

## Laparoscopic splenic hilum lymph node dissection for advanced proximal gastric cancer: A modified approach for pancreas- and spleen-preserving total gastrectomy

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### Abstract

**AIM:** To investigate the feasibility and optimal approach for laparoscopic pancreas- and spleen-preserving splenic hilum lymph node dissection in advanced proximal gastric cancer.

**METHODS:** Between August 2009 and August 2012, 12 patients with advanced proximal gastric cancer treated in Nanfang Hospital, Southern Medical University, Guangzhou, China were enrolled and subsequently underwent laparoscopic total gastrectomy with pancreas- and spleen-preserving splenic hilum lymph node (LN) dissection. The clinicopathological characteristics, surgical outcomes, postoperative course and follow-up data of these patients were retrospectively collected and analyzed in the study.

**RESULTS:** Based on our anatomical understanding of peripancreatic structures, we combined the characteristics of laparoscopic surgery and developed a modified approach (combined supra- and infra-pancreatic approaches) for laparoscopic pancreas- and spleen-preserving splenic hilum LN dissection. Surgery was completed in all 12 patients laparoscopically without conversion. Only one patient experienced intraoperative bleeding when dissecting LNs along the splenic artery and was handled with laparoscopic hemostasis. The mean operating time was 268.4 min and mean number of retrieved splenic hilum LNs was 4.8. One patient had splenic hilum LN metastasis (8.3%). Neither postoperative morbidity nor mortality was observed. Peritoneal metastasis occurred in one patient and none of the other patients died or experienced recurrent disease during the follow-up period.

**CONCLUSION:** Laparoscopic total gastrectomy with pancreas- and spleen-preserving splenic hilum LN dissection using the modified approach for advanced proximal gastric cancer could be safely achieved.

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**Key words:** Proximal stomach; Stomach neoplasm; Laparoscopy; Lymph node excision; Splenic hilum

**Core tip:** Pancreas- and spleen-preserving splenic hilum lymph node dissection in laparoscopic total gastrectomy is challenging. Even though a small number of skilled laparoscopic surgeons have demonstrated the safety and feasibility of this procedure, most surgeons adopt only the suprapancreatic approach. However, exposure and dissection of splenic hilum lymph nodes posterior to the splenic artery, especially its inferior branch is sometimes difficult and unpredicted injury or bleeding is more likely to occur if only through the suprapancreatic approach. We combined the supra- and infra-pancreatic approaches to better expose the posterior

## splenic artery lymph nodes at the splenic hilum and dissect more safely.

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## INTRODUCTION

The metastatic rate of splenic hilum lymph nodes (LNs) has been reported to range from 8% to 21% in advanced proximal gastric cancer<sup>[1-6]</sup>, and the removal of splenic hilum LNs might bring about potential survival benefit for these patients. Accordingly, splenic hilum LN dissection is recommended in the surgical treatment for advanced proximal gastric cancer<sup>[7]</sup>.

Traditionally, the dissection of splenic hilum LNs and nodes along the splenic artery (SA) is achieved through pancreatectomy or pancreas-preserving splenectomy. However, it has been suggested that the combined resection of pancreas and/or spleen would significantly increase postoperative morbidity and mortality rather than improve prognosis, as well as decrease immunological function<sup>[8-12]</sup>. As an alternative, pancreas- and spleen-preserving splenic hilum LN dissection might decrease postoperative morbidity without compromising oncological principles<sup>[13]</sup>.

With the rapid development of minimally invasive surgery, the application of laparoscopic surgery for gastric cancer is gradually gaining popularity<sup>[14-16]</sup>. However, due to the tortuous splenic vessels and possibility of parenchymal injury to the spleen or pancreas, it is still a challenging and technically demanding procedure for conducting laparoscopic pancreas- and spleen-preserving splenic hilum LN dissection. Only a few experienced laparoscopic surgeons have suggested its safety and feasibility<sup>[17-19]</sup>, and most of them adopted the suprapancreatic approach to perform pancreas- and spleen-preserving splenic hilum LN dissection without using the infrapancreatic approach near pancreatic tail, while this method might not facilitate the dissection of LNs posterior to the splenic hilum.

