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Original Article

ORIGINAL ARTICLE

Safety and feasibility of laparoscopic surgery for colorectal and gastric cancer under the Chinese multi-site practice policy: admittance standards of competence are needed

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Abstract

Background: The multi-site practice (MSP) policy has been practiced in China over 10 years. This study aimed to investigate the safety and feasibility of performing laparoscopic surgery for colorectal cancer (LSCRC) and gastric cancer (LSGC) under the Chinese MSP policy.

Methods: We collected and analysed the data from 1,081 patients who underwent LSCRC or LSGC performed by one gastrointestinal surgeon in his original hospital ($n = 573$) and his MSP institutions ($n = 508$) between January 2017 and December 2020. Baseline demographics, intraoperative outcomes, post-operative recovery, and pathological results were compared between the original hospital and MSP institutions, as well as between MSP institutions with and without specific competence (surgical skill, operative instrument, perioperative multi-discipline team).

Results: In our study, 690 patients underwent LSCRC and 391 patients underwent LSGC. The prevalence of post-operative complications was comparable for LSCRC (11.5% vs 11.1%, $P = 0.89$) or LSGC (15.2% vs 12.6%, $P = 0.46$) between the original hospital and MSP institutions. However, patients in MSP institutions without qualified surgical assistant(s) and adequate instruments experienced longer operative time and greater intraoperative blood loss. The proportion of patients with inadequate lymph-node yield was significantly higher in MSP institutions than in the original hospital for both LSCRC (11.5% vs 21.2%, $P < 0.01$) and LSGC (9.8% vs 20.5%, $P < 0.01$).

Conclusion: For an experienced gastrointestinal surgeon, performing LSCRC and LSGC outside his original hospital under the MSP policy is safe and feasible, but relies on the precondition that the MSP institutions are equipped with qualified surgical skills, adequate operative instruments, and complete perioperative management.

Key words: health policy; gastrointestinal tumors; laparoscopic surgery; public health; quality in health care

INTRODUCTION

Significant disparity in health level, according to urban and rural residence, coastal and inland region, wealthy and distressed community, is still a prominent public health problem in China [1]. To take gastrointestinal cancers as an example, >90% of laparoscopic surgeries for colorectal and gastric cancer are performed in high-volume public hospitals in big cities [2]. To solve the uneven distribution of medical resources among regions, the Chinese government created the multi-site practice (MSP) policy, which is an important component of the new health reform in China, according to the "Opinions of the State Council on Deepening the Health Care System Reform (2009)."

The Chinese MSP policy refers to the performance that an individual practitioner may provide medical activities in two or more sites within his/her practicing period; usually, the practitioner from a first-tier high-volume public hospital also works in a primary public health institution or a private medical center. This policy aims to redistribute high-quality medical resources between urban and rural areas, between developed and developing regions, and between the public and private sectors [3]. The MSP policy in China has some similarities with the well-adopted dual practice (DP) in most other countries [4]. Both MSP policy and DP involve movement of practitioners and redistribution of high-quality medical resources between social sectors. They differ in that DP only refers to practitioners working in public health facilities also practicing in the private sector, whereas the MSP activity in China has its own features: (i) it is administrated mainly to elevate the level of health resources in rural and developing regions; (ii) it is initiated and managed mainly by government authorities rather than the practitioners; (iii) it is organized mainly by inter-institutional collaboration between medical facilities (usually public–public, seldom public–private) [5].

From 2011 to 2017, the Chinese government issued a series of regulations, aiming to expand the scope of practitioners' MSP and to deepen the MSP restructuring in China [6–8]. However, the efficiency and effectiveness of these policies are difficult to evaluate due to the lack of relevant high-quality reports or studies. Moreover, these MSP policies and regulations lack admittance standards for facilities undertaking MSP activities. Concerns have been voiced as to the quality of medical services, which seems to be one of the major barriers during the implementation phase of MSP, especially in surgery specialties [5]. The reasons include (i) MSP surgeons usually perform operations with unfamiliar and less-experienced assistants in medical facilities at the grass-roots level [9, 10]; (ii) perioperative care is usually conducted by local practitioners without the supervision of the MSP surgeon who only takes part in the operation; and (iii) some medical facilities are not equipped with adequate instruments to perform complicated surgeries. Therefore, the quality control of MSP in surgery specialties is controversial.

