ORIGINAL ARTICLE

Clockwise, Modularized Lymphadenectomy in Laparoscopic Gastric Cancer Surgery: a New Laparoscopic Surgery Model

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Abstract

Background The aim of the study is to present the clockwise, modularized lymphadenectomy model of laparoscopic gastrectomy for gastric cancer patients, which is based on our clinical practice experience in laparoscopic gastric cancer surgery.

Methods From Jan 2015 to July 2017, 116 patients who underwent laparoscopic gastrectomy were retrospectively collected and analyzed. According to the different resection models, patients were divided into two groups: traditional laparoscopic lymphadenectomy group (63 patients) and clockwise, modularized lymphadenectomy group (53 patients). Operation-related parameters were compared between the two groups.

Results The clockwise, modularized lymphadenectomy group had less dissection time (119.8 ± 19.1 min vs. 135.3 ± 23.8 min, $p < 0.001$) and less intraoperative blood loss (81.7 ± 42.9 ml vs. 91.4 ± 28.7 ml, $p = 0.016$) compared with the traditional laparoscopic lymphadenectomy group. Meanwhile, the clockwise, modularized lymphadenectomy group had more numbers of examined lymph nodes (40.5 ± 14.3 vs. 33.9 ± 11.0, $p = 0.007$) than the traditional laparoscopic lymphadenectomy group. Besides, there was no statistically significant difference in the postoperative complication rates between the two groups. The clockwise, modularized lymphadenectomy group had shorter postoperative hospital stay than the traditional laparoscopic lymphadenectomy group (8.7 ± 3.2 days vs. 10.4 ± 3.9 days, respectively, $p < 0.001$).

Conclusions Through the adoption of the fixed sequence of lymphadenectomy, requirements and standard of lymphadenectomy of each lymph node station, and specific surgical skills for intraoperative exposure by the clockwise and modularized lymphadenectomy model, we can optimize and facilitate the laparoscopic gastric cancer surgery.

Keywords Gastric cancer · Lymphadenectomy · Laparoscopy · Surgery

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Abbreviations

TLL	Traditional laparoscopic lymphadenectomy
CML	Clockwise, modularized lymphadenectomy
BMI	Body mass index
LEGV	Left gastroepiploic vein
ISV	Inferior spleen vein
REGV	Right gastroepiploic vein
ASPDV	Anterior superior pancreaticoduodenal vein
ARCV	Accessory right colic vein
RGA CHA	Common hepatic artery
LGA	Left gastric artery
LGV	Left gastric vein
SV	Splenic vein
SA	Splenic artery

Introduction

Laparoscopic surgical treatment of gastric cancer has been widely adopted in East Asian countries during the past decades.[1–3] This practice is not only based on the development of the laparoscopic surgical instrument but also due to the comprehensive recognition and understanding of the benefits of laparoscopic surgery for gastric cancer patients, as well as the accumulation of experience with its use in gastric cancer patients. Laparoscopic distal gastrectomy can be set as a routine treatment strategy for early gastric cancers according to the latest Japanese Gastric Cancer Treatment Guidelines.[4] Laparoscopic distal gastrectomy for early-stage gastric cancer patients has been successfully shown to produce short-term and long-term outcomes similar to traditional open surgery.[5–7] For advanced gastric cancers, laparoscopic D2 distal gastrectomy is as feasible and safe as open gastrectomy.[8–10] However, the long-term survival outcomes of laparoscopic gastrectomy for advanced gastric cancers still remain to be seen.[3,11,12]

The surgical techniques of laparoscopic gastrectomy have become increasingly developed during the last years.[13] However, how to consistently and perfectly perform each laparoscopic operation, which requires operational skills to overcome technical limitations, remains unclear. As one of the earliest hospitals to perform laparoscopic gastric cancer surgery in China, our team has been exploring the laparoscopic techniques for the treatment of gastric cancers since 2006.[14] To facilitate and achieve a more thorough lymphadenectomy and with the accumulated experience, we designed a laparoscopic gastrectomy model that is especially for the laparoscopic dissection of lymph nodes, which is called "clockwise, modularized lymphadenectomy".[15] This model includes three components: fixed sequence of lymphadenectomy, requirements and standard of lymphadenectomy of each lymph node station, and specific surgical skills for intraoperative exposure. Therefore, this study was conducted to summarize the experience and the primary results of applying the clockwise, modularized lymphadenectomy for laparoscopic gastric cancer surgery.