Based on our anatomical understanding of peripancreatic fascia and spaces, we attempted a novel strategy combining supra- and infra-pancreatic approaches to perform laparoscopic pancreas- and spleen-preserving splenic hilum LN dissection in total gastrectomy for treating advanced proximal gastric cancer. Herein, detailed procedure and preliminary results are presented.

## MATERIALS AND METHODS

### Patients

Between August 2009 and August 2012, 112 patients with

endoscopically biopsy-proven proximal gastric cancer underwent laparoscopic total gastrectomy in Nanfang Hospital, Southern Medical University. Among them, twelve consecutive patients underwent laparoscopic pancreas- and spleen-preserving splenic hilum LN dissection with curative intent.

### Surgical indications

The indications for this procedure were as follows: (1) tumors were located at the upper- or middle-third of the stomach without distant metastasis; (2) tumors penetrated over the mucosa layer without invading adjacent structures; and (3) no gross involvement of the gastrosplenic ligament or LN number 4sb, at the splenic hilum or along the SA. Preoperative staging was confirmed by endoscopic ultrasound, abdominal high-resolution multidirectional computed tomography (CT), and positron emission computed tomography if necessary.

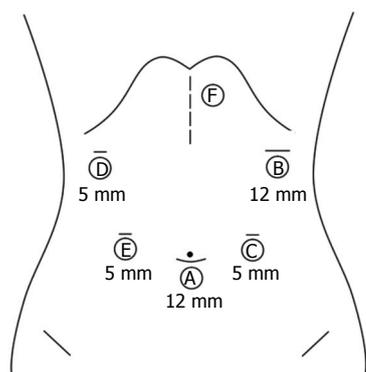
All surgical procedures were performed by Dr. Li GX, who had experience of over 500 laparoscopic gastrectomies for gastric cancer. All patients were given details about the operative procedure and potential risks before operation and provided written informed consent. This study was approved by the Ethics Committee of Nanfang Hospital.

### Surgical procedures

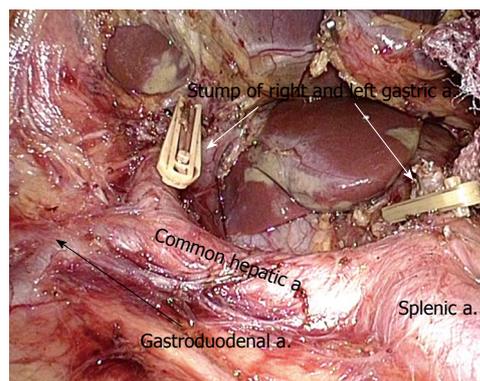
The regional LNs were numbered according to the Japanese Classification of Gastric Carcinoma (JCGC) guidelines and LN dissection was done with laparoscopic ultrasonic shears [laparoscopic coagulation shears (LCSs); Ethicon Endo-Surgery, Cincinnati, OH, United States].

Under general anesthesia, the patient was placed in the supine position with legs set apart in a reverse Trendelenburg position. The surgeon stood on the patient's left side, the assistant surgeon on the patient's right side, and the camera operator stood between the patient's legs. After pneumoperitoneum was established with CO<sub>2</sub> insufflated at a pressure of 12 mmHg, five working ports were introduced (Figure 1)<sup>[20]</sup>. Exploration of the abdominopelvic cavity was conducted to exclude distant metastasis and carcinomatosis.