Until now, few studies have reported the perioperative outcomes during surgical MSP activities. In this study, we aimed to investigate the safety and feasibility of performing laparoscopic surgery for colorectal and gastric cancer in MSP institutions. Meanwhile, the admittance standards of fundamental competence were also assessed for institutions undertaking MSP activities in laparoscopic surgery for colorectal and gastric cancer.

METHODS

Ethics

The study was registered at clinicaltrials.gov with the registry number: NCT04834661. The protocol of study was approved by Ruijin Hospital Ethics Committee (approval number: 2021–412). Informed consent was waived by Ruijin Hospital Ethics Committee due to the study's retrospective nature. Data were extracted from the practitioner's prospective database created in 2017 (raw data are available at http://crs.clinbrain.cn upon request) with the permission of the ethics committees of all facilities.

MSP practitioner

Dr Feng has practiced laparoscopic gastrointestinal surgery for >15 years and currently performs >250 cases of laparoscopic surgery for colorectal cancer (LSCRC) and >150 cases of laparoscopic surgery for gastric cancer (LSGC) per year. He is the vice-director of the Department of Gastrointestinal Surgery in Ruijin

Hospital, affiliated to Shanghai Jiaotong University School of Medicine, Shanghai, China (original hospital). He registered as an MSP practitioner in 2016 and has provided MSP activities for >4 years.

MSP institutions and their competences

Between 2017 and 2020, Dr Feng practiced laparoscopic gastrointestinal surgery in 29 institutions outside his original hospital (excluding 8 institutions that were not willing to participate in this study). Of these, 18 (62.1%) are municipal-level institutions whereas the rest are county-level facilities. Most institutions (20/29) are located in the southeast coastal regions while the remaining are located in the central inland regions. The competences of these institutions were evaluated from the following three different dimensions:

i. Surgical skill competence
   a. First assistant: competent to perform laparoscopic cholecystectomy/appendicectomy/inguinal hernia repair without assistance; completed specific training curriculums for LSCRC/LSGC in high-volume first-tier public hospitals (duration of >6 months, experience of 20 LSCRC and 10 LSGC as first assistant).
   b. Cameraman: can perform laparoscopic cholecystectomy/appendicectomy/inguinal hernia repair with assistance; experience of 20 LSCRC and 20 LSGC as cameraman during training curriculums.
ii. Operative instrument competence [11]
   a. High-definition scope for laparoscopy (including 3D/4K scope)
   b. Rigid 30' degree scope or flexible scope
   c. Bipolar device or ultrasonic device
   d. Goose-neck curved grasper
   e. Laparoscopic linear stapler and circular stapler
iii. Perioperative multi-discipline competence
   a. More than 20 beds in the department of gastrointestinal surgery
   b. Treat >100 cases of gastric or colorectal cancer per year
   c. Operative nurse(s) specialized in laparoscopic surgery
   d. Anesthesiologist(s) specialized in laparoscopic surgery
   e. Nutritionist(s) specialized in gastrointestinal surgery
   f. Pathologist(s) specialized in gastrointestinal cancers

Patient selection

Patients who underwent LSCRC or LSGC in the original hospital or the above-mentioned MSP institutions between 2017 and 2020 were included in our study. The inclusion criteria were as follows: (i) patients with colorectal or gastric cancer confirmed by histopathological evaluation; (ii) LSCRC or LSGC performed by Dr Feng; (iii) patients aged between 18 and 100 years. The exclusion criteria were as follows: (i) emergency procedures; (ii) conventional open surgery; (iii) simultaneous LSCRC and LSGC in one patient; or (iv) palliative diversion (gastrojejunostomy, ileostomy, colostomy, etc.) performed without resection of the primary tumor.

Surgical procedures

A standardized surgical procedure for either LSCRC or LSGC was performed during these 4 years in every institution according to the national guidelines for operative procedure of laparoscopic radical resection of colorectal cancer (2018 edition) [12] and the national guidelines for laparoscopic gastrectomy for gastric cancer (2016 edition) [13].