Materials and Methods

Patients

The clinicopathological characteristics of the study patients were gathered from the database of Surgical Gastric Cancer Patient Registry in West China Hospital. Its registration number is WCH-SGCPR-2017-05. The establishment of the database of Surgical Gastric Cancer Patient Registry was approved by the Biomedical Ethics Committee of the West China

Hospital, Sichuan University, China. Patient records were anonymized and deidentified prior to analysis.

Between January 1st, 2015, and July 31st, 2017, a total of 116 consecutive gastric cancer patients who received laparoscopic gastrectomy at the Department of Gastrointestinal Surgery, West China Hospital, were retrospectively collected and analyzed in this study. Patients were divided into two subgroups according to the different resection models: patients who underwent surgery between January 2015 and August 2016 were the traditional laparoscopic lymphadenectomy (TLL) group, and patients who underwent surgery between September 2016 and July 2017 were the clockwise, modularized lymphadenectomy (CML) group. We have performed the CML surgery since September 2016 with the aim to establish standard procedures for laparoscopic gastric cancer surgery. Patients who received any preoperative chemotherapy or radiotherapy were excluded from this study.

Clinicopathological Characteristics

The preoperative, intraoperative, and postoperative parameters of those patients were included and analyzed in this study. Preoperative clinicopathological features included in this study were age, gender, and body mass index (BMI) level. The intraoperative parameters were tumor size, tumor location, resection types, total operation time, lymphadenectomy time, and intraoperative blood loss. Postoperative characteristics were the pathologic T stage, N stage, and TNM stages, the number of examined lymph nodes, postoperative 30-day complications and 90 day readmission. The pathological examination was conducted by pathologists at West China Hospital according to the 7th staging manual of the American Joint Committee on Cancer and Japanese Gastric Cancer Classification, 3rd English edition.[16,17] Postoperative 30-day complications were also recorded and analyzed according to the Clavien-Dindo classification.[18] The 90-day postoperative readmission rate was also analyzed.

Surgical Treatment

Prof. Jian-Kun Hu is the chief surgeon of the operative team and responsible for all the laparoscopic gastrectomies. All surgeons in this team were well trained and had cooperated with Prof. Hu for more than 6 years (the first assistant had cooperated with Prof. Hu for more than 10 years). Patients who were preoperatively evaluated for early gastric cancer would recommend having laparoscopic surgery. For locally advanced gastric cancers, based on the experience of the participants in the clinical trials of the Chinese Laparoscopic Gastrointestinal Surgery Study (CLASS) group, the surgical indications referred to the inclusion and exclusion criteria of the CLASS-01 and CLASS-04 trials.[8,19]

During the operation, patients were placed in a supine position with legs apart, and the operator stood on the right side

of the patient. All tissue and lymph node dissections were performed intracorporeally with a laparoscope with a pneumoperitoneum of 12–14 mmHg. For operations in the traditional laparoscopic lymphadenectomy group, the specific surgical procedures were similar to open gastrectomy, as described in our previous reports.[14] For patients undergoing traditional laparoscopic procedures, there is no need for a specific sequence of lymph node dissections of each lymph node station; lymphadenectomy from the right side to the left side or from the left side to the right side are both acceptable. The standard of lymph node dissection is adopted from the treatment guidelines of the Japanese Gastric Cancer Association.[20] Additionally, for patients undergoing traditional laparoscopic lymphadenectomy, there are no specific demands for the surgical skills and techniques for lymph node dissection.
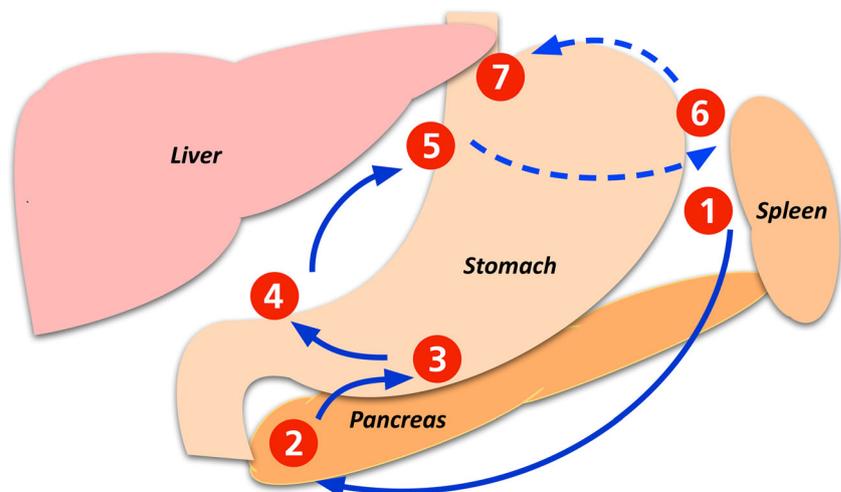
For the clockwise, modularized lymphadenectomy (Supplementary Video 1), each operation must be completed with the following three conditions: a fixed sequence of lymphadenectomy, specific requirements and a standard of lymphadenectomy, and specific surgical skills for exposure. In the example of the distal gastrectomy, first, the surgical procedures follow a fixed sequence, from left to right in a clockwise direction (Fig. 1). Specifically, we divide the lymph node dissection into five sections: first, the left gastroepiploic vessel and greater curvature area (no. 4d and no 4sb lymph nodes); second, the infrapyloric area (no. 6 lymph nodes); third, the superior pancreatic and celiac trunk area (no. 7, 8a, 9, and 11p lymph nodes); fourth, the supra pyloric area (no. 5 and no. 12a lymph nodes); and fifth, the lesser curvature area (no. 1 and no. 3 lymph nodes). For patients undergoing total gastrectomy, lymph node dissection in the spleen hilar area (sixth part) and para-cardia area (seventh part) are performed last.

