Cohort Study

Anatomy and assessment of a modified technique during totally robotic distal gastrectomy: A retrospective cohort study

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ABSTRACT

Background: Robotic surgery has potential benefits in the management of gastric cancer patients. This study compares the outcomes between totally robotic distal gastrectomy (TRDG) with modified port placement and arm positioning technique and conventional totally laparoscopic distal gastrectomy (CTLDG).
Materials and methods: Fifty-two patients were enrolled into the study following a retrospective review of an inpatient database between January 2019 and June 2021. Patients who underwent gastric resection with the modified robotic technique were recruited into the study. Patients who did not receive treatment using the modified technique were excluded from the study. Data on demographic, clinical data and surgical outcomes were collected, analyzed, and presented. All statistical analyses were done using IBM SPSS statistical software.
Results: Nineteen patients were in the TRDG group, and their mean age was 60.42 ± 11.53 years. There were no differences in demographic characteristics (all $p > 0.05$); nonetheless, laparoscopic patients had a significantly higher preoperative albumin level ($p = 0.000$). The operative time was longer in the TRDG group (223min), but the difference was insignificant. The reconstruction time was significantly shorter for the laparoscopic group ($p = 0.000$). Except for a significantly higher value of postoperative albumin level (p-value $= 0.005$) in the robotic group, there were no significant differences in all other surgical outcomes between the two groups. One (5.3%) patient had a severe complication in the robotic group compared to four (12.1%) in the laparoscopic group. Nevertheless, the differences in complications were statistically insignificant.
Conclusion: The modified approach is a safe and feasible in totally robotic distal gastrectomy for the treatment of gastric cancer patients.

1. Introduction

Gastrectomy (gastric resection) has served as the core of treatment for both early and advanced gastric cancer [1]. Recently, there has been an increased adoption of laparoscopy in the management of gastric cancer following favorable outcomes. Many trials showed superior benefits compared to open techniques such as less blood loss, and less postoperative pain [2,3]. Nonetheless, a 2D view, human tremors, straight rigid instruments and inconvenient surgical position have remained to be setbacks [4,5].

Robotic technology as an advanced minimally invasive surgical modality mitigates the setbacks from laparoscopic surgery [6–9]. Furthermore, studies done comparing outcomes between robotic and laparoscopic gastrectomy have provided favorable results particularly on blood loss, lymph node yields and postoperative complications [10, 11]. Yet, the drive towards excellence in outcomes, workflow and minimization of postoperative morbidity burden on patients has been a continuing and emphasized expedition. These advances include innovations in surgical instruments, surgical techniques, ports placements and arm positioning. This can be well exemplified by Roh et al. in their study on integrated robotic distal gastrectomy in comparison with conventional distal gastrectomy [12]. Moreover, Liu et al. stressed on the need for cooperation between doctors and companies to create new tools such as the repeating hemoloc clip in robotic arms and improved energy systems that will minimize operative time [13].

Consistent with the desire to partake creativity during robotic

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surgery, we conceptualized a modified technique involving port placement and arm positioning. The conception of this modified approach followed the difficulties we encountered while using the existing setups in both dissection and intracorporeal reconstruction, which necessitated set up change or arm position change. The layouts used by foreign countries are linear or almost linear and more suitable for patients with large body sizes (longer xiphoid-pubis symphysis distance) [4,9,14]. However, most Chinese patients have small body sizes (decreasing the xiphoid-pubis symphysis distance) that make these setups unsuitable, particularly if intracorporeal anastomosis is desired without setup change. Thus we hypothesized that this approach will be suitable for both dissection and reconstruction. After conception, we applied it on our consecutive patients and herein present our initial findings and compare them with conventional totally laparoscopic distal gastrectomy. This study is the first report detailing these comparative outcomes to the best of our knowledge.