Outcomes and statistical analysis

Patient demographics, intraoperative outcomes, post-operative recovery, and pathological results were recorded and analysed. Post-operative complications within 30 days were assessed according to the Clavien–Dindo classification [14]. Statistical Package for the Social Sciences (SPSS 13.0, Chicago, IL, USA) was used for statistical analysis. Numerical variables were analysed using the non-parametric Wilcoxon rank-sum test. Pearson's Chi-Square or Fisher's exact test was adopted to analyse categorical data. Multivariate analysis was performed using binary logistic regression. The difference was statistically significant if two-sided P-values were <0.05.

RESULTS

Baseline demographics of patients

In total, 690 patients undergoing LSCRC and 391 patients undergoing LSGC were included in our study. Clinicopathological features of these patients are summarized in Tables 1 and 2, respectively. With regard to baseline characteristics, patients in MSP institutions were older and had a higher proportion of hypoalbuminemia than those in the original hospital. There was no statistically significant difference between the original hospital and MSP institutions with respect to patients' American Society of Anesthesiologists classification, tumor location, or extent of gastrointestinal tract resection. Compared with MSP institutions, the original hospital admitted more patients who had received neoadjuvant chemoradiotherapy (NCT) prior to LSCRC (8.9% vs 1.5%, $P<0.01$), but not LSGC.

Intraoperative indicators

Median operative time differed statistically significantly between the original hospital and MSP institutions in patients undergoing LSCRC (129 vs 135 min, $P=0.04$) but not LSGC. Median blood loss was statistically significantly lower in patients undergoing LSCRC (20 vs 50 mL, $P<0.01$) or LSGC (50 vs 50 mL, $P<0.01$) in the original hospital than in MSP institutions. A statistically significantly higher proportion of severe bleeding (blood loss > 300 mL) was observed in MSP institutions during LSCRC (0% vs 2.6%, $P<0.01$) or LSGC (1.8% vs 5.4%, $P=0.05$). However, there was no statistically significant difference in the conversion rate between the original hospital and MSP institutions during LSCRC (1.1% vs 0.3%, $P=0.37$) or LSGC (0% vs 1.2%, $P=0.18$).

Post-operative recovery

Median post-operative hospital stay was statistically significantly longer in patients after LSCRC (7 vs 12 days, $P<0.01$) or after LSGC (8 vs 13 days, $P<0.01$) in MSP institutions than in the original hospital. However, there was no significant difference in the overall prevalence of post-operative complications either after LSCRC (11.5% vs 11.1%, $P=0.89$) or after LSGC (15.2% vs 12.6%, $P=0.46$). All complications are shown in Table 3. Anastomotic leakage (AL) and deep surgical site infection (SSI) not associated with AL were the most common complications in both the original hospital and MSP institutions.

Multivariate analysis demonstrated that preoperative hypoalbuminemia and neoadjuvant chemoradiotherapy were

Table 1. Clinicopathological characteristics of 690 patients undergoing laparoscopic surgery for colorectal cancer

