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# Gasless Total Laparoscopic Hysterectomy with New Abdominal-Wall Retraction System

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## ABSTRACT

**Background and Objectives:** Gasless laparoscopy is an alternative method to reduce the number of carbon dioxide ($CO_2$)-insufflated, pneumoperitoneum-related problems including shoulder pain, postoperative nausea/vomiting, and decreased cardiopulmonary function. In this study, we investigated the feasibility of gasless total laparoscopic hysterectomy (TLH) with a newly developed abdominal-wall retraction system.

**Methods:** Abdominal-wall retraction for gasless laparoscopy was performed using the newly developed J-shape retractor and the Thompson surgical retractor. Surgical outcomes between gasless TLH and conventional $CO_2$-based TLH were compared for each of 40 patients for the period from January 2017 to October 2019.

**Results:** Between gasless TLH and conventional $CO_2$-based TLH, no significant differences were observed for age, body mass index, parity, or surgical indications. The mean retraction setup time from skin incision was 7.4 min (range: 4–12 min) with gasless TLH. The mean total operation times were 87.9 min (range: 65–170) with gasless TLH and 90 min (range: 45–180) with conventional TLH, which showed no significant difference. Estimated blood loss and uterus weight also showed no significant intergroup difference. No major complications related to the ureter, bladder, or bowel were encountered.

**Conclusion:** Our new abdominal-wall retraction system for gasless TLH allowed for easy setup and a proper operation field in the performance of laparoscopic hysterectomy.

**Key Words:** gasless laparoscopy, laparoscopic hysterectomy, abdominal-wall retraction.

## INTRODUCTION

Laparoscopic surgery compared with open abdominal or pelvic surgery has a number of advantages including less bleeding, less pain, less infection, early recovery, and cosmesis. To obtain a stable operation field, conventional laparoscopy requires carbon dioxide ($CO_2$)-insufflated pneumoperitoneum, which could cause some physiologic changes and problems. $CO_2$ pneumoperitoneum increases intraabdominal pressure and pushes the diaphragm upward, which affects pulmonary function by decrease of functional residual capacity, tidal volume, and vital capacity, eventually resulting in decreased total lung volume, reduced pulmonary compliance, and hypoventilation.[1,2] The cardiovascular system also is affected by $CO_2$ pneumoperitoneum, which induces hypercapnia and increased intraabdominal pressure. During $CO_2$ pneumoperitoneum, intraabdominal pressure decreases stroke volume and cardiac output up to 30%.[3–5] Additionally, $CO_2$ pneumoperitoneum increases systemic vascular resistance. As a result, mean arterial pressure remains unchanged or increases.[3,6] Notwithstanding the altered cardiorespiratory function induced by $CO_2$ pneumoperitoneum, young and healthy patients are affected minimally. In elderly or cardiopulmonary-compromised patients, however, laparoscopic surgery with $CO_2$ pneumoperitoneum might be a limited option because of the decreasing cardiopulmonary function (during anesthesia) that is induced by intraabdominal pressure, $CO_2$ absorption, and the Trendelenburg position.

Moreover, $CO_2$ pneumoperitoneum is suggested for shoulder pain when stretching and irritation of the diaphragm or peritoneum arises, which stimulates the phrenic nerve (C3–5) and, as a result, sometimes arouses the supraclavicular nerve (C3–4).[7–9] Shoulder pain after

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laparoscopy is known as referred pain. Unfortunately, shoulder pain is less responsive to analgesics.[10] Intraabdominal pressure and hypercapnia, induced by $CO_2$ pneumoperitoneum, is suggested as a cause of postoperative nausea vomiting (PONV) by gastrointestinal mucosa irritation and decreased blood flow in the gastrointestinal tract, which, in turn, induces serotonin release, although the exact cause is still not fully understood.[11,12] To overcome shoulder pain, PONV and decrease of cardiopulmonary function arising from $CO_2$ pneumoperitoneum, many trials of medications and low-pressure pneumoperitoneum have been conducted. Improvements have been shown, but they have been limited.

To overcome these problems, since the 1990s, gasless laparoscopy not requiring $CO_2$ pneumoperitoneum has been introduced and performed with abdominal-wall retraction systems.[13] Gasless laparoscopy has been reported to result in less shoulder pain, less PONV, and less influence on cardiopulmonary function.[14–17]

Curiously, reports on gasless total laparoscopic hysterectomy (TLH) have been limited. The reason might be that no widely used abdominal retractors of simple and easy setup have been introduced. Recently we developed a new abdominal-wall retraction system for gasless laparoscopy.