In addition, this model requires the adoption of some specific interpretative exposure techniques, including hanging and fixing the liver (Fig. 2a) and bundling the stomach and great omentum (Fig. 2b), which can facilitate the exposure of

the surgical field. Additionally, we require the assistant to acquire some specific skills to help with the operative field of exposure. For example, in the dissection of lymph nodes of the upper pancreas area, we require the assistant to adopt the "non-pressing pancreas" technique, which requires the lifting of the stomach upward with the right hand, pulling the capsule of the pancreas, and turning the pancreas outward with the left hand, rather than pressing down the pancreas. These changes make the pancreatic-stomach plica surface flat so that the tissue of the upper pancreas area is maintained with sufficient tissue tension, and the tissue between the pancreas and splenic artery is superficial and facilitates operation. Additionally, we require that the assistant adjust the scope and view the operation field. For the most important aspect in this model, we set up standard procedures and have specific requirements for the surgeons for the lymphadenectomy in each lymph node area. For the first part (left gastroepiploic vessel and greater curvature area), reveal the starting point of the left gastroepiploic vessel and its first branch to the greater curvature, and cut off the left gastroepiploic vessel and remove the no. 4sb lymph nodes from the confluence of the left gastroepiploic vessel and its first branch (Fig. 3a). Then, bare the greater curvature of the stomach, and clean the no. 4d lymph nodes.

For the second part (infrapyloric area), cut the gastrocolic ligament along the edge of the transverse colon to the hepatic flexure and separate it from the space of the anterior and posterior lobe of the transverse mesocolon to the lower edge of the pancreas. Expose the shallow gap between the head of the pancreas and the transverse mesocolon and then, moving upward, reveal the confluence of the right gastroepiploic vein and anterior superior pancreaticoduodenal artery. Remove all the lymphatic tissues (no. 6v) from the surface of the head of the pancreas and cut the right gastroepiploic veins. Then, again moving upward, clear the lymph nodes of the right gastroepiploic artery (no. 6a) and cut off the right gastroepiploic artery at a point after it originates from the gastroduodenal artery (Fig. 3b). Meanwhile, clarify the origin