Characteristic	Original hospital ($n = 349$)	MSP institutions ($n = 341$)	P-value
Sex, *n* (%)			0.478
Male	221 (63.3)	207 (60.7)	
Female	128 (36.7)	134 (39.3)	
Age (years), median (quartile)	64 (55–70)	66 (55–72)	0.046
Body mass index (kg/m^2), median (quartile)	23.0 (21.2–25.0)	23.4 (21.9–25.3)	0.195
Hypoalbuminemia, *n* (%)			<0.001
No	308 (88.3)	241 (70.7)	
Yes	41 (11.7)	100 (29.3)	
ASA classification, *n* (%)			0.812
I–II	342 (98.0)	335 (98.2)	
III	7 (2.0)	6 (1.8)	
Neoadjuvant chemoradiotherapy, *n* (%)			<0.001
No	318 (91.1)	336 (98.5)	
Yes	31 (8.9)	5 (1.5)	
Tumor location, *n* (%)		(Missing = 3)	0.558
Mid-low rectum	80 (22.9)	76 (22.5)	
High rectum and rectosigmoid junction	156 (44.7)	139 (41.1)	
Left colon	24 (6.9)	32 (9.5)	
Right colon	89 (25.5)	91 (26.9)	
Extent of coloproctectomy, *n* (%)		(Missing = 7)	0.088
Proctectomy	235 (67.3)	204 (61.1)	
Colectomy	114 (32.7)	130 (38.9)	
Operative time (min), median (quartile)	129 (105–160)	135 (120–165)	0.039
Intraoperative blood loss (mL), median (quartile)	20 (10–20)	50 (20–50)	<0.001
Intraoperative blood loss > 300 mL, *n* (%)			0.002
No	349 (100.0)	332 (97.4)	
Yes	0 (0.0)	9 (2.6)	
Conversion to open surgery, *n* (%)			0.373
No	345 (98.9)	340 (99.7)	
Yes	4 (1.1)	1 (0.3)	
Post-operative hospital stay (days), median (quartile)	7 (6–8)	12 (10–14)	<0.001
Post-operative complications, *n* (%)			0.895
No	309 (88.5)	303 (88.9)	
Yes	40 (11.5)	38 (11.1)	
Tumor size (cm), median (quartile)	4.0 (3.0–5.0)	4.0 (3.0–5.0)	0.002
pTNM stage, *n* (%)	(Missing = 2)	(Missing = 3)	0.280
I	85 (24.5)	64 (18.9)	
II	109 (31.4)	128 (37.9)	
III	128 (36.9)	134 (39.6)	
IV	25 (7.2)	12 (3.6)	
Number of lymph-node yield, median (quartile)	15 (13–19)	15 (12–18)	0.012
Adequate lymph-node yield, *n* (%)	(Missing = 1)	(Missing = 1)	0.001
Yes (≥12)	308 (88.5)	268 (78.8)	
No (<12)	40 (11.5)	72 (21.2)	
			0.451
Resection margin ≥ 5 mm, *n* (%)			
Yes	344 (98.6)	339 (99.4)	
No	5 (1.4)	2 (0.6)	

MSP, multi-site practice; ASA, American Society of Anesthesiologists.

Table 2. Clinicopathological characteristics of 391 patients undergoing LSGC

Characteristic	Original hospital ($n = 224$)	MSP institutions ($n = 167$)	P-value
Sex, *n* (%)			0.685
Male	154 (68.8)	118 (70.7)	
Female	70 (31.2)	49 (29.3)	
Age (years), median (quartile)	63 (56–68)	67 (59–72)	<0.001
BMI (kg/m^2), median (quartile)	23.1 (20.6–25.3)	22.7 (20.9–24.6)	0.327
Hypoalbuminemia, *n* (%)			0.019
No	201 (89.7)	136 (81.4)	
Yes	23 (10.3)	31 (18.6)	
ASA classification, *n* (%)			0.590
I–II	215 (96.0)	162 (97.0)	
III	9 (4.0)	5 (3.0)	
NCT, *n* (%)			0.574
No	217 (96.9)	160 (95.8)	
Yes	7 (3.1)	7 (4.2)	
Tumor location, *n* (%)	(Missing = 1)		0.888
Stomach	179 (80.3)	135 (80.8)	
EG junction	44 (19.7)	32 (19.2)	
Extent of gastrectomy, *n* (%)			0.312
Partial gastrectomy	157 (70.1)	109 (65.3)	
Total gastrectomy	67 (29.9)	58 (34.7)	
Operative time (min), median (quartile)	180 (156–206)	180 (150–225)	0.377
Blood loss (mL), median (quartile)	50 (20–50)	50 (50–100)	<0.001
Blood loss > 300 mL, *n* (%)			0.049
No	220 (98.2)	158 (94.6)	
Yes	4 (1.8)	9 (5.4)	
Conversion to open surgery, *n* (%)			0.182
No	224 (100.0)	165 (98.8)	
Yes	0 (0.0)	2 (1.2)	
Post-operative stay (days), median (quartile)	8 (7–10)	13 (11–16)	<0.001
Post-operative complications, *n* (%)			0.464
No	190 (84.8)	146 (87.4)	
Yes	34 (15.2)	21 (12.6)	
Tumor size (cm), median (quartile)	3.1 (2.0–4.8)	3.5 (2.5–5.0)	0.028
pTNM stage, *n* (%)		(Missing = 1)	0.231
I	85 (37.9)	50 (30.1)	
II	50 (22.3)	51 (30.7)	
III	79 (35.3)	58 (34.9)	
IV	10 (4.5)	7 (4.2)	