2. Materials and methods

2.1. Patients

We conducted a retrospective review of TRDG and CTLDG patients from a prospectively maintained data registry at the Gastrointestinal Department of the Second Hospital of Shandong University, Jinan, China. Between January 2019 and June 2021, a total of 52 patients had undergone either TRDG or CTLDG (19 TRDG and 33 CTLDG). Robotic surgeries began in April 2020 using the Da Vinci Xi ™ system. All patients fit for the study had their diagnoses confirmed through a biopsy study from two independent pathologists. Esophagogastroduodenoscopy was done, and CT imaging was performed for clinical staging. We collected data on demographic and clinical features, intraoperative and postoperative courses. The inclusion criteria were all patients who had undergone robotic distal gastric resection with the modified technique from a biopsy confirmed gastric adenocarcinoma and all patients who underwent conventional totally laparoscopic distal gastric resection. We excluded all patients who underwent robotic distal gastric resection without the modified technique, patients with a diagnosis other than gastric adenocarcinoma or underwent a procedure other than distal gastric resection and patients with remnant gastric cancer. Informed consent was obtained from all patients enrolled in the study. The primarily targeted points were operative time, reconstruction time, blood loss, pre-and postoperative albumin and hemoglobin, and secondary targeted endpoint was postoperative complications. The Clavien-Dindo classification (CD) was employed to assess complications that arose during the study period. Follow-up was within the first 30 days. Pathological staging followed the American Joint Committee on Cancer 8th Edition [15]. Lymphadenectomy was according to the Japanese Gastric Cancer Treatment guidelines 2020, 5th Edition [16]. The study was reviewed and approved by the Institutional Review Board of The Second Hospital, Cheeloo College of Medicine, Shandong University Institutional Review Board. The study complied with the Declaration of Helsinki. This study was retrospectively registered at Research registry with a unique identification number (UIN): researchregistry7569 and has been reported in line with the STROCSS criteria [17].

2.2. Preoperative management

All patients included in the study had been reviewed by the anesthesiologist for anesthetic fitness. Bowel preparation was planned according to surgery time. Intravenous fluid were instituted prior to surgery. Medicines review was performed for surgical safety of the patients.

2.3. Operative procedures

The surgeries were performed by the same surgeon being assisted by

different teams. The operating surgeon performs atleast two hundred laparoscopic gastric resections each year. The surgical techniques were similar in both TRDG and CTLDG. However, in TRDG group a modified technique in port settlement and arm positioning was employed. We herein describe the modified technique.

2.4. Modified port placement and arm positioning technique for TRDG

Following general anesthesia and positioned in supine reverse Trendelenburg's position with abdomen prepped and draped, a 12 mm Infra-umbilical vertical incision was made 3.0–5.0 cm below the navel and used to establish pneumoperitoneum with 12 mmHg of Carbon dioxide. The first trocar was introduced through the initial infra-umbilical incision, followed by camera insertion and laparoscopy. The position of the stomach was noted and used to locate the junction between the Henle trunk and the right gastro-epiploic artery that the surgical team regarded as a landmark (the lowest position) in setting the right upper quadrant trocar (R1). Then two 8 mm transverse incisions at the level of the umbilicus 8 cm apart were made on both sides of the umbilicus for ports that will hold arm R2 and R3. After that, a distance of 8 cm was measured moving laterally from R2 and R3 and marked using a permanent marker. Next, while moving up towards the subcostal margins from the marked points (on a horizontal umbilical plane), the team used a distance of 3.0–5.0 cm to make incisions on both sides of the abdomen for ports that are to hold arm R1 and R4 (making an angle around 45⁰ with an imaginary horizontal plane) (Fig. 1). An Infra-umbilical port, A was used as the assistants' port (other studies used it as a camera port). Arm R2 was positioned on the patients' right side second port (which preceding studies described as assistants' port) and used for the robot camera, arm R3 for harmonic shears, R1 for fenestrated forceps, and R4 was used for Cadiere forceps (Fig. 2). The robot was then stationed at the