Fig. 1 The diagram of lymph node dissection procedures of the clockwise, modularized lymphadenectomy of laparoscopic gastrectomy. Step one: left gastroepiploic vessel and great curvature area (no. 4ds and no 4sb lymph nodes); step two: infrapyloric area (no. 6 lymph nodes); step three: superior pancreas and celiac trunk area (no. 7, 8a, 9 and 11p lymph nodes); step four: suprapyloric area (no.5 and no.12a lymph nodes); step five: lesser curvature area (no. 1 and no. 3 lymph nodes)
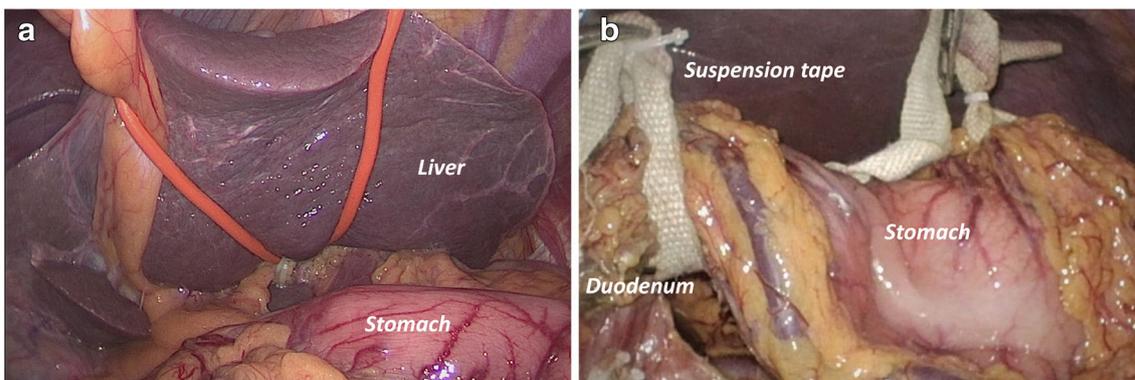
Fig. 2 The exposure tips of the clockwise and modularized lymphadenectomy. Hanging and fixing the liver (**a**) and bundling the stomach and great omentum (**b**)

of the infrapyloric artery, remove the no. 6i lymph nodes, and then cut off the infrapyloric artery. For the third part (superior pancreas and celiac trunk area), pulling upward with a strap, open the plica gastropancreatica, ossify the celiac trunk and its three branches (left gastric artery, common hepatic artery, and splenic artery), and reveal the splenic vein as much as possible. Then, cut off the roots of the left gastric artery and left gastric vein (Fig. 3c). Resect from the red-yellow borderline of

the right crura of the diaphragm to the right of the cardia area. In particular, focus on the complete resection of the lymphatic tissue in the gap between the pancreas and the common hepatic artery (no. 8a) and between the pancreas and the splenic artery (no. 11p). For the fourth part (suprapyloric area), open the nonvascular window of the upper part of the duodenal bulb, reveal the root of the right gastric artery along the vascular window, cleaning

Fig. 3 The illustration of lymphadenectomy of the clockwise and modularized model in view of laparoscopy. Left gastroepiploic vessel and great curvature area (**a**); infra pyloric area (**b**); superior pancreas and celiac trunk area (**c**); supra pyloric area and exposure the portal vein (**d**); lesser curvature area (**e**). Abbreviations: LEGV, left gastroepiploic vein; ISV, inferior spleen vein; REGV, right gastroepiploic vein; ASPDV, anterior superior pancreaticoduodenal vein; ARCV, accessory right colic vein; RGA CHA, common hepatic artery; LGA, left gastric artery; LGV, left gastric vein; SV, splenic vein; SA, splenic artery
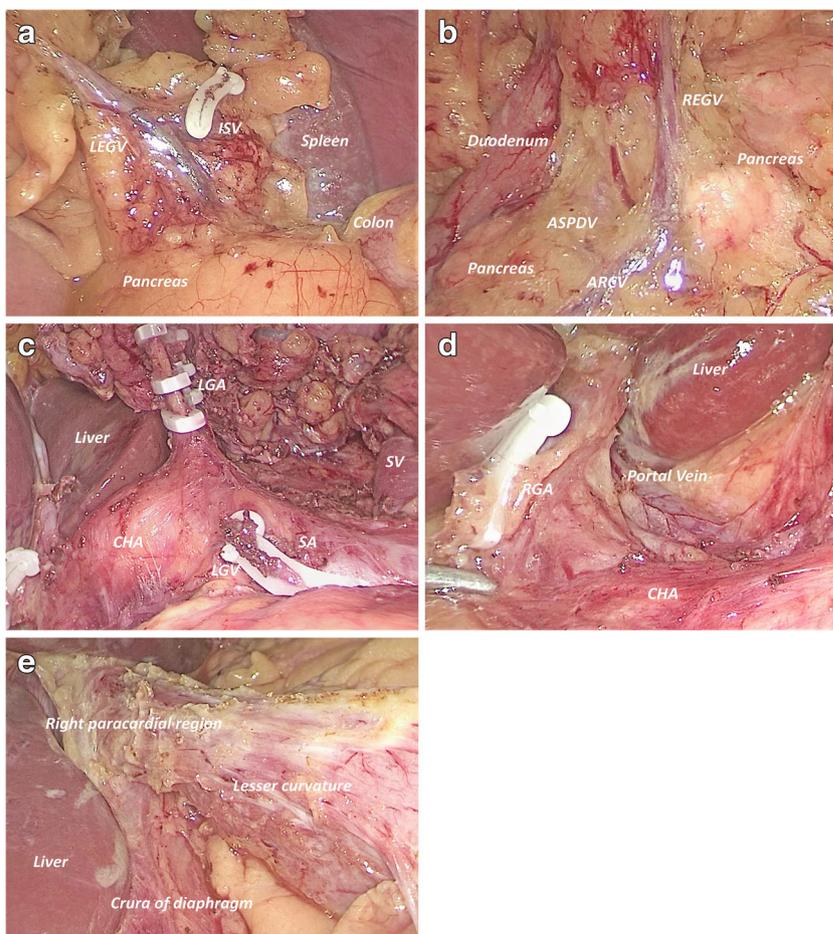
no.5 lymph nodes and then cut off it at the root. Clear lymph nodes, expose the anterior and medial walls of the proper hepatic artery and the portal vein, and remove the no.12a lymph nodes (Fig. 3d). For the fifth part (lesser curvature area), the upper lesser curvature skeletonization technique is needed to complete resection of the no. 1 and 3a lymph nodes.[21] (Fig. 3e).

