A comparative study of robotic and laparoscopic radical resection for locally advanced gastric cancer on the dissection of lymph nodes in the upper pancreas and the effect on the pancreas

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Case Report

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Abstract

Purpose By comparing the short-term clinical outcome of robotic gastrectomy versus laparoscopic gastrectomy in D2 radical gastrectomy for locally advanced gastric cancer, we explored whether robotic surgery has advantages in suprapancreatic lymph node dissection and examined its effect on the pancreas.

Methods We collected the clinical data of 210 consecutive patients with locally advanced gastric cancer who had undergone radical gastrectomy at our center between September 2017 and June 2018. Two groups of patients were analysed: the robotic group (n = 95) and the laparoscopic group (n = 115). Operative outcomes and postoperative complications as well as pathological data were statistically analysed.

Results In cases of total radical gastrectomy, the robotic group was associated with lower intraoperative blood loss compared with the laparoscopic group (108.17±92.33 VS 142.00±80.23) mL (P=0.045). Among overweight patients with BMI>25, the robotic group still showed lower intraoperative blood loss in comparison with the laparoscopic group (126.60±80.80 VS 149.11±93.23) mL (P=0.041). In cases of distal subtotal radical gastrectomy, the number of harvested No.9 lymph nodes, No.11P lymph nodes, station 2 lymph nodes and suprapancreatic lymph nodes was higher in the robotic group as compared with the laparoscopic group (p =0.043,0.034, 0.01,0.01). In cases of total radical gastrectomy, the robotic group revealed more harvested NO.8a lymph nodes, station 2 lymph nodes and suprapancreatic lymph nodes than that in the laparoscopic group P =0.026 0.043,0.03 . Whether or not the patients were overweight, the robotic group was associated with more harvested lymph nodes P=0.001 0.036 .The robotic group was associated with lower drainage fluid amylase levels on postoperative day 1 and lower blood amylase on postoperative day 2 and day 3 when compared with the laparoscopic group P=0.043 0.014 0.001 . The robotic group reported 5 cases 5.3% of biochemical leak compared with 16 cases 13.9% in the laparoscopic group P=0.038). Among patients with BMI 25(kg/m2), the robotic group showed lower levels of blood amylase on postoperative day 3. Among patients with BMI≥25(kg/m2), the robotic group showed lower ascitic fluid amylase level on postoperative day 1, lower blood amylase level on postoperative day 2 and less intraabdominal drainage liquid P=0.043 0.008 0.043 on postoperative day 1.

Conclusion In cases of D2 radical gastrectomy for locally advanced gastric cancer, the robotic group was associated with less blood loss and more harvested perigastric lymph nodes in the suprapancreatic area as well as less pancreatic injury compared with the laparoscopic group. Among overweight patients, the robotic group showed advantages as well.

Introduction

Gastric cancer is the fifth most common malignant cancer worldwide and the second most commonly diagnosed cancer in China[1, 2]. To date, radical gastrectomy is the main method in gastric cancer treatment. Since Kitano et al [3]. first reported laparoscopic gastrectomy(LG), LG has been proven to have good short-term surgical results and long-term oncological outcomes, and has been widely carried out in Asian countries[4, 5].

Safe and reliable, laparoscopic gastrectomy is a minimally invasive surgical approach in comparison with open gastrectomy. However, due to laparoscopic gastrectomy's limitations such as 2D views, non-articulated instruments with restricted degrees of motion, and increased physiologic tremor of surgeon's hand, it is difficult to dissect the regional lymph nodes in D2 radical gastrectomy. What's more, during suprapancreatic lymph node dissection, compression of the pancreas leads to high incidence of postoperative fistula. It was reported that the rate of postoperative pancreatic fistula after laparoscopic gastrectomy for gastric cancer was 5.3% – 11.8%[6–8].

The merits of the robotic surgery such as 3D high-definition views, flexible instrument arms and precise dissection in narrow surgical area can overcome limitations of the laparoscopic surgery to some extent. Robotic surgery is expected to perform better in perigastric lymph node dissection, and reduce the occurrence of pancreatic injury and postoperative pancreatic fistula in radical gastrectomy for locally advanced gastric cancer.

To date, with the gradual application of robot-assisted D2 radical gastrectomy for locally advanced gastric cancer, surgical robots are becoming a hotspot of research in minimally invasive surgery for gastric cancer. However, there were few reports on whether surgical robots have advantages in suprapancreatic lymph node dissection and the impact of surgical robots on the pancreas (especially in D2 radical gastrectomy) [9–10].

Therefore, we compared the short-term clinical outcome of robotic surgery versus the laparoscopic surgery in D2 radical gastrectomy for locally advanced gastric cancer, and examined the effect of robotic surgery in suprapancreatic lymph node dissection and the impact of robotic surgery on the pancreas.

1 Materials And Methods

1.1 Patient and data collection

210 consecutive patients with locally advanced gastric cancer who underwent D2 radical gastrectomy at our center between September 2017 and June 2018 were selected. Among them, 95 patients underwent da Vinci robotic surgery and 115 patients underwent laparoscopic surgery. The clinical data of the patients included gender, age, BMI, the American Society of Anesthesiologists (ASA) Physical Status Classification System, surgical approach, reconstruction approach, TNM stage of tumor pathology after operation, harvested lymph nodes, ascites and blood amylase, and postoperative complications. Tumor pathology TNM staging was based on the eighth edition of UICC-AJCC TNM classification of malignant tumors. Postoperative complications were classified according to the Clavien-Dindo Classification[11]. Pancreatic fistula was defined according to the 2016 update of the International Study Group (ISGPS) definition and grading of postoperative pancreatic fistula [12].