In this study, gasless TLH was performed with our newly designed abdominal-wall retraction system. We investigated the feasibility of the system by review of pertinent surgical outcomes.

## MATERIALS AND METHODS

### Patient population

This study included a retrospective medical record review of women who had undergone conventional and gasless TLH between January 2017 and October 2019 at International St. Mary's Hospital, Incheon, Korea. Gasless TLH was performed between April 2018 and October 2019, and for comparison, conventional TLH was performed between January 2017 and March 2018. Two groups, namely conventional TLH and gasless TLH, were compared in the study. The hysterectomy indications included myoma, adenomyosis, and atypical endometrial hyperplasia. Preoperative diagnosis was done by sonography in myoma, adenomyosis, or both. Endometrial hyperplasia was diagnosed with endometrial biopsy or dilatation and curettage. Cases of gynecologic malignancy were excluded. Patients' characteristics included age, parity, body mass index (BMI), and previous low-abdominal medical history. The intrasurgical results included retractor setup time from skin incision to retractor placement, total operation time, estimated blood loss, uterus weight, and adhesion. Postoperative complications including bowel injury, urologic injury, and abdominal-wall injury were evaluated. All of the patients of both groups received preoperative bowel preparation with marcrogol 50 g as routine procedure. All of the surgical procedures, including abdominal-wall retraction and others, were performed by one surgeon (B.W.K.). All patients understood and agreed to informed consent of abdominal-wall retraction for gasless laparoscopy. This study was approved by the Institute of Review Boards of International St. Mary's Hospital.

### Conventional $CO_2$ pneumoperitoneum for laparoscopy

After a 1-cm umbilical incision, a veress needle was inserted into the abdominal cavity and $CO_2$ was insufflated up to 12 mm Hg. One 10mm trocar was then inserted into the umbilical incision, and two 5-mm trocars were inserted into the left lower abdomen and suprapubic area, respectively. The fascia of the 10-mm port incision is sutured before skin closure.

### Abdominal-wall retraction for gasless TLH

For gasless TLH, abdominal-wall retraction with a new J-shaped retractor was applied. After a vertical 2- to ~2.5-cm incision of the umbilicus and subsequent incisions of the fascia and peritoneum, an Alexis retractor (Applied Medical, Rancho Santa Margarita, CA) or an Endo Keeper (Nelis, Bucheon-si, Gyeonggi-do, Korea) was introduced to expand the umbilical wound. A newly developed J-shaped retractor, designed for attachment to the Thompson surgical retractor in the Obstetrics and Gynecology Department of International St. Mary Hospital and produced in either stainless steel (**Figure 1A**) or plastic (**Figure 1B**) (DCTKorea, Seoul, Korea), was used. **Figure**

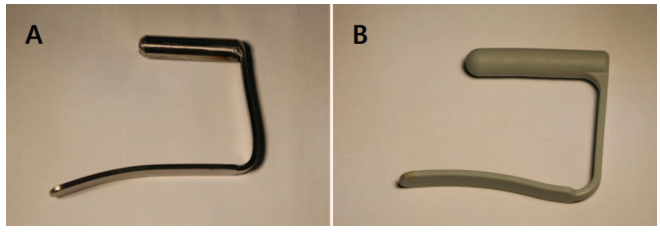


**Figure 1.** J-shaped retractor. **A**. stainless-steel J-shaped retractor. **B**, Plastic J-shaped retractor.

**2** demonstrates the abdominal-wall retraction with the J-shaped retractor and Thompson retractor, which had been set up in simple steps. The Thompson retractor was mounted on the surgical table with its angled arm clamped to the joint of a rail clamp, and one or two J-shaped retractors were clamped to the angled arm with a joint instrument. The J-shaped retractors were elevated manually and then finally clamped to secure the working space (**Figure 2**).

### Surgical procedure

After the gasless retractor was set up, 30° rigid laparoscopy was performed in the pelvic cavity via the umbilical incision. When the ancillary port was required, one trocar was introduced to the suprapubis. Bowel gauze packing was used to move small bowel from the pelvic cavity to the upper abdomen. Uterine manipulator for uterine handling and colpotomy with Rumi (Cooper Surgical, Trumbull, CT) was utilized. LigaSure (5 mm; Covidien, Boulder, CO) was used for cutting of the artery and round ligament. A monopolar hook or a bipolar coagulator was used to cut the peritoneum and vaginal cuff or to control bleeding, respectively. Vaginal closure was performed by intracorporeal suture with V-lock #1–0 in conventional TLH and by vaginal suture with Vicryl #1–0 in gasless TLH.