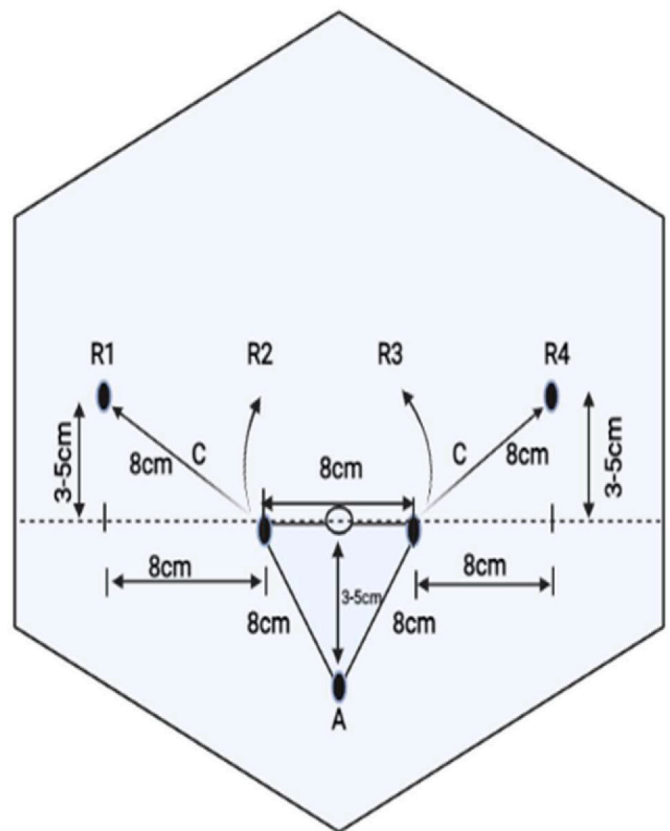

Fig. 1. Schematic presentation of a modified port placement and arm positioning on the abdomen(**C** represents the distance formed by an imaginary line connecting R1 and R2 + R3 and R4, **A** represents assistant's port).
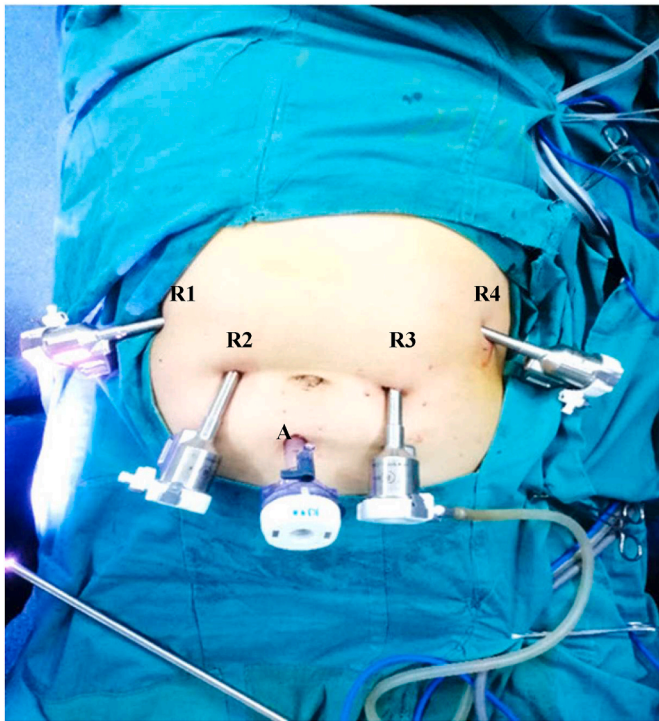
Fig. 2. Showing a modified port placement and arms positioning technique for TRDG (forming a V shape configuration). **R1** for fenestrated forceps, **R2** arm for endoscopic camera, **R3** arm for harmonic shears, **R4** arms for Cadiere forceps and **A**-port for the assistant.

patients' right side, arms docked, and the surgery began. Generally, five ports were used.