The inclusion criteria of this study were as follows: D2 lymph node dissection (cT1N+M0, cT2-4N0/+M0) was performed for locally advanced adenocarcinoma confirmed by histopathological examination after operation; age≤80 years ASA physical status class III and below; no radiotherapy and chemotherapy was performed before operation. Exclusion criteria were an emergency operation, gastric stump cancer, multivisceral resection, and conversion to laparotomy. Written informed consent was obtained from all

patients and their families before operation. This study was approved by the Medical Ethics Committee of Chongqing Southwest Hospital.

1.2 Operative method

All patients were operated on according to the Japanese Gastric Cancer Treatment Guidelines (5th edition) [13]. The tumor was located by gastroscopy before the surgery, and was confirmed pathologically. Endoscopic ultrasonography was used for T staging, and enhanced CT was used for N staging. Total gastrectomy with D2 lymph node dissection was performed for tumors located in the upper part of the stomach and at the junction of esophagus and stomach (Siewert type II and III), and distal subtotal gastrectomy with D2 lymph node dissection was performed for tumors located in the middle and lower part. There were no cases of proximal radical gastrectomy and radical pylorus-preserving gastrectomy in this study. All patients were operated on by three surgeons at our center, each of whom had performed more than 200 cases of robotic radical gastrectomy and laparoscopic radical gastrectomy. All the three surgeons have passed the learning curve. In this study, Professor Zhao performed 34 cases of robotic surgery and 37 cases of laparoscopic surgery; Professor Qian performed 29 cases of robotic surgery and 43 cases laparoscopic surgery; Professor Shi performed 32 cases of robotic surgery and 35 cases of laparoscopic surgery. All surgical operations were recorded by video and were reviewed regularly.

Operative process of the laparoscopic radical total gastrectomy with D2 lymph node dissection: OLYMPUS laparoscope and HD camara were used. After general anesthesia, the patient was in a knee flexion and abduction position. A trocar was inserted 2 cm below the umbilicus; one trocar was placed in the left anterior axillary line 2 cm below the costal margin; one trocar was placed in the right anterior axillary line 2 cm below the costal margin; one trocar was placed in the left midclavicular line 2 cm below the umbilicus; one trocar was placed in the right midclavicular line 2 cm above the umbilicus. The surgeon stood on the left side of the patient.

Along the transverse colon, the greater omentum was divided from the transverse colon leftward until the splenic flexure of the colon by ultrasound scalpel, and the left gastro-epiploic artery (LGEA) and the left gastro-epiploic vein (LGEV) were identified. Then the LGEA and the LGEV were clipped with bio clip and titanium clip and sectioned, and No.10 lymph nodes and adipose tissue were dissected.The division continued along the greater curvature toward the cardia until the left of the cardia, and the short gastric artery was clipped with bio clip and sectioned with ultrasound scalpel. NO.2 NO.4sa NO.4sb lymph nodes and adipose tissue were dissected en-bloc.The division went rightward until the hepatic flexure of colon, and the anterior lobe of transverse mesocolon behind the gastric antrum was removed. Then the right gastro-epiploic vein (RGEV), the right gastro-epiploic artery (RGEA) and the inferior pyloric artery (IPA) were identified, and lymph node around them were dissected to bare the vessel. The RGEV, the RGEA and the IPA were clipped at their root with bio clip and titanium clip and sectioned by ultrasound scalpel. NO.4d,NO.6 lymph nodes and adipose tissue were dissected en-bloc.The pancreatic capsule was removed, and the serosa of the gastropancreatic wrinkle wall was opened on the upper edge of the pancreas. Subsequently the left gastric artery, the left gastric vein, splenic artery and common hepatic artery were identified, and NO.7 NO.8a NO.9 NO.11p NO.11d lymph nodes and adipose tissue were dissected. The left gastric vein and

the left gastric artery were clipped at their root with bio clip and titanium clip and sectioned by ultrasound scalpel. The duodenum was bared, and the mesoduodenum was divided until 2 cm away from the pylorus. The lesser omentum was opened to expose the proper hepatic artery, the right gastric artery (RGA) and the right gastric vein (RGV). The RGA and the RGV were clipped at their root with bio clip and titanium clip and sectioned by ultrasound scalpel. NO.5 NO.12a lymph nodes and adipose tissue were dissected.The division continued upward along the lesser omentum to divide and bare the left side of the cardia. NO.1 and NO.3 lymph nodes were dissected. The pneumogastric nerve was sectioned, and 3-centimeter-long oesophagus above the cardia was bared. A straight-line suture device was inserted under endoscopy through a trocar located in the left lower abdomen. The duodenum was clipped, and the duodenum and stomach were sectioned.

Operative process of the robotic radical total gastrectomy with D2 lymph node dissection: Da Vinci S system was used in the operation. After general anesthesia, the patient was in a knee flexion and abduction position. One trocar was inserted 2 cm below the umbilicus for the major camera; one trocar was placed in the left anterior axillary line 2 cm below the costal margin for the 1st robotic arm; one trocar was placed in the right anterior axillary line 2 cm below the costal margin for the 3rd robotic arm; one trocar was placed in the left midclavicular line 2 cm below the umbilicus as the major operation port; one trocar was placed in the right midclavicular line 2 cm above the umbilicus for the 2nd robotic arm. The basic operation process was similar with the laparoscopic radical total gastrectomy.

The lymph nodes of NO.2, NO.4sa, NO.10 and NO.11d were not dissected in robotic radical distal subtotal gastrectomy and laparoscopic radical distal subtotal gastrectomy. Finally, robotic radical total gastrectomy and laparoscopic radical total gastrectomy were performed with Roux-en-Y digestive tract reconstruction while robotic radical distal subtotal gastrectomy and laparoscopic radical distal subtotal gastrectomy were performed with Billroth II or Roux-en-Y digestive tract reconstruction. 5-fluorouracil-based chemotherapy was used routinely after operation.(fig1.2.3.4)

1.3 Statistical analysis

Statistical analysis was conducted using SPSS Statistics Version 19.0. The measurement data in normal distribution were expressed as $\bar{x}$ s. The t test was used for inter-group comparison, and the X^2 test or Fisher's exact test was used for counting data comparison. The non-parametric test was used for ordinal data. P value < 0.05 was considered statistically significant.

