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Gasless laparoscopy for benign gynecological diseases using an abdominal wall-lifting system

Yue WANG, Heng CUI[†‡], Yan ZHAO, Zhi-qi WANG

(*Department of Obstetrics and Gynecology, Peking University People's Hospital, Beijing 100044, China*)

[†]E-mail: cuiheng20@163.com

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Abstract: Objectives: The use of gasless laparoscopy with an abdominal wall-lifting device for benign gynecological diseases was compared to conventional laparoscopy with CO_2 pneumoperitoneum. Methods: From February 2007 to July 2007, 76 women with uterine and/or adnexal benign diseases and candidates for laparoscopic surgery were recruited in this study. Thirty-two women underwent gasless laparoscopic surgery and 44 women underwent pneumoperitoneum laparoscopic surgery. Results: Diverse pathologies, including adnexal cyst, uterine myoma and ectopic pregnancy, were treated successfully with gasless laparoscopic surgery. Compared with the patients in the pneumoperitoneum group, the similar hospital stay (P=0.353) and intraoperative blood loss (P=0.157) were observed. However, the mean operative time in the gasless group was significantly longer than that in the pneumoperitoneum group (P=0.003). No severe intraoperative or postoperative complications were found in either group, except for one case of laparotomic conversion in the pneumoperitoneum group due to dense pelvic adhesions. The total hospital charges were significantly less in the gasless group than in the pneumoperitoneum group (P=0.001). In 38 cases of ovarian cyst resection, the mean operative time in the gasless group remained longer than that in the pneumoperitoneum group (P=0.017). The total hospital charges were also significantly less in the gasless group than in the pneumoperitoneum group (P<0.001). Conclusion: Our preliminary results demonstrated that the laparoscopic procedure using the gasless technique was a safe, effective method to treat benign gynecological diseases. Moreover, it was easy to master. As a minimally invasive treatment, gasless laparoscopic surgery provides a good choice to patients in the undeveloped regions in China without increasing the patients' and the government's burden significantly.

Key words: Gasless laparoscopy, Pneumoperitoneum laparoscopy, Ovarian cyst resection
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INTRODUCTION

The laparoscopic procedure was described firstly by Semm (1978; 1979), with the advantages of minimal invasiveness, less postoperative pain and a shorter recovery period. This technique has been employed broadly for gynecological diseases in many developed countries. However, the expensive laparoscopic instruments and the difficulty of mastering the skills limit its wide use in many undeveloped regions. The increased hospital cost is also dramatic due mainly to general anesthesia and increased operative time. Till now, laparotomy is still the most frequently employed treatment for the excision of a small adnexal cyst or a leiomyoma in the undeveloped regions in mainland China. In 1993, a new technique, isobaric (gasless) laparoscopic surgery using an abdominal wall-lifting device, was introduced (Smith *et al*., 1993; Chin *et al*., 1993). This procedure can be performed under epidural anesthesia rather than general anesthesia. It can be also performed by using conventional surgical instruments, which can be introduced through small abdominal incisions (Topel, 1994; Hill *et al*., 1994). Thus, the possible financial savings by avoiding general anesthesia and expensive laparoscopic instruments made it a promising alternative minimally invasive procedure to treat pelvic diseases.

[‡] Corresponding author

Presently, some reports about gasless laparoscopic surgery for gynecological diseases have been appearing (Damiani *et al*., 2003; Kruschinski *et al*., 2004; Tintara and Choobun, 2004; Sesti *et al*., 2006). However, limit data are available in China (Li *et al*., 2001). We performed a series of gasless laparoscopic procedures using a subcutaneous abdominal wall-lifting system in patients with benign pelvic disease and without any contraindication for laparoscopic surgery. The outcomes of these procedures were evaluated retrospectively and compared to those of the procedures using pneumoperitoneum. The aim of this study is to assess the feasibility and the economic benefit of gasless laparoscopic surgery, and to evaluate the advantages and disadvantages of this technique in comparison with the conventional laparoscopic procedure using CO_2 pneumoperitoneum.

MATERIALS AND METHODS

Patients

From February 2007 to July 2007, 76 women with uterine and/or adnexal benign diseases and candidates for laparoscopic surgery at the Department of Obstetrics and Gynecology, Peking University People's Hospital, Beijing, China were recruited in this study. Informed consent was obtained from all patients after the risks and the complications were explained. Thirty-two patients underwent gasless laparoscopic surgery with the abdominal subcutaneous wall-lifting system; during the same period, 44 patients underwent conventional laparoscopic surgery using CO_2 pneumoperitoneum as a comparison.