Statistical Analysis

All statistical analyses were conducted with R Software (Version 3.1.2. http://www.R-project.org/). Continuous variables are expressed as the mean and standard deviation and categorical variables are expressed as numbers (%). A Mann–Whitney U test was used to analyze continuous variables and ordinal categorical variables, whereas a chi-square test was used for unordered categorical variables. A p value < 0.05 (2-sided) was defined to be statistically significant.

Results

Clinicopathological Characteristics

A total of 116 complete medical records of patients who underwent laparoscopic gastrectomy were collected from a consecutive series. There were 53 patients in the CML group and 63 patients in the TLL group. The CML group had shorter dissection and lymphadenectomy time (119.8 ± 19.1 vs. 135.3 ± 23.8, $p < 0.001$), shorter total operation time (234.7 ± 37.4 vs. 256.3 ± 49.8, $p = 0.011$), and lesser intraoperative blood loss (81.7 ± 42.9 ml vs. 91.4 ± 28.7 ml, $p = 0.016$) than the TLL group. In addition to the T stage ($p = 0.004$), the N stage and TNM stages showed no significant difference between the two groups. The age, gender, BMI level, tumor location, resection type, and tumor size were comparable between the CML and TLL groups (Table 1). The overall postoperative complication rates were compared between the CML and TLL groups (17.0% and 18.5%, $p = 0.834$). However, the CML group had a shorter postoperative hospital stay than the TLL group (8.7 ± 3.2 days vs. 10.4 ± 3.9 days, respectively, $p < 0.001$). The postoperative 90-day readmission rates were comparable between the CML and TLL groups (3.8% vs. 3.2%, $p = 1.000$). The reasons for readmission were postoperative ileus ($N = 2$) in the CML group and pulmonary infection ($N = 1$) in the TLL group.

Metastatic Lymph Node Status

Overall, on average, the numbers of positive lymph nodes were comparable between the CML group and TLL group (2.2 ± 3.3 vs. 1.5 ± 2.4, respectively, $p = 0.138$). However, the number of examined lymph nodes was 40.5 ± 14.3 in the CML group, which was 33.9 ± 11.0 more than that of the TLL group ($p = 0.007$). The subgroup areas of examined and positive lymph nodes were compared between the CML and TLL groups. The numbers of positive lymph nodes were comparable between the CML and TLL groups in the no. 1 and no. 3 stations ($p = 0.233$), the no. 4sb and no. 4d stations ($p = 0.194$), the no. 6 station ($p = 0.822$), and the no. 7, 8a, 9, and 11p stations ($p = 0.142$). However, the CML group had greater average numbers of examined lymph nodes than the TLL group in the no. 7, 8a, 9, and 11p stations (10.0 ± 4.8 vs. 7.6 ± 3.5, respectively, $p = 0.004$). However, the number of the examined lymph nodes was not significantly different in the other three areas (Table 2).