2 Result

2.1 General characteristics of the enrolled patients

All 210 patients were successfully operated on, including 134 males and 76 females, with an average age of 58.1 years (21-79 years) and an average body mass index(BMI)of 22.4 kg/m^2. There were no significant differences in gender, age, BMI and ASA scores between the two groups (P>0.05). (Table 1)

Table 1
General characteristics of the patients enrolled

	Laparoscopic (n=115)	Robotic (n=95)	P value
Gender (M:F)	71:44	63:32	0.492
Age	58.5±22.5	57.6±21.4	0.581
Body mass index (kg/m^2)	22.4±3.4	22.4±2.9	0.937
ASA score			0.851
	28	24	
	67	52	
	20	19	

2.2 Surgical outcomes and short-term postoperative courses

Pathological examination showed that R0 resection was achieved in all patients. There was no statistical significance in the surgical approach, reconstruction approach, operation time (time to dismantle and install the robot was not included), time to remove abdominal drainage tube, postoperative hospital stay, and PTNM staging (P>0.05). In cases of total radical gastrectomy, the robotic group was associated with lower intraoperative blood loss compared with the laparoscopic group (108.17±92.33 VS 142.00±80.23) mL (P=0.045). (Table 2)

Table 2
Surgical outcomes and short-term postoperative courses

	Laparoscopic (n=115)	Robotic (n=95)	P value
Operative time (min)			
DG	210.5±52.9	228.9±40.8	0.092
TG	258.7±37.1	274.9±33.1	0.095
Type of resection (DG:TG)	66:49	49:46	0.400
Type of reconstruction (B-II:R-Y)	61:54	43:52	0.262
Blood loss (mL)			
DG	123.75±67.10	99.72±52.98	0.086
TG	142.00±80.23	108.17±92.33	0.045
Extubation time after operation (d)	6.25±1.72	6.21±1.61	0.905
Postoperative hospital stay (d)	9.40±3.05	8.66±2.62	0.208
PTNM staging □□B□□□□□	36:26:53	34:25:36	0.489

Abbreviations DG=Distal subtotal gastrectomy TG=total gastrectomy B-II=Billroth II digestive tract reconstruction R-Y=Roux-en-Y digestive tract reconstruction

2.3 Comparison of postoperative complications between the two groups

There were no statistically significant differences in postoperative complications and classification of postoperative complications (P>0.05). 4 patients in the robotic group (4.2%) and 7 patients in the laparoscopic group (6.1%) were classified as Clavien–Dindo grade II and above. In the robotic group, 1 case of distal gastrectomy with Billroth anastomosis reported postoperative duodenal stump fistula, pulmonary infection and fat liquefaction in surgical incision, and was successfully treated after CT-guided puncture and drainage together with symptomatic treatment. 2 cases was reported with pulmonary infection, and 1 case was reported with deep vein thrombosis complicated with liquefaction and infection in the post-surgical incision. Three patients above were successfully treated after conservative treatment.

In the laparoscopic group, 1 case of distal subtotal gastrectomy with Billroth anastomosis reported bleeding in the duodenal stump, and was complicated with pulmonary infection after reoperation for bleeding. After symptomatic treatment the patient was cured. 1 case of total gastrectomy with Roux-en-Y anastomosis reported esophagojejunal anastomosis fistula (with overlap anastomosis), while after endoscopic placement of feeding tubes, the patient was complicated with deep venous catheterization infection and was cured after symptomatic treatment. 1 case of pulmonary infection, 1 case of delayed gastric emptying, 2 cases of deep venous catheterization infection and 1 case of fat liquefaction in surgical

incision were cured after conservative treatment. Except for 2 patients with anastomotic fistula, no somatostatin was used in the treatment of other patients. All patients were discharged home. (Table 3)

Table 3
Comparison of postoperative complications between the two groups

	Laparoscopic (n=115)	Robotic (n=95)	P value
Postoperative complications			0.482
Anastomotic bleeding	1	0	
Anastomotic fistula	1	1	
Pulmonary infection	2	3	
Gastric emptying disorder	1	0	
Deep vein infection or thrombosis	3	1	
Wound infection or liquefaction	1	2	
The Clavien-Dindo classification grade	5:1:1:0	3:1:0:0	0.18

2.4 Lymph node dissection

In cases of distal subtotal radical gastrectomy, the number of harvested No.9 lymph nodes, No.11P lymph nodes, station 2 lymph nodes and suprapancreatic lymph nodes was higher in the robotic group than in the laparoscopic group (p =0.043,0.034, 0.01,0.01). In cases of total radical gastrectomy, the robotic group revealed more harvested NO.8a lymph nodes, station 2 lymph nodes and suprapancreatic lymph nodes than the NO.8a lymph nodes, station 2 lymph nodes laparoscopic group P =0.026 0.043,0.03 . (Table 4 5)

Table 4
Comparison of lymph node detection between the two groups after D2 lymph node dissection after distal subtotal gastrectomy

	Laparoscopic (n=66)	Robotic (n=49)	P value
Number of lymph nodes detected in each group			
N0.1	1.21±1.46	1.38±1.91	0.659
N0.3	8.43±3.94	8.22±4.67	0.823
N0.4	7.48±4.16	7.97±5.11	0.629
N0.5	1.27±1.19	1.88±1.73	0.24
N0.6	5.88±2.96	4.66±3.18	0.074
N0.7	5.95±3.07	6.31±2.97	0.588
N0.8a	2.41±1.62	2.84±1.89	0.37
N0.9	1.71±1.66	2.47±1.65	0.043
N0.11p	1.12±1.04	1.75±0.93	0.034
N0.12a	1.39±0.89	2.09±1.69	0.064
Number of lymph nodes detected at each station			
Station 1	30.21±9.60	30.41±10.02	0.929
Station 2	6.54±3.48	9.16±5.86	0.01
Number of regional lymph nodes detected			
Subpyloric region	5.88±2.96	4.66±3.18	0.074
Superior pancreatic region	13.75±5.23	17.34±7.47	0.01
Cardiac region	1.21±1.46	1.38±1.91	0.659
Total number of lymph nodes detected	36.75±10.46	39.56±12.34	0.259