2.5. Distal gastrectomy procedure

A stay suture was used to retract the liver after fixation to the anterior abdominal wall. The gastro-colic ligament was then lifted and dissected to the splenic flexure, splenic hilar region, and the short gastric vessels with localization, ligation, and dissection of the left gastro-epiploic vessels and lymph nodes group 4sb. Attention was then turned to the right gastroepiploic vessels, involving its localization and division removing lymph node groups 6 and 4d. Transection of the duodenum, 3 cm below the pylorus, was done using a 60 mm endoscopic linear cutting device. Localization of the right gastric vessels, with ligation and division at its root and dissection of lymph nodes group 12a and 5 followed. Dissection of lymph node groups 8a, 9, and 11p (i.e., along common hepatic, celiac, and splenic artery) was then carried out. The left gastric artery was localized and dissected at its root together with lymph nodes group 7. Lymph node groups 1 and 3 were dissected along the lesser curvature. Then, stomach division was carried out 5 cm away from the upper edge of the tumor using a 60 mm endoscopic linear cutting device. Specimen retrieval was done through a 3 cm supra-umbilical longitudinal incision after undocking the robot arms. The robot was after that re-docked, pneumoperitoneum re-established, and gastro-jejunal anastomosis performed in Billroth II fashion involving the jejunum, 25 cm distal to Treitz Ligament, and Braun's jejunojejunostomy 5 cm distal to Treitz Ligament. All anastomoses were done intracorporeally.

2.6. CD classification of postoperative complications

The assessment of complications were defined by Clavien-Dindo system described elsewhere [18]. For patients with multiple complications, the most severe complication was used.

2.7. Postoperative management

All patients received patient-controlled analgesia, antibiotics and venous thromboembolism prevention measures. Intravenous fluids continued postoperative. Early ambulation was encouraged. Oral intake was initiated after first flatus. Patients were discharged only when complications-free and had adequate feeding. Patients were scheduled for outpatient clinic as per operative dates.

2.8. Statistical analysis

All statistical analyses were done using Statistical Package for Social Sciences (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp). Continuous variables were tested for normality of distribution using one-sample Kolmogorov-Smirnov test. Continuous variables with a normal distribution were presented as means ± standard deviation and compared using independent sample *t*-test. Continuous variables without normal distribution were compared using Mann-Whitney *U* test. Categorical variables were presented using absolute numbers and their percentages and compared using Chi-square or Fisher's exact test where pertinent. A two-sided p-value <0.05 was considered significant.

3. Results

3.1. Demographic and clinical characteristics

Among 52 patients enrolled in the study, 19 had undergone TRDG with a mean age of 60.42 ± 11.53 years. The population had more males than females in both TRDG and CTLDG, though the difference was insignificant. There were no significant differences among ASA scores, BMI, history of previous abdominal surgery, preoperative hemoglobin, and Charlson Comorbidity Index. However, there was a significant difference in preoperative albumin levels between the two groups (p-value = 0.000), with CTLDG having a slightly higher mean level (Table 1).

3.2. Surgical and pathologic outcomes

Regarding surgical outcomes, there was no significant difference in operative time between the two groups. However, the reconstruction time was significantly longer in the robotic group than in the laparoscopic group. The mean estimated blood loss was lower in the TRDG group than CTLDG (88.95 vs. 107.27). However, the difference was statistically insignificant. Additionally, there was no difference in the

Table 1
Demographic and clinical characteristics of study participants, n = 52.