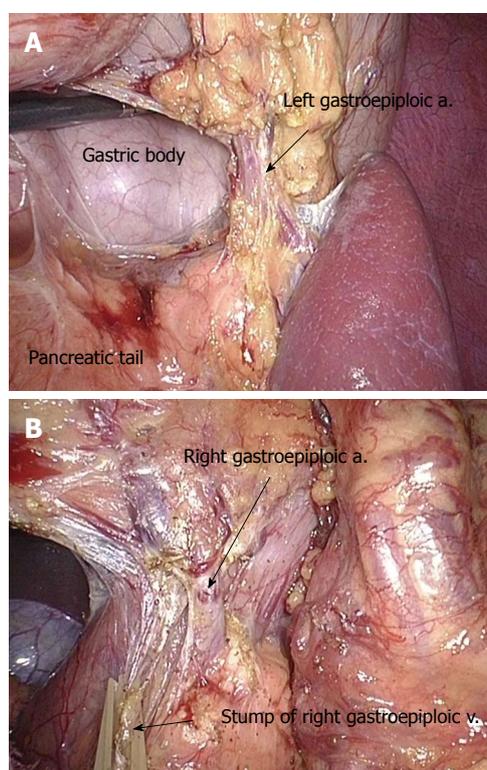
The greater omentum was divided along the border of the transverse colon toward the inferior pole of the spleen. By dividing the gastrocolic ligament, the lesser sac was entered. The stomach was then overturned cephalad and the left gastroepiploic vessels were located at the boundary between the gastrocolic ligament and the gastrosplenic ligament, which were then divided at their roots (Figure 2A). By separating the gastrosplenic ligament up to the left side of the esophageal hiatus, the short gastric vessels were divided just adjacent to the spleen and the upper part of the greater curvature was mobilized. LN numbers 4sa and 2 were dissected. The right gastroepiploic vein was identified by tracing proximally along the gastrocolic trunk or dissecting the mesogastrium inferior to the gastric antrum off the transverse mesocolon, which was then ligated and divided at its origin. The right gastroepiploic artery was usually identified



**Figure 1** Positions of trocars. The trocars were inserted into the abdomen in the order A-E. Position F stands for the 4-5 cm midline minilaparotomy incision for reconstruction.



**Figure 3** Tracing gastroduodenal artery to locate celiac trunk and its branches (arrows). a: Artery.



**Figure 2** Gastroepiploic artery. A: Dividing left gastroepiploic artery (arrow); B: Dividing right gastroepiploic vessels (arrow). a: Artery; v: Vein.

next to the vein, which was also divided to allow the removal of LN numbers 4d and 6 (Figure 2B). After overturning the gastric antrum cranially, the gastropancreatic fold was exposed. The gastroduodenal artery was usually located in the groove between the duodenum and pancreatic head, which was a clue to trace the celiac trunk and its branches. By following the common hepatic artery, the proper hepatic artery was traced. The right gastric artery was located in the hepatoduodenal ligament as a small branch running from the proper hepatic artery to the supra-pylorus. By ligating the right and left gastric arteries and veins at origin and dissecting the tissues around the proper hepatic artery, common hepatic artery and celiac

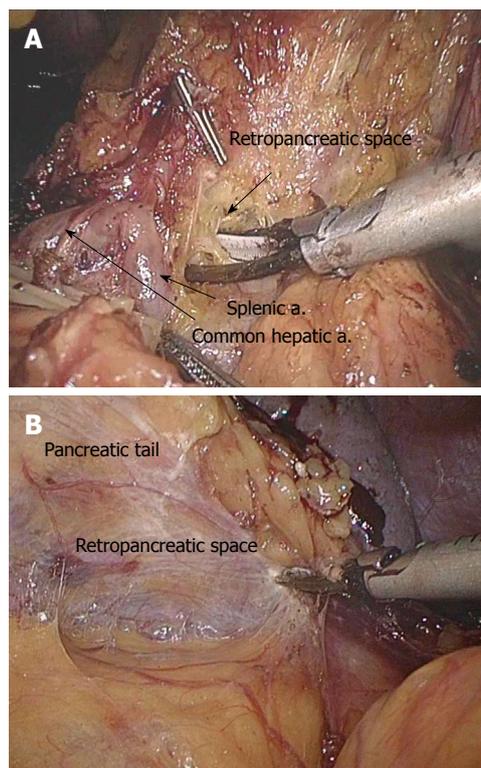
trunk, the right side of the suprapancreatic LNs (numbers 5, 7, 8a, 9 and 12a) were removed *en bloc* (Figure 3).