Table 5
Comparison of lymph node detection between the two groups after total gastrectomy and D2 lymph node dissection

	Laparoscopic (n=49)	Robotic (n=46)	P value
Number of lymph nodes detected in each group			
N0.1	3.44±2.56	3.69±1.81	0.654
N0.2	3.40±2.64	3.21±2.13	0.81
N0.3	10.80±6.18	9.38±6.79	0.428
N0.4	10.16±5.95	9.48±8.64	0.743
N0.5	1.32±0.84	1.55±0.76	0.639
N0.6	3.40±2.27	2.97±2.57	0.517
N0.7	3.84±2.41	5.21±4.76	0.182
N0.8a	2.20±2.02	3.48±2.06	0.026
N0.9	2.08±1.38	1.97±0.97	0.809
N0.10	0.8±0.38	1.34±0.56	0.149
N0.11p	1.68±1.17	1.76±1.10	0.862
N0.12a	1.56±1.08	2.07±1.23	0.355
Number of lymph nodes detected at each station			
Station 1	36.36±10.58	35.48±17.69	0.829
Station 2	8.32±4.22	10.62±3.91	0.043
Number of regional lymph nodes detected			
Splenic region	8.52±5.20	8.66±5.60	0.927
Subpyloric region	3.40±2.27	2.97±2.57	0.517
Superior pancreatic region	12.68±5.69	16.03±5.34	0.03
Cardiac region	6.84±4.75	6.90±2.96	0.958
Total number of lymph nodes detected	44.68±12.53	46.10±18.02	0.741

Splenic region(No.(4sa 4sb) No.10 No.11d),Subpyloric region(No.6),Superior pancreatic region No.5 No.7 No. 8a No.9 No.11p No.12a ,Cardiac region No.1 No.2

2.5 Comparison of postoperative pancreatic injury between the two groups

The robotic group was associated with lower drainage fluid amylase levels on postoperative day 1, lower blood amylase on postoperative day 2 and day 3, and less abdominal drainage when compared with the

laparoscopic group. With regard to pancreatic fistula, the robotic group reported 7 cases (7.4%) compared with 18 cases (15.7%) in the laparoscopic group. The robotic group reported 5 cases (5.3%) of biochemical leak, which is significantly less in comparison with 16 cases (13.9%) in the laparoscopic group P<0.05). (Table 6)

Table 6
Comparison of postoperative pancreatic injury between the two groups

	Laparoscopic (n=115)	Robotic (n=95)	P value
Ascites amylase value（U/L）			
Day 1	788.19±467.03	578.16±446.53	0.043
Day 2	499.48±248.16	321.65±248.80	0.205
Day 3	269.24±114.81	206.17±130.53	0.274
Day 5	158.33±97.73	121.22±97.05	0.625
Blood amylase value (U / L)			
Day 1	215.40±148.96	186.64±114.95	0.217
Day 2	164.99±109.06	124.87±72.95	0.014
Day 3	124.20±65.56	85.36±52.29	0.001
Day 5	89.50±51.75	71.96±40.32	0.14
Postoperative drainage volume (ML)			
Day 1	193.06±166.21	157.30±111.79	0.128
Day 2	178.09±186.35	135.31±126.30	0.229
Day 3	121.25±126.89	88.57±78.47	0.061
Day 5	86.63±118.83	54.07±72.98	0.046
Pancreatic leakage	18 15.7%	7 7.4%	0.065
BL grade	16 13.9%	5 5.3%	0.038
B grade+C grade	2 1.7%	2 2.1%	1

The normal value of ascites amylase in this group is 0-140 (U/L); the normal value of ascites amylase is 20-100 (U/L).

2.6 The effect of body weight on the two groups

Analysis stratified by BMI: Among patients with BMI<25 (kg/m^2), the blood amylase value measured on postoperative day 3 of the robot group was lower than that of the laparoscopic group (P<0.05). Among patients with BMI ≥ 25 (kg/m^2), the ascites amylase value on postoperative day 1, the blood amylase value

on postoperative day 2 and the abdominal drainage volume on postoperative day 1 in the robotic group were lower than those in the laparoscopic group ($P<0.05$). Among overweight patients, the robotic group was associated with lower blood loss when compared to the laparoscopic group (126.60±80.80 VS 149.11±93.23) mL ($P=0.041$). Whether or not the BMI was greater than 25, more suprapancreatic lymph nodes were dissected in the robotic group than in the laparoscopic group (P 0.05) . (Table 7)