### Statistical analysis

Baseline characteristics were compared between the groups using the independent $t$ test for the continuous variables and the $\chi^2$ test for the categorical variables. Statistical analyses were performed using SPSS version 18.0 (SPSS Inc., Chicago, IL). A value of $P < .05$ was considered statistically significant.

## RESULTS

**Figure 3** shows a representative laparoscopic view after setup for abdominal-wall retraction. As can be seen, the abdominal-wall retraction system for gasless laparoscopy presented enough working space for surgery.

The 80 patients' clinical characteristics are compared between gasless and conventional TLH and summarized in **Table 1**. The mean ages were 46.7 (range: 24–70) and 46.2 y (range: 35–55) in the gasless and conventional TLH groups, respectively, showing no significant difference ($P = .69$). There also was no significant intergroup difference in BMI, parity, or pelvic-surgical history.

The surgical outcomes are shown in **Table 2**. Gasless TLH in this study was performed through umbilical incision according to single-port access. The median setup time from umbilical skin incision to abdominal-wall retraction was 8.0 min (range: 4–12 min). The number of single-port gasless TLH was 18 of 40 (45%), the other 22 gasless surgeries having been performed with one ancillary port. The median total operation times were 80.0 min (range: 65–170) and 82.5 min (range: 45–180) in gasless TLH and conventional TLH, respectively, showing no significant difference ($P = .706$). The median estimated blood loss was not significantly different between gasless and conventional TLH, presenting 100 mL (range: 50–500) and 200 mL (range: 50–800) of median volume, respectively. In gasless TLH, the maximal uterus weight was 940 g and the median uterus weight was 230 g, 80–940, whereas in conventional TLH, the median uterus weight was 260 g, 110–830. There was no blood transfusion in any of the gasless TLH. The median hemoglobin change between before surgery to postoperative day 1 was 1.5 g/dL in gasless TLH and 1.7 g/dL in conventional TLH, with no statistical significance ($P = .549$). Uterine myoma was the

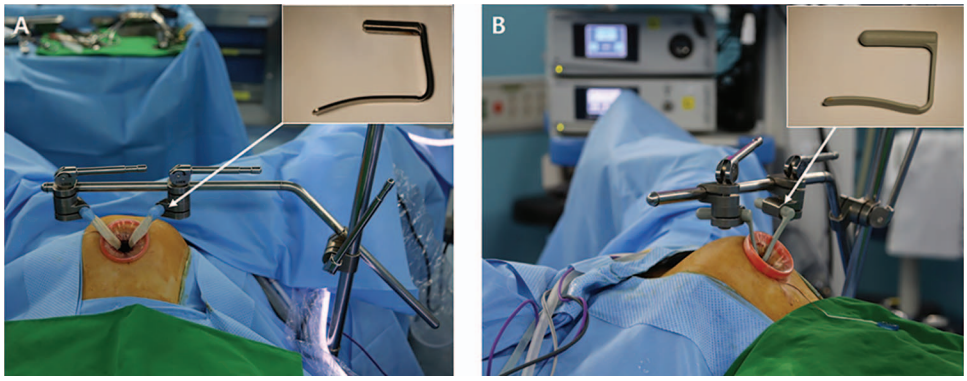


**Figure 2.** Abdominal-wall retraction for gasless TLH. **A**, Upper view using stainless-steel retractor. **B**, Lateral view using plastic retractor.

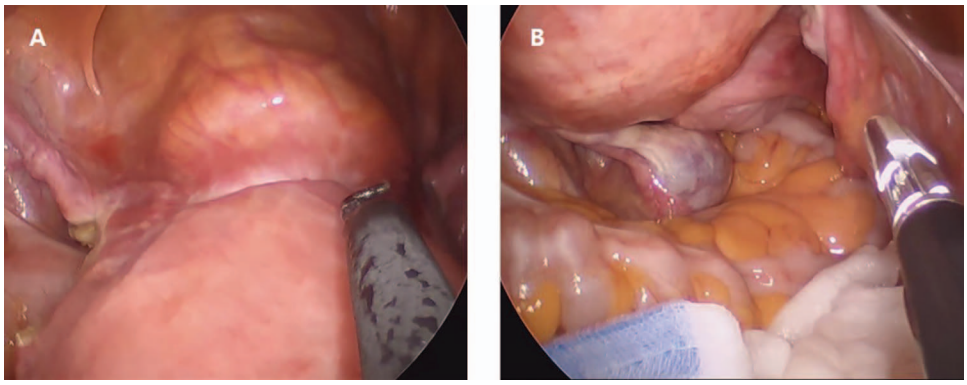


**Figure 3.** Representative laparoscopic view after setup for abdominal-wall retraction. **A**, View of anterior uterus. **B**, View of posterior uterus.