By retracting the pancreas meticulously in the caudal direction, the surgeon could dissect the soft tissue off the superior margin of the pancreatic body and tail in order to enter the retropancreatic space, thus uncovering the proximal SA (Figure 4A). From this step, in order to facilitate this manipulation, the surgeon changed his operating position and stood between the patient's legs. By opening the artery sheath and skeletonizing the SA from the proximal portion towards the distal portion, LN number 11p could be removed. When the bifurcation was reached, two secondary branches of the SA could be seen in most cases. The superior branch coursed towards the superior pole of the spleen and the inferior one coursed directly towards the splenic hilum. The pancreatic tail was mobilized using the infrapancreatic approach to enter the retropancreatic space (Figure 4B). The superior and inferior branches of the SA were then skeletonized until they reached the splenic parenchyma (Figure 5). Meanwhile, the remaining short gastric vessels originating from the SA were further ligated and divided. By skeletonizing the SA, fatty tissues bearing LN numbers 10 and 11d were removed, and all vessels in the splenic hilum area were saved with the preservation of both the pancreas and the spleen.

The duodenum was transected 2 cm distal to the pylorus using an endoscopic linear stapler (Echelon 60 Endopath Stapler; Ethicon Endo-Surgery, Guaynabo, Puerto Rico, United States). Subsequently, the phrenoesophageal and both vagus nerves were divided, along with the removal of LN number 1. The transaction of the esophagus and Roux-en-Y esophagojejunostomy were carried out extracorporeally through a 4-5-cm midline minilaparotomy just below the xiphoid process using a circular stapler. An end-to-side jejunojejunostomy was performed by hand suture.

## RESULTS

The clinicopathological characteristics of the patients are shown in Table 1. Surgical outcomes and postoperative



**Figure 4** Entering retropancreatic space. A: Near the superior margin of the pancreas (arrows); B: Near the lower margin of the pancreatic tail. a: Artery.

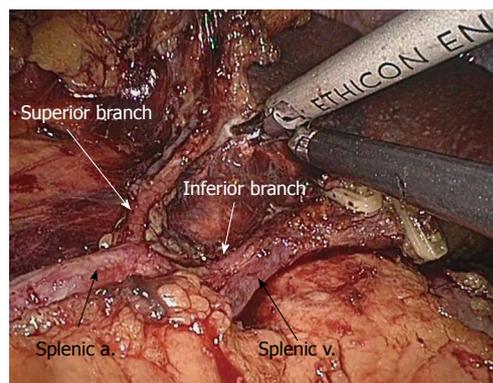
course are summarized in Tables 2 and 3. There were nine male and three female patients, with a mean age of 60.6 years (range, 45-75 years). The mean body mass index was 21.5 kg/m<sup>2</sup> (range, 19.1-25.6 kg/m<sup>2</sup>).

Laparoscopic total gastrectomy with pancreas- and spleen-preserving splenic hilum LN dissection was successfully performed in all 12 patients without conversion to open procedure. Only one patient experienced intraoperative bleeding during the skeletonization of the inferior branch of the SA. Pathological findings showed that tumor penetrated into the subserosal layer (T3) in only one patient and into the serosa without invasion to adjacent structures (T4a) in the other 11 patients. In accordance with the American Joint Committee on Cancer (AJCC) cancer staging manual, 7<sup>th</sup> edition, the TNM stages were distributed as follows: one stage II A, three stage II B, four stage III A, two stage III B, and two stage III C. The mean number of retrieved splenic hilum LNs per patient was 4.8 (range, 2-8) and only one patient had splenic hilum LN metastasis (8.3%). Postoperatively, neither morbidity nor mortality was observed (Table 3).

At a median follow-up of 21 mo (range, 1-37 mo), one patient had peritoneal metastasis after 12 mo of surgery and died 6 mo later. None of the other patients died or experienced recurrent disease during the follow-up period.