Table 7

Effect of body weight on operation methods of two groups

	BMI<25(kg/m2) n=160			BMI≥25(kg/m2) n=50		
	Laparoscopic (n=93)	Robotic (n=67)	P value	Laparoscopic (n=22)	Robotic (n=28)	P value
Gender (M:F)	59 34	48 19	0.277	12 10	15 13	0.945
Age	58.8±20.5	59.9±21.1	0.545	52.5±16.5	55.1±15.4	0.425
Operative time (min)			0.191			0.919
DG	50	29		16	20	
TG	43	38		6	8	
blood loss (mL)	127.3±64.8	105.7±23.0	0.248	149.11±93.23	126.60±80.80	0.041
Number of lymph nodes detected in superior pancreatic region	12.94±4.97	16.53±5.97	0.001	11.50±3.14	16.21±7.87	0.036
Ascites amylase value（U/L）						
Day 1	740.7±637.8	596.9±350.5	0.239	981.1±875.0	515.2±483.3	0.043
Day 2	435.7±329.8	272.7±190.9	0.105	515.2±360.4	336.23±303.9	0.312
Day 3	233.4±347.2	210.8±204.5	0.691	415.0±212.6	190.7±162.5	0.195
Day 5	175.7±176.3	141.49±120.7	0.794	102.0±86.6	80.7±61.3	0.597
Blood amylase value (U / L)						
Day 1	224.4±152.3	194.0±111.7	0.125	194.9±128.6	177.9±132.8	0.733
Day 2	118.1±67.7	123.1±73.1	0.854	176.3±114.4	125.4±73.7	0.008
Day 3	130.2±68.2	88.4±58.1	0.001	99.5±47.8	75.7±26.4	0.116
Day 5	94.0±56.6	70.0±40.4	0.113	76.8±33.4	76.6±42.6	0.993
Postoperative drainage volume (ML)						
Day 1	199.0±171.2	166.1±116.2	0.334	189.1±149.3	127.9±93.4	0.043
Day 2	190.6±191.5	139.6±120.6	0.087	168.9±146.3	127.3±159.3	0.465
Day 3	122.2±121.9	93.3±81.5	0.135	117.4±149.9	72.9±67.5	0.296
Day 5	87.0±118.3	58.3±78.4	0.126	85.3±124.7	39.9±50.8	0.196

Extubation time after operation (d)	6.25±1.87	6.26±1.79	0.979	6.25±0.93	6.07±0.83	0.586
Postoperative hospital stay (d)	9.49±3.15	8.87±2.72	0.280	9.38±2.16	8.36±1.69	0.166

3 Discussion

To date, existing studies showed that laparoscopic D2 radical gastrectomy is safe and feasible[14–15], and the long-term efficacy is comparable to that of open gastrectomy[16]. Compared with traditional open gastrectomy, laparoscopic gastrectomy have some advantages including minimally invasiveness, less bleeding, less pain, faster recovery and shorter hospital stay[17–19]. However, with the wide application of laparoscopic technology in clinical practice, limitations were exposed gradually, including two-dimensional views lacking hierarchical sense, non-articulated instruments that have difficulties to operate in deep narrow space, and longer learning curve[20, 21]. These factors hinder the application of laparoscopy in complex surgeries.

With three-dimensional views, wristed instruments and tremor filtration technology, robotic surgery fully shows its advantages of minimally invasiveness, accuracy and flexibility in the operation of advanced gastric cancer[22], and overcomes some limitation of laparoscopic surgery. In this study, we compared the short-term clinical efficacy of robotic versus laparoscopic gastrectomy, and found that there were two advantages in robotic gastrectomy.

First, more lymph nodes were dissected in the robotic group than in the laparoscopic group, especially the suprapancreatic nodes.

We collected 210 consecutive cases of locally advanced gastric cancer that received D2 radical resection and stratified the two types of gastrectomy with distal gastrectomy and total gastrectomy. The number of lymph nodes, lymph nodes at each station, lymph nodes in each region and total number of harvested lymph nodes were analyzed. We found that whether it was in distal gastrectomy or total gastrectomy. The number of lymph nodes dissected by surgical robots in the upper pancreatic region and the station 2 was higher (P = 0.01; 0.01; 0.043; 0.03). With BMI 25kg/m^2 as the boundary, further stratified analysis was conducted: whether or not the patients were overweight, the robotic group was associated with more harvested lymph nodes(P = 0.001, 0.036). We believe that in D2 radical gastrectomy, robotic surgery had significant advantage in the number of suprapancreatic lymph node dissection compared with the laparoscopic surgery.

The main reasons are: (1) Flat two-dimensional vision has no stereoscopic sense, and tremor of surgeon's hand caused by long-term operation leads to unstable surgical view and operation. However, lymphatic drainage channels in advanced gastric cancer is extensive, and metastatic lymph nodes mainly distribute around blood vessels, while vascular anatomy is complex and is often accompanied by variations. The large volume of bleeding following improper handling of vessels anatomy will affects the operation and increases

the difficulty, and such outcomes will not only challenge the surgeon's confidence seriously in the operation[23], but also hinder precise dissection.

(2) The non-articulated arms of laparoscopic device lacks flexibility and the operation area is limited. With the conventional straight forceps used in conventional laparoscopic surgery, the surgical field is limited and it is difficult for the surgeon to reach these deep areas during dissection of N0.8a lymph nodes, N0.11P lymph nodes and N0.12a lymph nodes. In addition, convex body of the pancreas often interfere with the laparoscopic device and obstruct surgeon from precise dissection[24], and affect the dissection of lymph nodes. (3) In laparoscopic surgery, it is difficult for assistants to cooperate well with the surgeon, and to achieve "proper" relative tension of tissue. Excessive traction of the lymph nodes and adipose tissue of the upper pancreas often leads to laceration, bleeding and inadequate dissection of lymph node. While robotic surgery can provide a higher-definition, three-dimensional and stable vision with better depth perception in the surgical area, which is conducive to the precise clearance of perivascular lymph nodes; the instrument arms of robots are flexible and tremor-filtering, and in the narrow operating space, the free rotation of the robot arms is undoubtedly an expansion of space, which makes it relatively easy to dissect perigastric lymph nodes and adipose tissue, especially the lymph nodes in the upper and posterior area of the pancreas which are difficult to reach by traditional laparoscopic instruments. In addition, the autonomous control the 2nd robotic arm and 3rd robotic arm can greatly reduce the surgeon’s dependence on the cooperation of assistants and reduce the incidence of damage.