Indications for surgery were benign uterine and/or adnexal tumor or ectopic pregnancy with stable vital signs. All patients underwent transvaginal ultrasound examinations to assess the uterine and adnexal abnormalities and presence/absence of associated pelvic diseases, since many cysts are physiological in nature and regress over time. The patients with an ovarian cyst were all reevaluated in at least six weeks, and any persistent mass was considered a potentially true neoplasm and operative evaluation pursued. In addition, if the patient was symptomatic with hemorrhage of a ruptured cyst or pain of an ovarian torsion, either physiological or pathological, operative intervention was indicated.

Contraindications for surgery included suspected malignancy and communicable diseases. Cervical cancer was excluded by cytological examination. When patients had abnormal uterine bleeding, an endometrial biopsy was performed to exclude suspected endometrial cancer. For ovarian tumors, suspected malignancy was carefully excluded by the preoperational evaluation, including history, clinical findings, ultrasound scans and the levels of serum cancer antigen 125 (CA-125), alpha fetoprotein (AFP), carcino-embryonic antigen (CEA) and cancer antigen 199 (CA-199). In addition, communicable diseases were screened by tests of serum antibodies for human immunodeficiency virus, hepatitis B virus and hepatitis C virus. Syphilis was screened by treponemal hemagglutination (TPHA) test.

Operators

Ten experienced gynecologists performed conventional laparoscopic surgery. Five of them also performed laparoscopic surgery using the gasless device. Sixteen younger gynecologists participated in the surgeries as assistants.

Surgical procedure

During the gasless laparoscopic procedure, special surgical instruments (Mizuho Medical Inc., Tokyo, Japan, Fig.1a) and conventional surgical instruments were both employed. Briefly, after anesthesia was induced, the patient was positioned in either a prostrate or lithotomy position, a sterilized stainless steel scaffold consisting of a lifting arm was attached to the operating table (Mizuho Medical Inc., Tokyo, Japan, Fig.1b). A sterilized needle was inserted through the subcutaneous tissue in the hypogastric zone and drafted by an abdominal wall retractor. The abdominal wall was then slightly elevated to make a working space (Fig.1c). A 10-mm telescope was inserted into the umbilical mini-laparotomy incision. After inspection of the pelvis and ensuring there was no severe dense adhesions in the operating field, a 2-cm minilaparotomy was performed under direct vision (Fig.1d) and another 10-mm valveless cannula was inserted in the bilateral lower abdominal walls respectively as the instrument ports; then the instruments could be introduced via the minilaparotomy incisions.

