasive versus Abdominal Radical Hysterectomy for Cervical Cancer. The New England Journal of Medicine. 2018; 379: 1895–1904.
[13] Laskov I, Alpern S, Ronel I, Segal R, Zindel O, Zoborovsky I, *et al*. Cardiac Function and Hemodynamic Changes during Minimally Invasive Hysterectomy with Pneumoperitoneum and Steep Trendelenburg Position for Patients with Endometrial Cancer Who Are Obese. Journal of Minimally Invasive Gynecology. 2021; 28: 1079–1085.
[14] Gnanaraj J, Rhodes M. Laparoscopic surgery in middle- and low-income countries: gasless lift laparoscopic surgery. Surgical Endoscopy. 2016; 30: 2151–2154.
[15] Farrow NE, Commander SJ, Reed CR, Mueller JL, Gupta A, Loh AHP, *et al*. Laparoscopic experience and attitudes toward a low-cost laparoscopic system among surgeons in East, Central, and Southern Africa: a survey study. Surgical Endoscopy. 2021; 35: 6539–6548.
[16] Takeda A, Imoto S, Nakamura H. Gasless laparoendoscopic single-site surgery for management of adnexal masses during pregnancy. European Journal of Obstetrics, Gynecology, and Reproductive Biology. 2014; 180: 28–34.
[17] Liu K, Huang Q, Wang Y, Zhang Q, Feng D, Gong Z, *et al*. Impact of gasless vNOTES vs. traditional vNOTES on hemodynamic profiles and outcomes in patients with benign gynecological disease: study protocol of a randomized controlled trial. BMC Anesthesiology. 2023; 23: 373.
[18] Bouwman F, Smits A, Lopes A, Das N, Pollard A, Massuger L, *et al*. The impact of BMI on surgical complications and outcomes in endometrial cancer surgery–an institutional study and systematic review of the literature. Gynecologic Oncology. 2015; 139: 369–376.
[19] de la Orden SG, Reza MM, Blasco JA, Andradas E, Callejo D, Pérez T. Laparoscopic hysterectomy in the treatment of endometrial cancer: a systematic review. Journal of Minimally Invasive Gynecology. 2008; 15: 395–401.
[20] Durdağ GD, Alemdaroğlu S, Baran ŞY, Şimşek SY, Yetkinel S, Çelik H. Safety of laparoscopic surgery in the management of endometrioid endometrial cancer. Indian Journal of Cancer. 2023; 60: 366–372.
[21] Shoman H, Sandler S, Peters A, Farooq A, Gruendl M, Trinh S, *et al*. Safety and efficiency of gasless laparoscopy: a systematic review protocol. Systematic Reviews. 2020; 9: 98.
[22] Freed JS, Landrigan P. Gasless Laparoscopy: A Double-Edged Sword in the Developing World. Journal of the American College of Surgeons. 2021; 232: 799.
[23] GlobalSurg Collaborative. Surgical site infection after gastrointestinal surgery in high-income, middle-income, and low-income countries: a prospective, international, multicentre cohort study. The Lancet. Infectious Diseases. 2018; 18: 516–525.
[24] Galizia G, Prizio G, Lieto E, Castellano P, Pelosio L, Imperatore V, *et al*. Hemodynamic and pulmonary changes during open, carbon dioxide pneumoperitoneum and abdominal wall-lifting cholecystectomy. A prospective, randomized study. Surgical Endoscopy. 2001; 15: 477–483.