Kim et al[25] studied 375 cases of radical distal gastrectomy for gastric cancer and found that the number of lymph node dissections in the robotic group and the laparoscopic group was 37.1 and 34.1, respectively. The number of station 2 lymph node dissections in the robotic group was significantly higher than that in the laparoscopic group(16.3 vs 13.2). It was considered that the robotic group had advantage in station 2 lymph node dissection. Shen et al[26]. compared 93 cases of robotic-assisted gastrectomy with 330 cases of laparoscopic-assisted gastrectomy for lymph node dissection (33 vs 31.3 P = 0.047). Huang K. et al[27]. compared open, laparoscopic and robotic gastrectomy (n = 586, 64 and 39 cases), and found that the number of lymph node dissection in robotic gastrectomy and open gastrectomy was similar, and was more than that in laparoscopic gastrectomy. Huang K. et al believed that robotic gastrectomy was associated with easy operation in perigastric lymph node dissection compared with laparoscopic gastrectomy, especially in the soprapancreatic areas and subpyloric regions. Our findings were comparable to the results of Huang K. et al.

Second, there was no significant difference in the rate of pancreatic fistula between the two groups, while the robotic group showed less pancreatic injury.

In this study, the robotic group reported 7 cases of postoperative pancreatic fistula (7.4%) in comparison with 18 cases (15.7%) in the laparoscopic group. There was no statistical difference between the groups. There was no significant difference between severe POPF grade B and C. However, there was a statistical difference in biological leakage which needs no additional therapeutic intervention, with 5 cases (5.3%) in the robotic group and 16 cases (13.9%) in the laparoscopic group.

The robotic group was associated with lower levels of blood amylase and drainage fluid amylase on postoperative day 1, day 2, day 3 and day 5 when compared with the laparoscopic group. There was significant difference in amylase levels of drainage fluid on postoperative day 1 and in levels of blood amylase on postoperative day 1 and day 3 between the groups. It can be seen that the robotic and laparoscopic surgery were equally safe for lymph node dissection in the surface of the pancreas, and the robotic surgery had less trauma to the pancreas.

Considerations are as follows: (1) In laparoscopic surgery, with the absence of effective tactile feedback, it is difficult for the surgeon to identify the pancreatic boundary clearly and accurately only by the flat two-dimensional vision provided by the laparoscope. In addition, the pancreas is fragile in texture, rough in surface and irregular in shape, so it is difficult to prevent pancreatic injury. However, surgical robots have 3D views with strong depth perception, real vision and high resolution, so the surgical view of robotic surgery is more closer to the view in open surgery, and can effectively overcome the limitation of insufficient tactile feedback and improve positioning accuracy. Therefore, during the operation in the upper pancreatic region, the surgeon can better identify the local tiny anatomical gap and reduce the occurrence of iatrogenic trauma [28]. (2) D2 radical gastrectomy for gastric cancer is indeed a anatomy conducted around the upper edge of the pancreas. The location of pancreatic tissue is fixed. In laparoscopic surgery, difficulties exposed when dissecting lymph nodes on the upper edge of the pancreas, especially No. 8p lymph nodes along the common hepatic artery, No. 11p lymph nodes along the proximal splenic artery, and No. 12a lymph nodes in hepatogastric ligament. A high tail in the pancreas, high BMI, and excess visceral fat all increase the difficulty of surgical field exposure and lymph node dissection.

In order to meet the operation requirement of the expert consensus on quality control of the laparoscopic radical resection for gastric cancer in China (2017 edition), it is often necessary to press the pancreas to the lower left to expose the deep lymphatic adipose tissue as much as possible. Even though the laparoscopic group routinely uses T-shaped gauze[29] to protect the pancreas and reduce the superficial tear of the pancreas, it was difficult to avoid direct compression caused by the tip of forceps, which resulted in deep injury of pancreatic tissue, and rupture of pancreatic acinar, trypsin-induced bleeding, pancreatitis and even pancreatic fistula and other complications are caused by pancreatic acinar rupture and pancreatic enzyme activation. At the same time, the surgeons were worried about postoperative pancreatitis or pancreatic fistula caused by injury of pancreas due to excessive compression, therefore they had no choice but to reduce the number of lymph node dissection, which explained why the number of harvested lymph node in the laparoscopic group was significantly less than that in the robotic group. During lymph node dissection in the deep area, the flexible arm of the robot can be lifted, therefore directed compression to the pancreas can be avoided. Thus all the lymph node can be dissected with less pancreatic injury.

Kumagai et al[30]. believed that compression caused by forceps is a risk factor for postoperative fistula in laparoscopic gastrectomy. Satoshi et al[31]. made it clear that long-time direct compression caused by assistant’s forceps in a swine model would lead to pancreatic injury and pancreatic leakage. Tsujiura et al[32]. reached similar conclusions.

In addition, the heat conduction of ultrasound scalpel was also a major factor of pancreatic injury. During lymph node dissection on the upper edge of the pancreas, it is more convenient for robot to grasp the tissue and reduce the direct thermal damage of the functional surface of ultrasound scalpel to the pancreas. Postoperative peritoneal drainage in the robotic group was also less than that in the laparoscopic group, and there was a significant difference in the amount of peritoneal drainage fluid on the first day, suggesting that the robotic group had a better treatment for the exudation of surgical field wounds and lymphatic leakage.

Seo et al[33] compared 40 cases of robot-assisted distal gastrectomy(RADG) with 40 cases of laparoscopy-assisted distal gastrectomy(LADG). They found that the incidence of postoperative fistula was lower in the RADG than that in the LADG group (10% vs 22%), and the difference was statistically significant according to the univariate analysis of risk factors for postoperative fistula. Suda et al[34]. performed radical gastrectomy on 520 patients (robotic group n = 88, laparoscopic group n = 438), and found that there was no pancreatic fistula in the robotic group in their study (robotic 0% vs conventional lap 4.3%, p = 0.029).

This study had some limitations:

1. This was a single-center study without matching research, and the sample size of selected cases was relatively small, which may have caused selection bias.
2. There was no further stratified analysis of the data according to T-staging, therefore the result might be a little biased.
3. This was a retrospective but not a prospective randomized controlled study, so the argument strength was comparatively weak.
4. There was no further analysis of the long-term clinical outcome of robotic surgery in oncology.