A Trendelenburg position at approximately 30°

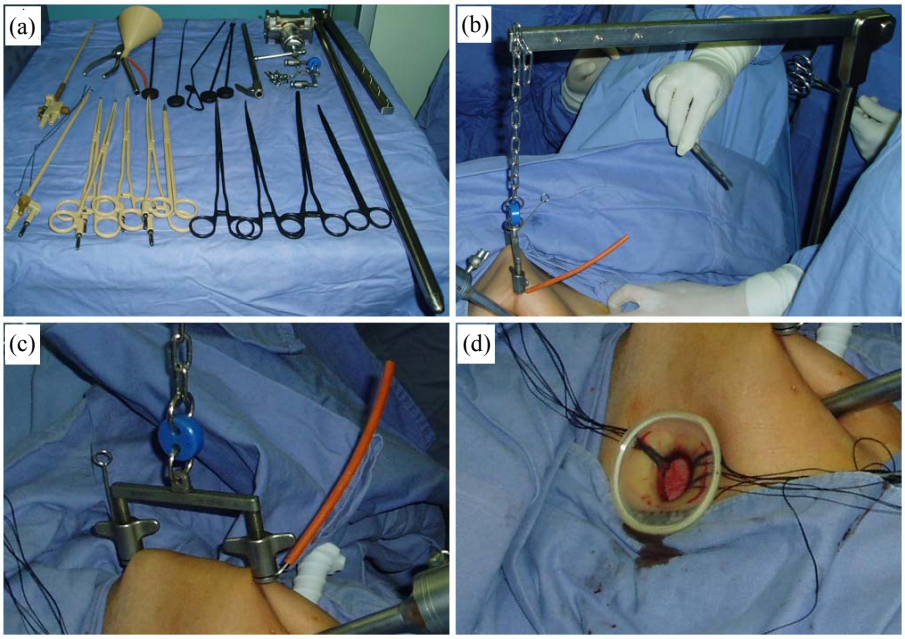

Fig.1 The subcutaneous abdominal wall-lifting system. (a) Special surgical instruments were used in the gasless laparoscopic procedures; (b) The sterilized stainless steel scaffold consists of a lifting arm; (c) The abdominal wall was drafted by the abdominal wall retractor; (d) The minilaparotomy incision was performed in the lower abdominal wall as an instrument port

was taken. The surgical steps were the same between the gasless group and the pneumoperitoneum group. The appropriate procedure selected depended on the patient's diseases, age and desire for future fertility. For larger ovarian cysts, the cyst was punctured and its contents aspirated endoscopically. For bigger size myomas, myomectomy was carried by the electrical morcellators. The excised specimens were removed either via the biggest port directly or by an extraction pouch. Bipolar coagulation and ligation were used to control bleeding. Finally, at the end of each intervention, the pelvis was washed with saline solution. At the completion of the procedure, incisions larger than 10-mm were all closed by sutures.

Intravenous drip levofloxacin and metronidazole were routinely used for 3 or 4 d in all cases as prophylactic antibiotics. Complications were defined as those occurrences that required active treatment or prolonged hospital stay.

Materials collection

Patient's characteristics were recorded, including age, parity, body mass index (BMI), and previous laparotomies. The indication of surgery, pathological results and the subtype of ovary tumors were also recorded. The duration of surgery was calculated by studying the anesthesia record. The intraoperative blood loss was calculated by the total volume of the fluid in the suction bag taking the irrigation away. Intraoperative and postoperative complications as well as hospital stay were recorded. Total hospital charges were calculated from the account that patients paid after they were discharged. It was the sum of operation charges plus other charges that covered the anesthesia, drugs (including antibiotics, anesthetics and others), nursing and others.

Data analysis

Statistical analysis was performed by using the One-way analysis of variance (ANOVA) test for continuous variables using the Statistical Package for Social Science for Windows 12.0 (SPSS Inc., Chicago, USA). Statistical significance was set at $P<0.05$.

RESULTS

No significant differences in patients' age, parity and BMI were detected between the two groups except

the previous laparotomes (Table 1). Eight women had a previous caesarean section history; seven of them underwent pneumoperitoneum laparoscopic surgery and one in the gasless group. Four women had previous laparotomies, which were appendectomy, cholecystectomy, sterilization and sub-hysterectomy, respectively. They all underwent pneumoperitoneum laparoscopic surgery. The medical conditions were also assessed in each patient. Three women were diagnosed with hypertension, two with type II diabetes mellitus, and six women each with asthma, atrioseptopexy, chronic hepatitis type B, L4–5 protrusion of intervertebral disc, leucocytopenia and epilepsy after tuberculous meningitis, respectively. In addition, a woman underwent previous surgery for early stage breast cancer.

To test the feasibility and safety, the gasless laparoscopic procedure was performed in diverse pathologies. The most common indication was pelvic mass, including 49 cases of adnexal cyst (22 in the pneumoperitoneum group, 27 in the gasless group) and 12 cases of uterine myoma (8 underwent pneumoperitoneum laparoscopy, 4 underwent gasless laparoscopy). Emergent surgeries were performed, including 9 cases of ectopic pregnancy (8 underwent pneumoperitoneum laparoscopy, 1 case of rudimentary horn pregnancy was treated successfully with gasless laparoscopy), 2 cases of the rupture of corpus luteum (both in the pneumoperitoneum group), 2 cases of ovarian cyst with pedicle torsion (both in the gasless group) and 1 case of rupture of abscess (in the pneumoperitoneum group). In addition, 4 patients underwent pneumoperitoneum laparoscopy because of adenomyoma, endometrial hyperplasia, pelvic organ prolapse, and chronic pelvic inflammatory (including chronic salpingitis bilateral hydrosalpinx and tuboovarian abscess), respectively. Pathological results of ovarian tumors include serous, mucinous, mature cystic teratoma, simple cyst, cystic adenofibroma, fibrothecomas, inclusion cyst and thecoma. In addition, parovarian cyst, mesosalpinx cyst, ovarian endometrioma, tuboovarian cyst, mesonephric cyst and ovarian low malignant potential fibroid were also detected.