Variable	Entire cohort, n = 52		
	CTLDG, n = 33	TRDG, n = 19	p-value
Age ± SD (years)	62.94 ± 10.2	60.42 ± 11.53	0.418
Gender			
Males	21 (61.8)	13 (68.4)	0.768
Females	12 (36.4)	6 (31.6)	
ASA score			
I	15 (44.1)	12 (66.7)	0.226
II	13 (38.2)	2 (11.1)	
III	6 (17.7)	4 (22.2)	
BMI, Kg/m^2	22.43 ± 5.01	23.51 ± 3.14	0.591
Previous abdominal surgery			
Yes	7 (63.6)	4 (36.4)	1.000
No	27 (65.9)	14 (34.1)	
Charlson Comorbidity index			
1–2	2 (66.7)	1 (33.3)	0.365
3–4	8 (50.0)	8 (50.0)	
≥5	24 (72.7)	9 (27.3)	
Pre-operative hemoglobin (g/l)	124.28 ± 22.67	125.21 ± 14.67	0.408
Pre-operative albumin (g/l)	39.65 ± 4.35	35.85 ± 4.62	0.000

CTLDG-Conventional Totally Laparoscopic Distal Gastrectomy, TRDG-Totally robotic distal gastrectomy, ASA-American Society of Anesthesiologist.

mean number of harvested lymph nodes and abdominal drainage between the two groups. Nonetheless, TRDG patients exhibited lower drainage than CTLDG patients (668.14 vs. 802.68). Moreover, no differences were noted in the reconstruction technique between the two groups. However, a significant difference was observed in histologic type between TRDG and CTLDG groups; most patients had poorly differentiated histologic patterns (p = 0.035). There were no differences among pathological stages and postoperative hemoglobin. Nonetheless, there was a significant difference in the mean postoperative albumin level between the two groups (p = 0.005), with the TRDG group having a higher value than the CTLDG group (41.32 vs. 34.68). There was no significant difference in days to remove the abdominal drainage tube, time to first flatus, first liquid intake, or length of hospital stay between the two groups (Table 2).

3.3. Complications

Concerning postoperative complications, most of the patients had grade II of the Clavien-Dindo system, with hypoalbuminemia being the most common complication. Only one (5.3%) patient developed a severe complication (Clavien-Dindo ≥ IIIa) in the TRDG group compared to four in the CTLDG group. There was no mortality in either group. Generally, there was no statistical difference in all Clavien-Dindo grades between the two procedures (Table 3).

4. Discussion

This study has shown non-inferiority in the performance of the modified technique applied in robotic distal gastrectomy compared to conventional laparoscopic techniques in operative time, blood loss, and

Table 2
Surgical and Pathological outcomes following CTLDG and TRDG.

Variable	Entire Cohort (n = 52)		p-value
	CTLDG (n = 33)	TRDG (n = 19)	
Operative time (min)	207.82 ± 47.34	223.74 ± 38.90	0.220
Estimated blood loss (ml)	107.27 ± 92.20	88.95 ± 26.85	0.403
Number of harvested lymph nodes	29.78 ± 11.39	27.05 ± 8.52	0.371
Abdominal drainage amount (ml)	802.68 ± 420.91	668.14 ± 348.94	0.338
Reconstruction technique			
Billroth II + Braun's J-J	31(62.0)	19(38.0)	0.527
Uncut Roux + Braun's J-J	2(100)	0(0.0)	
Reconstruction time (min)	16.89 ± 1.99	23.84 ± 2.83	0.000
Histology			
G1	2 (5.9)	7 (36.8)	0.035
G2	8 (23.5)	3 (15.8)	
G3	23(67.6)	9 (47.4)	
SRCC	1 (2.9)	0 (0.0)	
pTNM Stage			
IA	8 (23.5)	8 (42.1)	0.104
IB	1 (2.9)	3 (15.8)	
IIA	1 (2.9)	2 (15.8)	
IIB	4 (11.8)	0 (0.0)	
IIIA	8 (23.5)	2 (10.5)	
IIIB	7 (20.6)	2 (10.5)	
IIIC	4 (11.8)	1 (5.3)	
IV	1 (2.9)	0 (0.0)	
pT stage			
T1	8 (23.5)	8 (44.4)	0.077
T2	3 (8.8)	3 (16.7)	
T3	3 (8.8)	3 (16.7)	
T4	20 (58.8)	4 (22.2)	
Post-operative haemoglobin (g/l)	125.36 ± 17.79	129.79 ± 19.50	0.874
Post-operative albumin (g/l)	34.68 ± 3.59	41.32 ± 3.39	0.005
Time to drain removal (day)	12.84 ± 8.49	8.93 ± 3.03	0.110
Time to first flatus (day)	4.00 ± 4.16	3.12 ± 1.58	0.407
Time to first liquid intake (day)	7.86 ± 8.09	6.59 ± 4.46	0.554
Length of hospital stay (day)	15.00 ± 7.34	13.42 ± 3.19	0.379