In conclusion, in D2 radical gastrectomy for locally advanced gastric cancer, robotic gastrectomy was associated with lower intraoperative blood loss compared with traditional laparoscopic gastrectomy, and it revealed more harvested lymph nodes especially in the suprapancreatic area. Meanwhile, robotic gastrectomy showed less damage to the pancreas.

Declarations

Ethics approval and consent to participate

This study was approved by the medical ethics committee of the First Affiliated Hospital of the Army Medical University (Chongqing Southwest Hospital). The written informed consent of the patient and his family members was obtained.

Consent for publication

Not applicable

Availability of data and materials

The related detailed data from this study is available from the corresponding author.

Competing interests

All the authors of this study have no competing interests.

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Authors' contributions

Xuqi shen: writing- original draft preparation Dazhi Xie: Data curation. Junhui Jiang: Supervision. Di Zhang Investigation. Haiyan Bao: Visualization. Hao Yan: Software. Hui An Editing. Hongbin Tian: Supervision. ZhonghuaWang Writing-Reviewing. Jian Miao: Conceptualization. Yongliang Zhao: Methodology.

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Figures

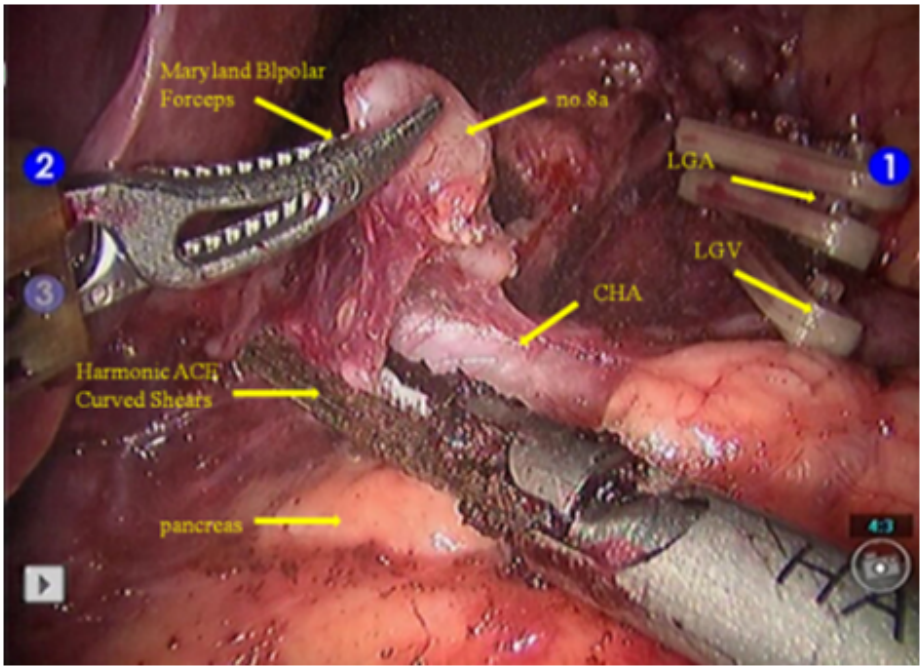

Figure 1

When the robot cleans the lymph nodes in the upper area of the pancreas, it can lift and clean without pressing the pancreas

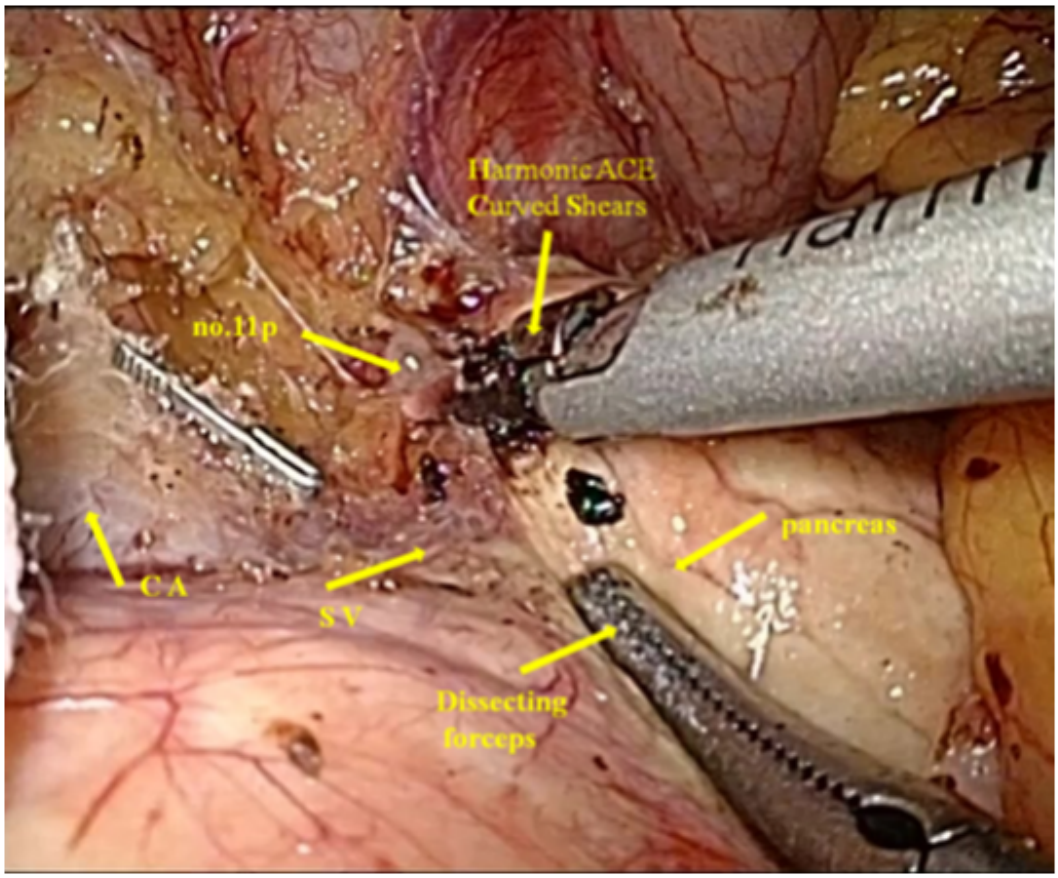

Figure 2

Laparoscopic lymph node dissection of the upper pancreatic region requires compression of the pancreas