## DISCUSSION

Splenic hilum LN involvement was reported to range



**Figure 5** Skeletonizing the branches of the splenic artery (arrows). a: Artery; v: Vein.

between 8% and 21%<sup>[1-6]</sup> and was identified as an important prognostic factor for gastric carcinoma in previous studies<sup>[4,6,9,21]</sup>. Splenic hilum LN involvement rate correlates with the depth of tumor invasion over the mucosal layer<sup>[2,3]</sup>, the tumor is classified as Bormann's type III or IV<sup>[3,5,22]</sup>, the tumor is located at the greater curvature<sup>[5]</sup>, and the tumor size is > 5 cm<sup>[4]</sup>. Thus, splenic hilum LN dissection should be conducted in patients with advanced proximal gastric cancer, especially those whose tumor has the above mentioned properties.

For the complete removal of splenic hilum LNs, in traditional open surgery, extended total gastrectomy including pancreatosplenectomy was once recommended as the classic procedure by some surgeons<sup>[23,24]</sup>. However, combined resection of the distal pancreas is associated with increased postoperative complications, including acute pancreatitis, pancreatic fistula, abdominal abscess, and postoperative diabetes, which may even adversely affect survival. As a result, total gastrectomy with pancreas-preserving splenectomy has been proposed by other surgeons<sup>[11,25]</sup>. Other studies have demonstrated that splenectomy may result in higher morbidity and mortality, and has no significant survival benefit<sup>[11,9,10,22,26]</sup>. Accordingly, pancreas- and spleen-preserving total gastrectomy has been attempted in open surgery<sup>[13]</sup>, although it is still controversial.

Laparoscopic gastrectomy, as an alternative to traditional open surgery for early gastric cancer, has been suggested to produce comparable morbidity and mortality, as well as long-term survival as open gastrectomy, while possessing the benefits of minimally invasive approaches<sup>[27-32]</sup>. With respect to the above reasons, laparoscopic distal gastrectomy has gradually gained popularity for the treatment of early gastric cancer located in the lower portion of the stomach<sup>[14-16,32]</sup>. However, only a few studies have reported the application of laparoscopic total gastrectomy in advanced proximal gastric cancer<sup>[33-35]</sup>. With the development of laparoscopic devices and accumulation of experiences, a small number of skilled laparoscopic surgeons in high-volume specialized centers have attempted to extend the indications to advanced proximal gastric cancer using the strategy of splenic hilum LN dis-

**Table 1 Clinicopathological characteristics of patients**

Patient No.	Gender	Age (yr)	BMI (kg/m <sup>2</sup> )	Tumor location	Tumor size (cm)	Tumor depth <sup>1</sup>	TNM stage <sup>1</sup>	No. of retrieved LN <sup>2</sup>	No. of metastatic LN <sup>2</sup>	No. of retrieved splenic hilum LN <sup>2</sup>	No. of metastatic splenic hilum LNC
1	Male	60	19.1	U	5.0	T4a	III C	21	7	3	0
2	Male	73	24.8	U	6.0	T4a	III B	18	5	4	0
3	Male	61	20.6	U	8.5	T4a	III A	34	2	8	0
4	Male	62	20.2	U	7.0	T3	II A	39	0	4	0
5	Male	59	20.8	U	4.5	T4a	II B	16	0	3	0
6	Female	54	20.4	M	5.0	T4a	III A	20	1	5	0
7	Female	57	24.0	U	5.0	T4a	III A	20	1	7	0
8	Male	57	19.1	U	8.0	T4a	III C	28	21	6	3
9	Male	61	25.6	U	3.5	T4a	III A	16	2	4	0
10	Male	63	21.1	M	2.9	T4a	II B	24	0	5	0
11	Female	75	21.8	U	5.5	T4a	III B	19	3	2	0
12	Male	45	20.6	M	4.0	T4a	II B	35	0	6	0

<sup>1</sup>“Tumor depth” and “Tumor node metastasis (TNM) stage” were in accordance with the AJCC cancer staging manual-7<sup>th</sup> edition; <sup>2</sup>Lymph nodes (LN). BMI: Body mass index.