**Table 1.**
Baseline Characteristics of Patients between Gasless and Conventional TLH

| Variables | Gasless TLH (N = 40) | Conventional TLH (N = 40) | *P* value |
|---|---|---|---|
| Mean age, y (range) | 46.7 (24–70) | 46.2 (35–55) | .690 |
| BMI (range) | 24.1 (19.4–33.6) | 24.6 (18.6–32.5) | .558 |
| Parity (range) | 1.5 (0–4) | 1.7 (0–3) | .496 |
| Previous pelvic surgery (%) | 19 (47.5) | 13 (32.5) | .254 |
| Preoperative diagnosis (%)[a] | | | .762 |
| Myoma | 22 (55.0) | 19 (47.5) | |
| Adenomyosis | 8 (20.2) | 12 (30.0) | |
| Myoma and adenomyosis | 6 (15.0) | 6 (15.0) | |
| Endometrial hyperplasia | 4 (10.0) | 3 (7.5) | |
| Preoperative Hb (g/dL, range) | 12.0 (9.5–14.7) | 12.0 (9.3–15.1) | .999 |

BMI, body mass index; TLH, total laparoscopic hysterectomy; Hb, hemoglobin.

[a]Preoperative diagnosis was done by sonography in myoma, adenomyosis, or both. Endometrial hyperplasia was diagnosed with endometrial biopsy or dilatation and curettage.

most common pathology: 19 of 40 (47.5%) and 13 of 40 (32.57%) in gasless and conventional TLH, respectively. No serious complications such as ureter, bladder, or bowel injury were noted. There were no cases of conversion to open surgery, and neither were there any cases of retraction-site abdominal-wall injury.

## DISCUSSION

In the current study, a new abdominal-wall retraction system for gasless TLH was developed, which was shown to provide easy setup and a proper operation field for laparoscopic hysterectomy; moreover, it was demonstrated to effect operation outcomes similar to those of conventional $CO_2$-based laparoscopy.

Gasless TLH has been reported to present several advantages over $CO_2$ pneumoperitoneum. Gasless TLH has less effect on cardiopulmonary function, and it reduces the number of complaints of shoulder pain and PONV that arise frequently after $CO_2$ pneumoperitoneum.[13,14] Another advantage of gasless TLH is the continuous suction with no abdominal-wall collapse; indeed, no vaginal occluder for gas sealing is required. In conventional laparoscopy using $CO_2$ gas, abdominal-wall collapse arises from oversuction or gas leakage through the vaginal incision site. When abdominal-wall collapse arises from oversuction of active bleeding in conventional laparoscopy, waiting for reaccumulation of $CO_2$ gas is a waste of time, and more time to control

**Table 2.**
Surgical Results between Gasless TLH and Conventional TLH

| Variables | Gasless TLH (N = 40) | Conventional TLH (N = 40) | *P* value |
|---|---|---|---|
| Incision to retraction setup time (median, range) | 8.0 (4–12) | | NA |
| Single-port access (%) | 18 (45) | | NA |
| Total operation time (median, range) | 80.0 (65–170) | 82.5 (45–180) | .706 |
| Estimated blood loss, ml (median, range) | 100 (50–500) | 200 (50–800) | .096 |
| Uterus weight, g (median, range) | 230 (80–940) | 260 (110–830) | .107 |
| Pelvic adhesion (%) | 9 (22.5) | 7 (17.5) | .781 |
| Hb change[a] | 1.5 (0.3–2.9) | 1.7 (0.1–4.0) | .549 |
| Pathology (%) | | | .406 |
| Myoma | 19 (47.5) | 13 (32.5) | |
| Adenomyosis | 6 (15.0) | 11 (27.5) | |
| Myoma and adenomyosis | 11 (27.5) | 13 (32.5) | |
| Endometrial hyperplasia | 4 (10.0) | 3 (7.5) | |
| Major complications[b] | none | none | NA |

TLH, total laparoscopic hysterectomy; NA, not available; Hb, hemoglobin.

[a]Between preoperative and postoperative day 1.

[b]Major complications include ureter, bladder, and bowel injury.

bleeding is required. Gasless TLH can be performed without concern for gas leakage.