Table 2. (continued)

Characteristic	Original hospital ($n = 224$)	MSP institutions ($n = 167$)	*P*-value
Number of LN yield, median (quartile)	25 (19–29)	23 (16–30)	0.064
Adequate LN yield, *n* (%)		(Missing = 1)	0.003
Yes (>16)	202 (90.2)	132 (79.5)	
No (<15)	22 (9.8)	34 (20.5)	
Resection margin ≥ 5 mm, *n* (%)			0.454
Yes	214 (95.5)	162 (97.0)	
No	10 (4.5)	5 (3.0)	

LSGC, laparoscopic surgery for gastric cancer; MSP, multi-site practice; BMI, body mass index; ASA, American Society of Anesthesiologists; NCT, neoadjuvant chemoradiotherapy; EG junction, esophagogastric junction; LN, lymph node.

Table 3. Incidence of post-operative complications after LSCRC and LSGC

Complication (*n*, %)	Original hospital		MSP institutions	
	LSCRC ($n = 349$)	LSGC ($n = 224$)	LSCRC ($n = 341$)	LSGC ($n = 167$)
Anastomotic bleeding	1 (0.3)	1 (0.4)	2 (0.6)	2 (1.2)
Intra-abdominal bleeding	1 (0.3)	2 (0.9)	1 (0.3)	0
AL	20 (5.7)	8 (3.6)	7 (2.1)	6 (3.6)
Deep SSI	6 (1.7)	11 (4.9)	5 (1.5)	2 (1.2)
Wound infection	2 (0.6)	6 (2.7)	5 (1.5)	1 (0.6)
Urinary infection	6 (1.7)	0	3 (0.9)	0
Respiratory infection	0	6 (2.7)	4 (1.2)	5 (3.0)
lymphatic leakage	0	0	3 (0.9)	4 (2.4)
Intestinal obstruction	3 (0.9)	1 (0.4)	10 (2.9)	1 (0.6)
Delayed gastric emptying	1 (0.3)	2 (0.9)	0	5 (3.0)
Cardiovascular events	0	2 (0.9)	0	0
Organ dysfunction	1 (0.3)	2 (0.9)	2 (0.6)	1 (0.6)
Overall	40 (11.5)	34 (15.2)	38 (11.1)	21 (12.6)

LSCRC, laparoscopic surgery for colorectal cancer; LSGC, laparoscopic surgery for gastric cancer; MSP, multi-site practice; AL, anastomotic leakage; SSI, surgical site infection.

independent risk factors for post-operative complications after LSCRC, while older age (>75 years) was an independent risk factor after LSGC. However, operation performed in MSP institution was not a risk factor for post-operative complications after LSCRC or LSGC (Supplementary Tables 1 and 2).

Pathological results

Pathological evaluations revealed that tumor size and number of lymph nodes (LNs) were significantly different between original hospital and MSP institutions, whereas the tumor stage (pTNM) was similar. In addition, the ratio of inadequate LN yield (<for LSCRC or 15 for LSGC) was significantly higher in MSP institutions than in the original hospital for both LSCRC (11.5% vs 21.2%, $P < 0.01$) and LSGC (9.8% vs 20.5%, $P < 0.01$).

Subgroup analysis of MSP institutions

We compared patients undergoing LSCRC in MSP institutions with different competences (Table 4). The operative time (135 vs 155 min, $P < 0.01$) and the blood loss (30 vs 50 mL, $P < 0.01$) differed statistically significantly between institutions with and without surgical skill competence. Similarly, the operative time (130 vs 195 min, $P < 0.01$) and the blood loss (45 vs 50 mL, $P < 0.01$) were significantly different between institutions with and without operative instrument competence. A significantly greater number of LN yield (16 vs 12, $P < 0.01$) and lower proportion of inadequate LN yield (16.9% vs 29.6%, $P < 0.01$) was found in the institutions with perioperative multi-discipline competence.