Table 3
Postoperative complications following CTLDG and TRDG using Clavien-Dindo classification.

Grade	CTLDG, n = 27	TRDG, n = 17	p-value
Grade I	n = 6	n = 4	0.250
Fever	2	1	
Vomiting	0	2	
Wound fat liquefaction	1	1	
Delayed gastric emptying	3	0	
Grade II	n = 17	n = 12	0.372
Hypoalbuminemia	8	3	
Anemia	3	3	
Pneumonia	1	3	
Pleural effusion	0	1	
Duodenal stump leakage	1	0	
Pancreatic fistula	1	0	
Stress ulcer	3	1	
Fever	0	1	
Grade IIIa	0	0	
Grade IIIb	n = 4	n = 0	0.646
Anastomotic leakage	1	0	
Peri-splenic fluid collection	1	0	
Intra-abdominal fluid collection	1	0	
Intestinal obstruction	1	0	
Grade IVa	n = 0	n = 1	0.365
Respiratory insufficiency	0	1	
Grade IVb	0	0	
Grade V			
Death of a patient	0	0	
Overall complications	27	17	0.694
Clavien-Dindo ≥ IIIa	4(12.1%)	1(5.3%)	0.641

postoperative course. This is the first study comparing outcomes to conventional laparoscopic modality.

Following the adoption of a modified technique in distal gastrectomy, Seo et al. reported sufficient lymph node yields, minimal blood loss, less postoperative stay, and few minor complications. Similarly, innovative robotic technology was associated with adequate lymph node yield, less readmission, and less blood loss [12,19].

In a systematic review and meta-analysis, no significant difference in operative time was observed between robotic and laparoscopic gastrectomy [10]. This study's long albeit comparable operative time could be attributed to the additional setup time and inexperience of the surgical team with the modified approach. Furthermore, other authors gave an account of the additional setup time and inexperience of both the surgeon and the assistants as factors associated with increased operative time during robotic surgery [20–22]. Despite this, these results were similar to preceding reports [23].

Several studies showed no significant differences in blood loss between robotic and laparoscopic gastrectomy [24–26]. Similarly, we didn't observe significant differences in blood loss between the two groups. The system's known technological benefits (e.g. 3D visual system & easy maneuverability of robot arms) coupled with a modified approach could have contributed to the low but insignificant amount of blood loss. The amount of blood loss has been linked with the likelihood of peritoneal recurrence [27]. Thus, minimizing blood loss during gastrectomy is of paramount importance, and robotic surgery with the modified approach offers that.

Yang et al. concluded that 3D imaging made it easier to distinguish optimal dissection layer around an organ preserved [28]. Furthermore, we observed no differences in lymph node yields between the two procedures, and robotic distal gastrectomy with the modified approach met the standard definition of adequacy in lymphadenectomy during gastrectomy according to The Eighth AJCC Cancer Staging Manual, that is ≥ 16 [15]. Moreover, the technological superiority of robotic surgery has been documented on lymph node dissection around the splenic hilar and supra-pancreatic nodes. Robotic surgery was associated with increased lymph node yields [29,30]. We believe a longer acquaintance to this modified technique will prove valuable in the lymph nodes yield

as preliminary results are non-inferior.