To date, two abdominal-wall retraction systems have been introduced for gasless laparoscopy: intraabdominal-wall retraction and subcutaneous lifting of the abdomen. Intraabdominal-wall retraction lifts the full thickness of the abdominal wall from the intraabdominal peritoneum. Currently the modes of intraabdominal-wall retraction are as follows: intraabdominal fan retractor (Mizuho Co., Tokyo, Japan), AbdoLife system (Karl Storz GmbH & Co., KG, Tuettingen, Germany), and Laparolift (Origin Medsystems, Inc., Menlo Park, CA).[15,18,19] Other innovative intraabdominal-wall retraction systems have been reported as well.[20,21] The other abdominal-wall retraction system entails subcutaneous lifting of the abdomen while round or curved rigid wires are placed in the subcutaneous tissue of the abdomen and then fixed to a surgical retractor. Currently the two subcutaneous lifting systems are the Subcutaneous Lift System (Mizuho Co., Tokyo, Japan) and the Laparotenser (Lucini Surgical Concept, Milan, Italy).[22,23]

Our J-shaped retractor is one such intraabdominal-wall retraction system. In Korea, abdominal-wall retraction is rarely used for gasless laparoscopy, so we undertook to design a new system. Our J-shaped retractor was developed for wide elevation of the abdominal wall by a long blade clamped to the Thompson retractor, which is one of the most commonly used surgical retractors worldwide. Our system is easy and simple for lifting of the abdomen while creating a good operation field. In the current study, the mean setup time was 7.4 min from umbilical skin incision to abdominal-wall retraction. The mean lifting time from umbilical wound retraction to final lift of the abdomen was 3 min (data not shown). We used single-port incision of the umbilicus as the conventional single-port surgery, with which no additional incision is required for setup of abdominal-wall retraction. In addition to physiologic advantages, other, surgical advantages exist. Gasless single-port access through umbilical incision is cost effective.[19,21] Similarly, our intraabdominal retraction system using the J-shaped retractor and the Thompson retractor is also cost effective in that it incorporates a wound retractor such as the Alexis retractor, which is inexpensive relative to the costs of conventional single-port devices for gas sealing.

Thus far, several studies have been reported for gasless TLH, each having used its own retraction method. The number of studies in which more than 10 hysterectomies were performed is five. In these five studies, four used the intraabdominal-wall retraction method and one used subcutaneous lifting retraction.[19,21,24–26] Among five studies

with gasless laparoscopic hysterectomy, ureteral injuries were rarely reported, and there were no reports of any other major complications. The authors concluded that gasless TLH is a feasible and cost-effective method. This notwithstanding, gasless TLH is not widely performed. The reason might be that there is neither any standard retractor nor any commercially available supplement for abdominal-wall retraction systems. Another reason could be the close distance between the bowel and uterus, despite the adequate working field. What also should be noted is the potential for abdominal-wall injury from retractor pressure or subcutaneous penetration, not to mention the time consumption of retraction system setup. For this latter reason, abdominal-wall retraction systems should be simple and easy for minimal setup time.

Although gasless TLH has several advantages including cost-effectiveness and reduced incidence of postoperative shoulder pain and nausea/vomiting, several limitations had been reported. One of the main obstacles is the bowel's occupation of much of the pelvic space. $CO_2$ pneumoperitoneum elevates the whole abdominal wall, whereas the abdominal lifting method in gasless TLH raises mainly the lower abdominal wall only. Abdominal lifting for gasless TLH presents the bowel and target tissue in close proximity, whereas $CO_2$ pneumoperitoneum, by contrast, has the spacious upper abdominal cavity for the bowel. This problem might be resolvable by use of the steep Trendelenburg position and preoperative bowel preparation. Another solution, this one based on our experience, is placement of one or two surgical bowel gauze pads on the bowel, by which we move the bowel with the bowel gauze pads from the pelvic cavity to the upper abdomen and, finally, wet the gauze pads to hold the bowel by gravity. This is a simple and good surgical tip that we use for routine procedures. Usually, bowel occupation of the pelvic space does not constitute an obstacle in patients with low or normal BMI; obese women, however, present a difficult operation field. Obese patients or those lacking bowel preparation are not recommended for gasless TLH. Initially, we performed gasless TLH on all patients, but obese patients and those lacking bowel preparation proved difficult with respect to this procedure. Subsequently, we selected patients with a BMI of less than 25 and bowel preparation.

One of the limitations of this study is its having been a retrospective review. The other limitation is the different surgical techniques between conventional and gasless TLH: whereas conventional TLH uses three ports, gasless TLH uses either a single port or two ports. Also, because this was a feasibility study for our unique abdominal-wall retraction system, the number of patients was insufficient for any conclusions to be drawn on the issue of the system's safety against vessel, urinary, or bowel injury.

## CONCLUSION

Our new abdominal-wall retraction system was demonstrated to be feasible for TLH. Further study investigating the physiologic advantages of this system or of other gynecologic laparoscopic surgeries is required.

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