Discussion

Lymphadenectomy is a cornerstone of the gastric cancer surgery. Although several factors impact the overall survival outcomes, radical gastrectomy combined with D2 lymphadenectomy is the primary treatment strategy for advanced gastric cancers.[4,22,23] Precise, complete removal of all potential metastasized regional lymph nodes is critical to the prognosis of gastric cancer patients.[24,25] Although laparoscopic technology has made great progress in recent years, there are still some issues and concerns that need to be addressed, especially for patients with locally advanced disease: (1) using the magnification effect of the laparoscope to obtain the same or a better view as that of traditional open surgery; (2) optimizing the operational processes and reducing the risk of tissue damage and the spread of tumor cells, and (3) completely removing all regional lymph nodes. In view of these, we summarized the clockwise, modularized lymphadenectomy approach to facilitate the laparoscopic gastrectomy. We summarized the experience from our previous clinical practice and found that this manner allowed us to attain greater numbers of examined lymph nodes with less operation time and intraoperative blood loss compared with traditional laparoscopic surgery.

In recent decades, with the development of instruments and the improvement of operation techniques of laparoscopic surgery, substantial clinical evidence has supported the clinical application of laparoscopic gastrectomy for gastric cancer patients. An increasing number of surgeons and patients prefer to use laparoscopic surgery for gastric cancers because it has certain benefits in the postoperative recovery course and has enabled improved operative visibility compared with open surgery.[26–28] For early gastric cancers, the surgical safety and long-term survival outcomes of laparoscopic distal gastrectomy have been supported and validated by high-quality clinical evidence [5–7] For advanced gastric cancers, prospective clinical trials from Japan, Korea, and China also have confirmed the

Table 1 The clinicopathologic characteristics compared between CML and TLL groups

Characteristics		CML group N = 53 (%)	TLL group N = 63 (%)	p value
Age	Years	54.6 ± 10.8	56.2 ± 10.7	0.314
Gender	Male	38 (71.7)	54 (83.1)	0.138
	Female	15 (28.3)	11 (16.9)	
BMI	Kg/m^2	22.2 ± 2.8	22.3 ± 2.9	0.648
Tumor location	U	15 (28.3)	18 (27.7)	0.535
	M	3 (5.7)	8 (12.3)	
	L	35 (66.0)	39 (60.0)	
Dissection time	Minutes	119.8 ± 19.1	135.3 ± 23.8	< 0.001
Operation time	Minutes	234.7 ± 37.4	256.3 ± 49.8	0.011
Blood loss	ml	81.7 ± 42.9	91.4 ± 28.7	0.016
Resection type	Distal gastrectomy	38 (71.7)	45 (69.2)	0.770
	Total gastrectomy	15 (28.3)	20 (30.8)	
Macroscopic type	Type 0	14 (26.4)	29 (44.6)	0.070
	Type I	2 (3.8)	0 (0)	
	Type II	28 (52.8)	24 (36.9)	
	Type III	9 (17.0)	12 (18.5)	
	Type IV	0 (0)	0 (0)	
Tumor size	cm	3.2 ± 1.3	2.8 ± 1.5	0.078
T stage	T1	14 (26.4)	30 (46.2)	0.004
	T2	14 (26.4)	20 (30.8)	
	T3	19 (35.8)	13 (20.0)	
	T4	6 (11.4)	2 (3.0)	
N stage	N0	23 (43.4)	40 (61.5)	0.109
	N1	15 (28.3)	9 (13.8)	
	N2	9 (17.0)	11 (16.9)	
	N3	6 (11.3)	5 (7.8)	
TNM stage	I	20 (37.7)	37 (56.9)	0.088
	II	18 (34.0)	18 (27.7)	
	III	15 (28.3)	10 (15.4)	
	IV	0 (0)	0 (0)	
Postoperative hospital stay	Days	8.7 ± 3.2	10.4 ± 3.9	< 0.001
Complications	With	9 (17.0)	12 (18.5)	0.834
	Without	44 (83.0)	53 (81.5)	
Readmission (90 days)	Yes	2 (3.8)	2 (3.2)	1
	No	51 (96.2)	61 (98.2)	
Clavien-Dindo classification	Grade 1	8	8	
	Grade 2	1	2	
	Grade 3	0	1	
	Grade 4	0	1	