We hypothesized that this modified technique provides the advantage of being more minimally invasive, thus reducing the impact of surgical stress on the patients. In this study, we observed a significant difference in the levels of postoperative albumin between the two modalities, with the robotic group having a higher value than the laparoscopic group. Gastric cancer is known to induce an inflammatory response by producing cytokine IL-6, which increases C-reactive protein production, which in turn lowers albumin levels [31]. If this process is coupled with a less minimally invasive technique, the adversity can be unfathomably great on the postoperative course of the patients, in particular, postoperative complications. Several authors have described hypoalbuminemia as a potential risk factor for postoperative complications in various fields [32–34]. Thus, we believe this modified technique reduces unnecessary movements during both dissection and reconstruction phases, which lessens the burden of postoperative surgical stress to the existing inflammatory response from gastric cancer and the surgery. Otherwise, we remain to assess specific markers of inflammatory response to affirm these findings.

Regarding postoperative complications, we didn't observe mortality in either group, and all grades were comparable between the two groups. Similarly, previous reports show no differences in the rate of overall complications between robotic and laparoscopic groups [30,35]. Furthermore, we didn't observe any postoperative pancreatic fistula (POPF) in the robotic group with a modified technique, while one patient had POPF in the laparoscopic group. Robotic surgery has been linked with the potential of reducing pancreatic damage [36–38]. The low incidence can be ascribed to less need for pancreatic compression or rotation in exposing the dissection field. Besides, there were no reports of anastomotic site leak, intestinal obstruction, duodenal stump leak, or intra-abdominal fluid collection in the robotic group.

In contrast, four patients reported those complications in the laparoscopic group. This observation was consistent with previous studies [39,40]. This study elicits the meticulous nature of the modified approach coupled with the eminent benefits of the robot system. Subsequent assessment of severe complications revealed 12.1% had severe complications in the laparoscopic group compared to 5.3% in the robotic group. Our findings in severe complications were non-deviant from the preceding reports [41].

Nonetheless, our study had several limitations. Firstly, the study had a small sample size which may preclude drawing some conclusions. The small accrual of patients resulted from the high costs incurred by patients with robotic gastrectomy, presence of many other hospitals within the city, lack of insurance coverage, with only a small fraction of the supplies being paid for but not the procedure, and the study time frame involved. Secondly, the study was conducted in a single institution, limiting its generalizability due to a narrower range of population groups and limited geographical location. Lastly, this study didn't assess long-term outcomes due to the study time outlined, hence limited other conclusions to be drawn. However, this report came forth to describe initial findings of a modified technique and compare it with conventional laparoscopic gastrectomy.

Conclusively, the modified technique has satisfactory initial surgical performance in the management of gastric cancer. Thus, we recommend a randomized prospective study with a large patient accrual to further evaluate the depth of performance and long-term outcomes following application and a comparative study with other setups.

Ethical approval

Ethical approval was given by the Insitutional Review Board of The Second Hospital of Shandong University. Approval No. KYLL-2021(LW) 064.

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Author contribution

Ding YL-conceptualized the technique; Mranda GM, Wei T, Xiang Z P designed the study. Zhou X G, Xue Y, and Liu J J collected the data. Data was analysed by Mranda G M, Wang Y and Wei T. The manuscript was drafted by Mranda G M and Xue Y prepared Figs. 1 and 2, and initial review done Ding Y L. All authors read and approved the final draft of the manuscript.

Registration of research studies

1. Name of the registry: Researchregistry.
2. Unique Identifying number or registration ID: researchregistry7569.
3. Hyperlink to your specific registration (must be publicly accessible and will be checked): https://www.researchregistry.com/browse-the-registry#home/

Guarantor

Yin-Lu Ding.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Declaration of competing interest

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amsu.2022.103466.

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