In patients undergoing LSGC, the operative time (180 vs 210 min, $P = 0.02$) and the blood loss (50 vs 100 mL, $P < 0.01$) were significantly different between institutions with and without surgical skill competence (Table 5). In addition, the prevalence of post-operative complications (8.6% vs 21.6%, $P = 0.02$), the number of LN yield (25 vs 18, $P < 0.01$), and the proportion of inadequate LN yield (13.9% vs 20.5%, $P < 0.01$) were significantly different between institutions with and without perioperative multi-discipline competence.

DISCUSSION

Regarding the safety and feasibility of performing laparoscopic surgery for colorectal and gastric cancer under the Chinese MSP policy, we found an acceptable prevalence of post-operative complications although operative time was longer, blood loss was greater, bleeding was more severe, and LN yield was more inadequate in MSP institutions. Of note, the perioperative outcomes and pathological quality differed significantly in MSP institutions with and without some specific competences. Our results lead us to suggest that performing LSCRC and LSGC by an experienced gastrointestinal surgeon under MSP policy is safe and feasible in those institutions equipped with qualified surgical assistant(s), adequate operative instruments, and a complete perioperative treatment team (nursing, anesthesiologists, nutritionists, pathologists, etc.).

It is obvious that the volume of the facility significantly affects surgical quality. Patients with gastrointestinal cancer prefer high-volume facilities when deciding where they have surgery [15]. Although some practitioners in grassroots-level facilities have completed specific training curriculums and have been certificated to perform laparoscopic gastrointestinal surgery, the lack of patient recruitment is an insurmountable obstacle for them to climb the long learning curve. As a possible solution, MSP activities in this surgical specialty are expected to promote the support of high-quality medical resources (experienced surgeons and advanced surgical techniques) in grassroots-level facilities.

Despite the positive attitude to this policy among medical staff and patients [16], there was still a declining tendency of Chinese outpatient visits to primary care facilities in the past decade; Zhang *et al.* [17] owed this to the lack of a well-trained healthcare workforce in the primary care system. Publications reporting the actual outcomes of medical services provided in MSP institutions are rare, which prompted us to conduct this study for LSCRC and LSGC performed in MSP institutions.

It is conceivable that some results of patients' baseline characteristics were heterogeneous between the original hospital and MSP institutions. Older patients in poor nutritional condition tend to stay in local institutions instead of travelling to large-scale top-tier hospitals in Shanghai because the former facilitates family care and accompanying. Of note, a poorer baseline condition of patients in MSP institutions did not result in more post-operative complications in our study. The overall prevalence of complications was comparable between the

Table 4. Comparison of patient characteristics undergoing LSCRC between different MSP institutions