CML, clockwise, modularized lymphadenectomy; *TLL*, traditional laparoscopic lymphadenectomy; *BMI*, body mass index; *U*, upper; *M*, middle; *L*, lower; *EGC*, early gastric cancer

safety of laparoscopic distal gastrectomy[8–10] Although there is a lack of long-term survival results of laparoscopic distal gastrectomy in advanced gastric cancers, the results of these studies are promising. Meanwhile, laparoscopic total gastrectomy has been reported to be as safe and feasible as open total gastrectomy, but it still needs to be confirmed by large sample size prospective clinical studies.[2,29] Currently, several multicenter clinical studies of laparoscopic total gastrectomy are ongoing: JCOG 1401 trial in Japan, KLASS-03 and KLASS-05 trials in Korea, and CLASS-02 and CLASS-04 trials in China, which may provide more evidence to support its use in the future.

Table 2 The numbers of positive and examined lymph nodes compared between the CML group and TLL group

Characteristics		CML group $N = 53$	TLL group $N = 63$	p value
Total lymph nodes	Positive	2.2 ± 3.3	1.5 ± 2.4	0.138
Total lymph nodes	Examined	40.5 ± 14.3	33.9 ± 11.0	0.007
No.1 and no.3 stations	Positive	1.1 ± 2.2	0.7 ± 1.5	0.233
No.1 and no.3 stations	Examined	12.7 ± 6.7	11.9 ± 6.3	0.396
No.4sb and no.4d stations	Positive	0.1 ± 0.3	0.6 ± 1.6	0.194
No.4sb and no.4d stations	Examined	6.0 ± 4.1	4.8 ± 3.5	0.123
No. 6 station	Positive	0.3 ± 0.7	0.2 ± 0.5	0.822
No. 6 station	Examined	5.2 ± 2.9	4.9 ± 3.4	0.461
No.5 and no.12a stations	Positive	0.1 ± 0.4	0.2 ± 0.6	0.221
No.5 and no.12a stations	Examined	1.3 ± 1.5	0.8 ± 1.0	0.088
No. 7, 8a, 9 and 11p stations	Positive	0.4 ± 0.9	0.2 ± 0.7	0.142
No. 7, 8a, 9 and 11p stations	Examined	10.0 ± 4.8	7.6 ± 3.5	0.004
No. 2 and 4sa stations*	Positive	0.2 ± 0.6	0.1 ± 0.2	1
No. 2 and 4sa stations*	Examined	3.7 ± 3.2	2.6 ± 1.4	< 0.001
No. 10 and no. 11d stations*	Positive	0.0 ± 0.0	0.0 ± 0.0	1
No. 10 and no. 11d stations*	Examined	2.7 ± 2.4	2.2 ± 1.1	0.003

CML, clockwise and modularized lymphadenectomy; *TLL*, traditional laparoscopic lymphadenectomy

*Only for total gastrectomy

Because lymph node dissection is extensive and complex, gastric cancer surgery is one of the most complicated upper abdominal surgeries. At the same time, because of the lack of the direct sense of touch and stereoscopic vision in laparoscopic operations, this approach is unlike open surgery and is much more difficult with a longer learning period.[14] However, with the development of laparoscopic equipment, the emergence of high-definition, full high-definition, and even 3-dimensional laparoscopy have addressed the above limitations and allowed the understanding of the gastric cancer surgery to develop to a new level. According to the accurate operation of the anatomical space in the laparoscopic approaches, the surgery can become more precise, achieve complete tumor resection, minimize the risks of postoperative complications, and improve the patient's postoperative recovery course. The accumulation of surgical experience is also one of the factors making laparoscopic surgery for gastric cancer increasingly sophisticated.[30,31] A high level of cooperation is essential for the surgical team. Throughout the laparoscopic gastrectomy, all the procedures depend on the high-quality cooperation between the assistants and the surgeon. In clockwise, modularized lymphadenectomy, we propose fixed operating procedures, which can reduce repeated intraoperative procedures, synchronize the action of surgeons and the assistants, and facilitate effective teamwork. According to the primary results in this study, this new model can reduce operation times, especially the time of lymph node dissection. Our surgery team has worked cooperatively in laparoscopic surgery for more than 5 years. We conclude that the reduced time is not due to the improvement of the learning curve but due to the optimization of surgical procedures.