The major surgeries included 38 cases of ovarian cyst resection (19 in the pneumoperitoneum group, 19 in the gasless group), 9 cases of salpingo-oophorectomy (4 in the pneumoperitoneum group, 5 in the gasless group), 5 cases of myomectomy (1 in the pneumoperitoneum group, 4 in the gasless group), 13 cases of laparoscopic-assisted vaginal hysterectomy (LAVH) (11 in the pneumoperitoneum group, 2 in the gasless group), 9 cases of salpingectomy (all in the pneumoperitoneum group), 1 case of oophorectomy and 1 case of resection of rudimentary horn (both in the gasless group).

In each group, the durations of surgery, intraoperative blood loss, and intraoperative and postoperative complications as well as hospital stays were recorded and evaluated retrospectively for comparison (Table 2). General anesthesia was performed on all patients who received pneumoperitoneum laparoscopic procedure. Except 7 cases, 22 women received epidural and spinal anesthesia and 3 women received epidural anesthesia in the gasless group. The two groups had similar hospital stays (P=0.353) and intraoperative blood loss (P=0.157). However, the mean operative time in the gasless group was significantly longer than that in the pneumoperitoneum group (P=0.003) (Table 2). No severe intraoperative and postoperative complications were found in either group, except for one case of laparotomic conversion in the pneumoperitoneum group due to dense pelvic adhesions. The hospital charges of both treatment groups are shown in Table 2. Total hospital charges, operation charges and other charges were all significantly less in the gasless group than in the pneumoperitoneum group (P=0.001, 0.006 and 0.003, respectively).

Since various procedures were performed, we analyzed the operative outcomes in 38 cases of ovarian cyst resection only to reinforce the comparability. The diameters of the largest cyst of each patient ranged from 3 to 10 cm, and the mean sizes of the ovarian cysts in the two groups were comparable (P=0.631). No difference was detected between the two groups in hospital stay (P=0.492) and intraoperative blood loss (P=0.180) (Table 3). The mean duration of gasless laparoscopic procedures remained longer than that of pneumoperitoneum laparoscopic procedures (P=0.017). The total hospital charges, operation charges and other charges remained significantly less in the gasless group than in the pneumoperitoneum group (P<0.001, P=0.011 and P<0.001, respectively) (Table 3).

Meanwhile, in the 38 cases of ovarian cyst

Table 1 Patient characteristics

Group	Age (year)	Parity	Nulliparous women	Body mass index (kg/m^2)	Previous laparotomy (%)
PL (n=44)	36.9±12.3 (19~69)	0.6±0.7 (0~7)	19 (43.2%)	22.8±4.2 (17~34)	10 (22.7%)
GL (n=32)	35.0±12.5 (16~79)	0.8±1.0 (0~5)	12 (37.5%)	22.0±3.0 (17~28)	1 (3.1%)
P value[a]	0.517	0.345	0.398	0.411	0.02

PL: pneumoperitoneum laparoscopy; GL: gasless laparoscopy. Values expect P values are expressed as mean±SD (range) or n (%); [a]One-way ANOVA test

Table 2 Outcome and hospital charges

Group	Operating time (min)	Estimated blood loss (ml)	Hospitalization (d)	Total hospital charges (Yuan)	Operation charges (Yuan)	Other charges (Yuan)
PL (n=44)	82±38 (35~205)	140±132 (50~500)	9.2±3.1 (5~21)	6827±2184 (3881~16052)	2265±528 (1624~3722)	4562±2004 (2225~13640)
GL (n=32)	111±44 (45~205)	102±88 (50~400)	8.7±1.7 (6~12)	5275±1627 (3500~11269)	1945±414 (1524~2946)	3329±1335 (1822~8323)
P value[a]	0.003	0.157	0.353	0.001	0.006	0.003

PL: pneumoperitoneum laparoscopy; GL: gasless laparoscopy. Values expect P values are expressed as mean±SD (range); [a]One-way ANOVA test