Characteristic	Surgical skill competence			Operative instrument competence			Perioperative multi-discipline competence		
	With ($n=298$)	Without ($n=43$)	*P*-value	With ($n=289$)	Without ($n=52$)	*P*-value	With ($n=226$)	Without ($n=115$)	*P*-value
Sex, *n* (%)			0.333			0.043			0.671
Male	178 (59.7)	29 (67.4)		182 (63.0)	27 (51.9)		139 (61.5)	68 (59.1)	
Female	120 (40.3)	14 (32.6)		107 (37.0)	25 (48.1)		87 (38.5)	47 (40.9)	
Age (years), median (quartile)	66 (56–73)	62 (49–70)	0.028	66 (55–72)	66 (55–73)	0.866	65 (55–72)	67 (55–74)	0.169
Operative time (min), median (quartile)	135 (110–160)	155 (130–195)	0.001	130 (115–157)	195 (128–220)	<0.001	135 (120–165)	135 (110–165)	0.778
Blood loss (mL), median (quartile)	30 (20–50)	50 (50–55)	<0.001	45 (20–50)	50 (30–95)	0.007	50 (20–50)	50 (20–50)	0.282
Blood loss > 300 mL, *n* (%)			0.017			0.144			0.723
No	293 (98.3)	39 (90.7)		283 (97.9)	49 (94.2)		219 (96.9)	113 (98.3)	
Yes	5 (1.7)	4 (9.3)		6 (2.1)	3 (5.8)		7 (3.1)	2 (1.7)	
Post-operative hospital stay (days), median (quartile)	12 (10–14)	12 (10–16)	0.273	12 (10–14)	12 (10–16)	0.471	12 (10–14)	12 (10–14)	0.794
Post-operative complications, *n* (%)			0.602			0.291			0.426
No	266 (89.3)	37 (86.0)		259 (89.6)	44 (84.6)		203 (89.8)	100 (87.0)	
Yes	32 (10.7)	6 (14.0)		30 (10.4)	8 (15.4)		23 (10.2)	15 (13.0)	
Tumor size (cm), median (quartile)	4.2 (3.0–5.0)	4.0 (3.0–4.6)	0.023	4.0 (3.0–5.0)	4.0 (3.0–5.4)	0.804	4.5 (3.0–5.2)	4.0 (3.0–5.0)	0.115
Number of LN yield, median (quartile)	15 (11–18)	14 (11–19)	0.878	15 (11–18)	14 (11–18)	0.924	16 (12–21)	12 (10–15)	0.001
Adequate LN yield, *n* (%)	(Missing =1)		0.721	(Missing = 1)		0.458	(Missing = 1)		0.008
Yes (>12)	235 (79.1)	33 (76.7)		225 (78.1)	43 (82.7)		187 (83.1)	81 (70.4)	
No (<11)	62 (20.9)	10 (23.3)		63 (21.9)	9 (17.3)		38 (16.9)	34 (29.6)	

LSCRC, laparoscopic surgery for colorectal cancer; MSP, multi-site practice; LN, lymph node.

Table 5. Comparison of patient characteristics undergoing LSGC between different MSP institutions

Characteristic	Surgical skill competence			Operative instrument competence			Perioperative multi-discipline competence		
	With ($n=141$)	Without ($n=26$)	*P*-value	With ($n=149$)	Without ($n=18$)	*P*-value	With ($n=116$)	Without ($n=51$)	*P*-value
Sex, *n* (%)			0.114			0.346			0.063
Male	103 (73.0)	15 (57.5)		107 (71.8)	11 (61.1)		87 (75.0)	31 (60.8)	
Female	38 (27.0)	11 (42.3)		42 (28.2)	7 (38.9)		29 (25.0)	20 (39.2)	
Age (years), median (quartile)	68 (60–72)	63 (51–69)	0.009	67 (59–72)	66 (61–74)	0.928	67 (58–72)	69 (60–72)	0.458
Operative time (min), median (quartile)	180 (150–215)	210 (168–253)	0.018	180 (150–222)	190 (150–240)	0.751	180 (150–215)	185 (150–235)	0.551
Blood loss (mL), median (quartile)	50 (50–100)	100 (50–200)	0.006	50 (50–100)	50 (100–150)	0.074	50 (50–100)	60 (50–100)	0.254
Blood loss > 300 mL, *n* (%)			0.148			1.000			0.094
No	135 (95.7)	23 (88.5)		141 (94.6)	17 (94.4)		112 (96.6)	46 (90.2)	
Yes	6 (4.3)	3 (11.5)		8 (5.4)	1 (5.6)		4 (3.4)	5 (9.8)	
Post-operative stay (days), median (quartile)	13 (11–15)	17 (14–20)	0.001	13 (11–16)	15 (12–17)	0.391	13 (11–16)	15 (11–20)	0.259
Post-operative complications, *n* (%)			0.747			1.000			0.020
No	124 (87.9)	22 (84.6)		130 (87.2)	16 (88.9)		106 (91.4)	40 (78.4)	
Yes	17 (12.1)	4 (15.4)		19 (12.8)	2 (11.1)		10 (8.6)	11 (21.6)	
Tumor size (cm), median (quartile)	3.6 (2.5–5.0)	3.0 (2.0–4.4)	0.291	3.5 (2.5–5.0)	3.0 (2.0–5.4)	0.690	3.5 (2.5–5.3)	4.0 (2.5–5.0)	0.650
Number of LN yield, median (quartile)	23 (16–29)	23 (16–35)	0.489	23 (16–30)	18 (16–26)	0.292	25 (18–31)	18 (15–24)	<0.001
Adequate LN yield, *n* (%)	(Missing =1)		0.863		(Missing =1)	0.753	(Missing =1)		0.002
Yes (>16)	111 (79.3)	21 (80.8)		119 (79.9)	13 (76.5)		99 (86.1)	132 (79.5)	
No (<15)	29 (20.7)	5 (19.2)		30 (20.1)	4 (23.5)		16 (13.9)	34 (20.5)	