We summarized a series of intraoperative special exposure skills during the operation that are required of the assistant. On one hand, these skills may simplify the operation procedures. On the other hand, these exposure skills elevate the requirements for lymph node dissection and allow a more thorough dissection of the lymph nodes. The "non-pressing pancreas" approach, mentioned above, during dissection of the lymph nodes in the upper pancreas area is an example. During the lymph node dissection in this area, we changed the technique of pushing down pancreas from traditional laparoscopic surgery to turning the pancreas during clockwise lymphadenectomy procedures. We also require the scope to view the upper edge of the pancreas. According to the results of the present study, the number of examined lymph nodes of the upper pancreas area was significantly higher with the clockwise lymphadenectomy procedure than with the traditional lymph node dissection. These new exposure and operation requirements not only reduce the incidence of unnecessary intraoperative injury but also impose higher cooperation requirements on assistants and accelerate their progress.

We also used some special techniques to facilitate the surgery, which include the liver suspension technique and the omentum binding technique (Fig. 2). The liver suspension technique can expose the space between the liver, stomach, and the pancreas and also liberates one hand of the assistant. Therefore, the assistant can help the surgeon to attain better exposure and to complete meticulous operation procedures. Meanwhile, especially for obese patients, when completing

the lymph node dissection of the left gastroepiploic vessel area and infrapyloric area, the bundling of the omentum can reduce the coverage by the great omentum during lymph node dissection in the superior area of the pancreas. In addition, the assistant can expose the area by pulling the bundling band, rather than by directly pulling the great omentum or the stomach, thereby reducing the risk of unnecessary tissue injury and corresponding bleeding.

According to the lymphadenectomy recommendation in the Japanese gastric cancer treatment guidelines[4,22], we have summarized more detailed lymph node dissection requirements. For example, gastric cancer treatment guidelines only indicated that distal gastrectomy requires infrapyloric lymph node dissection. In these guidelines, the infrapyloric lymph nodes are defined as the "lymph nodes along the first branch and proximal part of the right gastroepiploic artery down to the confluence of the right gastroepiploic vein and the anterior superior pancreatoduodenal vein."[17] However, we refine the requirements of lymphadenectomy and develop operating standards for each step at every lymph node station. Considering the no. 6 lymph nodes as an example, we designed four required dissection steps, as follows. (1) Cut off the gastrocolic ligament along the transverse colon to the hepatic flexure of the colon and resect from the space between the anterior and posterior lobes of the transverse mesocolon to the inferior border of the pancreas. (2) Expose the anterior superior pancreaticoduodenal vein and the convergence of the right gastroepiploic vein and then, moving upward, clear the tissue from the left and right sides of the surface of the pancreas at the beginning of this conjunction area along the right gastroepiploic vein. (3) Then, cut off the right gastroepiploic vein in the distal of the convergence of the right gastroepiploic vein and the anterior superior pancreaticoduodenal vein. (4) Dissect the lymph nodes and cut off the artery after the gastroduodenal artery emerges from the anterior superior pancreaticoduodenal artery and then cut off the infrapyloric artery and clear lymph nodes around it. Through these lymphadenectomy standards, we can ensure the standardization of lymph node dissection for each operation and the closer collaboration of the surgeon and assistants.

As with any retrospective study, this study also has some limitations, which cannot be neglected. Selection bias is a major limitation of retrospective studies and existed in the present study. In addition, patients were divided into two groups according to the different time periods and, correspondingly, different learning curve, which may influence the operation-related parameters.

The study presents a new model of laparoscopic gastrectomy, namely the clockwise, modularized lymphadenectomy. Its three components, a fixed sequence of lymphadenectomy, specific requirements and a standard of lymphadenectomy, and specific surgical skills, can optimize and facilitate the laparoscopic gastric cancer surgery.

Author's Contributions Wei-Han Zhang, Kun Yang, and Jian-Kun Hu designed the study;
Wei-Han Zhang, Kun Yang, Kai Liu, and Wei-Wei Wu collected the clinical information;
Wei-Han Zhang, Kun Yang, Xin-Zu Chen, Zong-Guang Zhou, and Jian-Kun Hu analyzed and interpreted the data;
Wei-Han Zhang, Xin-Zu Chen, and Ying-Zhao conducted the statistical analysis;
Wei-Han Zhang, Wei-Wei Wu, and Jian-Kun Hu edited the surgical video.
Jian-Kun Hu and Zong-Guang Zhou supervised this study;
All authors contributed to the writing of the manuscript and final approval.

Compliance with Ethical Standards

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