Table 3 Outcome and hospital charges for ovarian cyst resection

Group	Size of the largest cyst (cm)	Operating time (min)	Estimated blood loss (ml)	Hospitalization (d)	Total hospital charges (Yuan)	Operation charges (Yuan)	Other charges (Yuan)
PL (n=19)	5.8±1.9 (3.0~10.0)	70±28 (35~150)	122±143 (50~500)	8.3±2.0 (6~13)	5839±829 (3881~7096)	2076±331 (1656~2757)	3763±713 (2225~4922)
GL (n=19)	6.1±1.8 (3.0~10.0)	98±40 (45~187)	73±59 (50~300)	8.7±1.8 (6~12)	4602±969 (3500~7923)	1802±298 (1556~2648)	2800±809 (1822~5275)
P value[a]	0.631	0.017	0.180	0.492	<0.001	0.011	<0.001

PL: pneumoperitoneum laparoscopy; GL: gasless laparoscopy. Values expect P values are expressed as mean±SD (range); [a]One-way ANOVA test

resection, the averages of total hospital charges were RMB (5704±848) Yuan in 22 cases who underwent laparoscopy under general anesthesia, RMB (4580±1079) Yuan in 15 cases who underwent laparoscopy under epidural and spinal anesthesia, and RMB 4176 Yuan in one remaining case under epidural anesthesia (ANOVA test, F=6.906, P=0.003, df=2, 35). To avoid bias from the inference of the experience of the surgeon to the operative time, we also analyzed the mean operative time by different operators in a total of 38 cases of ovarian cyst resection in both groups. No association was found between the duration of operation and the operators (ANOVA test, F=1.170, P=0.348, df=6, 31).

DISCUSSION

It is known that laparoscopy has an advantage over conventional laparotomy, such as shortened hospitalization, smaller incisions and quicker recovery. However, during conventional laparoscopic surgery, the pneumoperitoneum was established and maintained by constant CO_2 insufflation. It brings a series of problems, such as bradyarrhythmias, venous stasis, gas embolism, subcutaneous emphysema and hypercarbia. Gasless laparoscopy, however, is not associated with risks arising from CO_2 insufflation (Ogihara *et al*., 1999). Till now, the gasless technique had been employed widely in laparoscopic procedures, such as cholecystectomy (Larsen *et al*., 2001), colon rector tumors resection (Jiang *et al*., 2001), as well as gynecological surgery, including myomectomy (Damiani *et al*., 2003; Sesti *et al*., 2006), hysterectomy (Kruschinski *et al*., 2004), ovarian cyst resection (Tintara and Choobun, 2004), colposuspension (Davila *et al*., 2004) and radical hysterectomy (Bojahr *et al*., 1996). Furthermore, the gasless laparoscopic procedure can also be performed on high-risk patients with poor cardiorespiratory reserve (Alijani and

Cuschieri, 2001) or even on pregnant women (Oguri *et al*., 2005). In this study, we used the gasless technique successfully in different gynecological diseases with smooth procedures and good outcomes. The technique was also employed in two patients with atrioseptopexy and epilepsy after tuberculous meningitis, respectively. No related complications were observed.

During the pneumoperitoneum laparoscopic procedure, gas loss from the instrument ports and the frequent maneuvering of suction may decrease the space size of the operative field; therefore, the operator must await CO_2 re-insufflation to restore the operative space. In the gasless laparoscopic procedure, without the gas leak problem, smoke produced during coagulation or cutting can be sucked continuously to keep the operative field clear. In addition, removal of big solid specimens is always difficult in conventional laparoscopic surgery. However, using the gasless technique, the minilaparotomy incision makes it easy by introducing and removing an extraction pouch or by using the fingers to remove the specimens, such as bigger myomas (Damiani *et al*., 2006) or large bony parts in the dermoid cyst (Takeda *et al*., 2007). In the meantime, large vessels legation can be done by extracorporeal knot-typing, which saves time and avoids severe bleeding during surgery. In this study, no severe postoperative complications occurred. All patients were discharged successfully. The similar intraoperative blood loss during laparoscopic procedures between the gasless group and the pneumoperitoneum group indicated the safety of this new technique. The outcomes demonstrated that gasless laparoscopic surgery for benign pelvic pathologies could be performed as safely and effectively as conventional laparoscopy.