LSGC, laparoscopic surgery for gastric cancer; MSP, multi-site practice; LN, lymph node.

original hospital and MSP institutions, in line with the results (11.3% for LSCRC, 12.1% for LSGC, respectively) reported by other studies [18, 19]. Given the fact that the socioeconomic status of the community was strongly associated with surgical outcomes [20], the Chinese MSP activities are promising to help improve surgical quality in grassroots-level facilities in distressed regions. On the other hand, the prevalence of complications after LSGC was significantly higher in MSP institutions without perioperative multi-discipline competence than in those equipped with this competence, which means that perioperative care and management also played an important role in the prevention of post-operative complications.

Moreover, several intraoperative indicators in MSP institutions warrant attention. According to our study, institutions without qualified assistants and adequate instruments were associated with longer operative time, greater blood loss, and higher prevalence of severe bleeding. Hence, we suggest that qualified surgical assistant(s), trained in large-scale top-tier hospitals, and adequate operative instruments are indispensable to assure the safety and feasibility of LSCRC and LSGC in MSP institutions.

The higher proportion of inadequate LN yield in MSP institutions was another concern in our study. Our subgroup analysis suggested that institutions without pathologist(s) who specialized in gastrointestinal cancers might be responsible for this poor quality control. It is well known that adequate LN yield is an essential quality measure for radical resection of gastrointestinal cancer. According to relevant guidelines, a minimum of 12 and 16 LNs is required for colorectal cancer and gastric cancer, respectively [21, 22]. However, the LN yield depends not only on the extent of the lymphadenectomy performed by individual surgeons but also on the diligence with which pathologists search for LNs [23]. Thus, in order to match high-quality surgical services, emphasis should be addressed to the quality control of pathological reports in MSP institutions.

Our study has several limitations. First, this was a single practitioner's report. Notwithstanding, our individual experience and personal suggestions might help further refine the MSP policy, especially from the aspect of proposing admittance standards for institutions undertaking MSP activities. Second, the retrospective nature of this study was inevitably associated with a selection bias. Of note, 104 patients were excluded due to hospitals' declining participation, which might give rise to selection bias. Third, there was a tremendous difference in patient numbers between the institutions with and without specific competence, which might lower the statistical power of our analyses. Fourth, the lack of long-term follow-up data makes it impossible to establish any conclusion about survival.

In conclusion, performing laparoscopic surgery for colorectal and gastric cancer outside an experienced gastrointestinal surgeon's primary registered medical institution under the MSP policy is safe and feasible, under the circumstances that the MSP institutions are equipped with qualified surgical skill competence, adequate operative instrument competence, and complete perioperative treatment competence. An effort to put forward appropriate admittance standards of competence for institutions undertaking MSP activities needs reflection.

Supplementary Data

Supplementary data is available at *Gastroenterology Report* online.

Authors' Contributions

Acquisition of data: H.S., X.X., H.Z., Z.L., Y.Z., D.S., D.B., H.W., B.C., S.H., Y.Z., J.S., K.Y. Analysis and interpretation of data: Z.C., Z.H. Drafting of the manuscript: Z.C., H.S., Z.H. Critical revision of the manuscript for important intellectual content: A.F., B.F. Statistical analysis: X.X., H.Z. Obtaining funding: B.F. Administrative, technical, or material support: Y.L., J.L. Z.L., Y.Z., D.S., D.B., H.W., B.C., S.H., Y.Z., J.S., K.Y. Supervision: Y.L., J.L.

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Conflict of Interest

None declared.

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