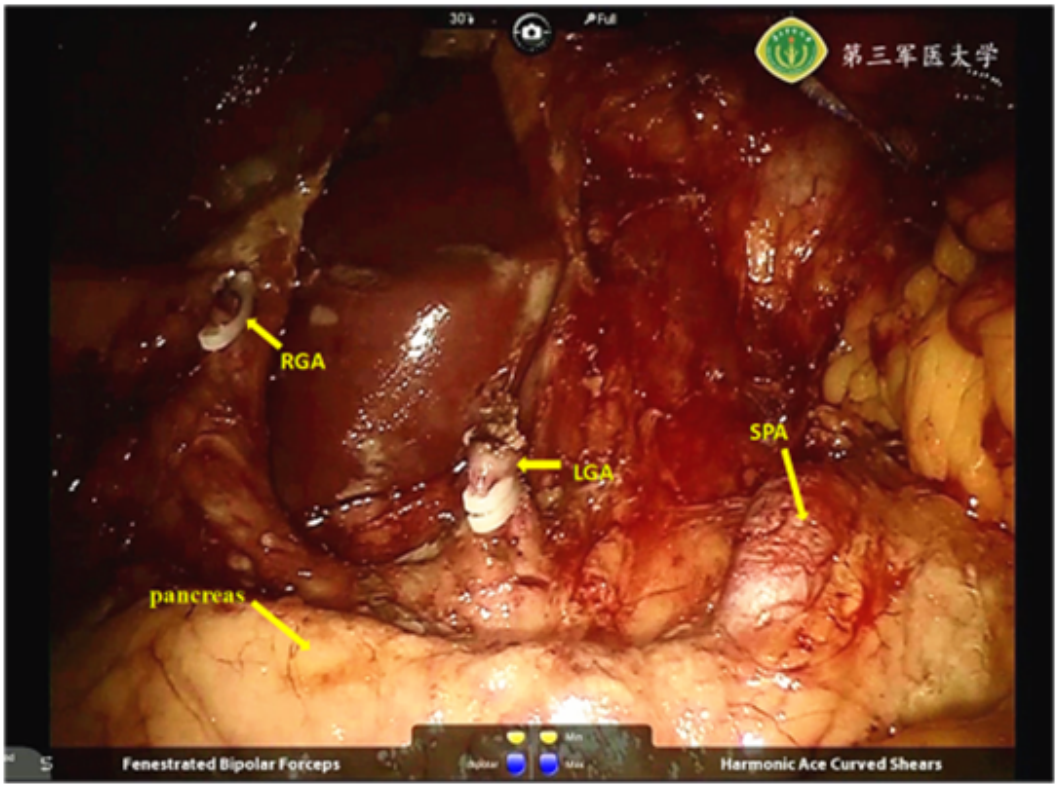

Figure 3

After robot dissection of lymph nodes in the upper pancreatic region

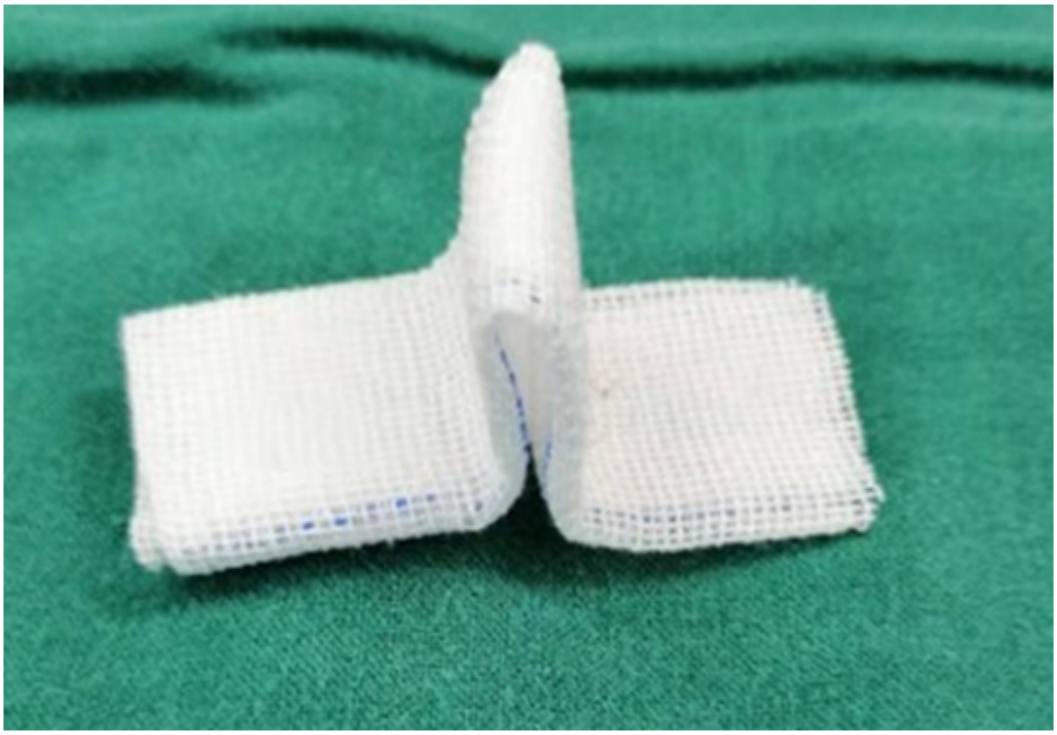

Figure 4

T-line yarn block