Today, various abdominal wall-lifting techniques have been reported (Hill *et al*., 1994; Nakamura *et al*., 1996; Tintara *et al*., 1998). In the present study, we employed the abdominal wall-lifting system (Mizuho Medical Inc., Tokyo, Japan) with a simplified lifting device that can be installed and used easily. No abdominal wall trauma was found. Compared with pneumoperitoneum laparoscopic procedure, the technique of the gasless laparoscopic procedure was relative easy to master. Although a relatively long operative duration was found in the gasless group compared with that in the conventional laparoscopy group, this may be due partially to this new technique being unfamiliar to the operators and assistants. Actually, from our experience, after a short period of learning and training, many young gynecologists without much laparoscopic surgery experience could be competent enough to be an assistant, because most of them were familiar with minilaparotomy. It is suggested that either experienced laparoscopists or the untrained ones could master this technique quickly. Therefore, the technique is recommended in the primary hospitals in developing regions and avoids high cost and long term surgeon's training.

The most important point is that the general anesthesia is required in conventional laparoscopic surgery using CO_2 pneumoperitoneum because of pulmonary restrictions resulting from increased intra-abdominal pressure during the procedures. In contrast, gasless laparoscopy avoids the derangement of pulmonary mechanics, so it can be performed under local and epidural anesthesia, and therefore decreases the operating room charges (Kruschinski and Homburg, 2005). In our study, the total hospital charges in the gasless group were significantly less than those in the pneumoperitoneum group. Excluding the operation charges, the other charges in the gasless group remained significantly less than those in the pneumoperitoneum group. Because a similar hospitalization was observed between the two groups and the same antibiotics were used, the difference in other charges between the two groups supposedly came from anesthesia and anesthetics. Moreover, among 38 women who underwent ovarian cyst resection, the analysis showed that the total hospital charges in cases under epidural and spinal anesthesia were significantly less than those in the cases under general anesthesia, so the saved cost came mainly from the anesthesia and related medication charges. Furthermore, for good visualization of the operative field with pneumoperitoneum, gas-sealing is required during surgery and results in high surgical equipment cost. However, the gasless technique, which allows the use of a valveless port and conventional surgical instruments, therefore avoids the high cost of insufflator and gas-sealing ports. This makes the technique a favorable alternative for small medical institutions.

As mentioned before, compared with conventional laparoscopic surgery, the gasless laparoscopic

procedure has the same advantages, such as decreased postoperative pain, a shorter hospital stay and recovery period (Guido *et al*., 1998; Sesti *et al*., 2008). But, in this study, we found a longer operative duration in the gasless group, although it may partially result from unfamiliarity with the new technique among the operators as mentioned above. Another important reason should also be considered. Although the operative field could be kept clear by continuous suction in the gasless laparoscopic procedure without the worry of a gas leak, the exposure created by an abdominal wall-lifting is not as wide as that obtained from CO_2 pneumoperitoneum. The roof of the pelvic cavity was a triangle created by the abdominal wall-lifting system. However, an arch type dome could be built by CO_2 insufflation. In addition, the intestines were easily dilated and moved into the pelvic cavity during the gasless laparoscopic procedure because there is no high pressure to push the intestines away like the CO_2 pneumoperitoneum does, especially in obese and nulliparous women. This may be related to increased technical difficulty and poorer visualization, such as when the tumor was located in a corner of the pelvis and not easy to remove, therefore leading to prolonged operative time. This drawback may offset some benefits of the gasless procedure and was also noted by others (Goldberg and Maurer, 1997; Johnson and Sibert, 1997; Lukban *et al*., 2000). So, careful clinical evaluation of the therapeutic indication in patients is very important. However, along with more clinical practice, the surgeons will master the skill more precisely and perform it more quickly in the future.

In conclusion, although limitations in patient recruitment within a reasonable time period reduce the likelihood of detecting complications, our preliminary results do suggest that the laparoscopic procedure using the gasless technique is a safe, effective method to treat benign gynecological pathologies, and that it is also easy to master. Gasless laparoscopy has some advantages over pneumoperitoneum laparoscopy, particularly in the saving of hospital charges. As a minimally invasive treatment, gasless laparoscopic surgery provides a high-level medical service to meet the requirement of patients in undeveloped regions in China, without increasing the patients' and the government's burden significantly, especially for people covered by the basic medical insurance.

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