**Table 2 Surgical outcomes, postoperative course and follow-up data of patients**

Patient No.	Operating time (min)	Estimated blood loss (mL)	Time to first flatus (POD)	Time to soft diet (POD)	Hospital stay (POD)	Follow-up (mo)	Follow-up outcome
1	230	50	5	10	10	37	No recurrence, alive
2	352	300	6	10	13	37	No recurrence, alive
3	180	100	4	8	11	36	No recurrence, alive
4	314	100	5	7	10	28	No recurrence, alive
5	278	100	4	8	12	24	No recurrence, alive
6	305	100	2	9	11	24	No recurrence, alive
7	298	300	5	8	12	24	No recurrence, alive
8	260	150	2	4	8	18	Peritoneal metastasis, death
9	280	200	3	5	6	6	No recurrence, alive
10	223	50	2	6	7	5	No recurrence, alive
11	221	150	3	4	5	4	No recurrence, alive
12	280	200	3	7	8	1	No recurrence, alive

POD: Postoperative days.

**Table 3 Surgical outcomes and postoperative courses of laparoscopic pancreas- and spleen-preserving splenic hilum lymph nodes dissection**

Items	mean ± SD (range)
Operating time (min)	268.4 ± 48.0 (180-352)
Estimated blood loss (mL)	150.0 ± 85.3 (50-300)
No. of retrieved LN	24.2 ± 7.9 (16-39)
No. of metastatic LN	3.5 ± 5.9 (0-21)
No. of retrieved splenic hilum LN	4.8 ± 1.8 (2-8)
No. of metastatic splenic hilum LN	0.3 ± 0.9 (0-3)
Time to first flatus (POD)	3.7 ± 1.4 (2-6)
Time to soft diet (POD)	7.2 ± 2.1 (4-10)
Hospital stay (POD)	9.4 ± 2.6 (5-13)
Intraoperative complication	1 (8.3%)
Postoperative complication	0
Mortality	0

LN: Lymph nodes; POD: Postoperative days.

section in pancreas- and spleen-preserving total gastrectomy<sup>[17-19,36]</sup>.

The major difficulties of this laparoscopic procedure lie in the complicated variations of the SA supplying the spleen with its variable branching. The greatest chal-

lenges to surgeons are the high probability of injuries to the splenic vessels, unpredicted avulsion of the splenic capsule, skillful manipulation of endoscopic devices in a limited space, and injuries to the splenic hilum during skeletonization of the splenic vessels. Our strategy to deal with these difficulties was based on our thorough understanding of anatomy under laparoscopic view<sup>[20]</sup> and team cooperation. The SA is located in the retropancreatic space, coursing near the superior margin of the pancreas and usually dividing into two terminal branches near the pancreatic tail<sup>[37-39]</sup>.

The inferior branch of the SA courses directly into the splenic hilum, therefore, the exposure and dissection of the LNs posterior to it are sometimes difficult. From our past experience, if the vascularization and dissection was continued leftward only through the suprapancreatic approach, bleeding and unpredicted injury were more likely to occur due to the exposure limit. Thus, in our clinical practice, the suprapancreatic approach was adopted for the vascularization of the SA trunk, its superior branch, and the upper hemisphere of its inferior branch. Then, the lower margin of the pancreatic tail was mobilized. Since the retropancreatic space was filled with loose

connective tissue near the lower margin of the pancreatic tail<sup>[40]</sup>, exposure of the lower hemisphere could easily be achieved with the assistant turning the pancreatic tail cephalad. The vascularization of the inferior branch was continued until coming across the upper hemisphere, in other words, the inferior branch of the SA was skeletonized both through the supra- and infra-pancreatic approaches. The splenic pedicle was also freed, allowing for the complete removal of the posterior splenic hilum LNs.

Our strategy for laparoscopic pancreas- and spleen-preserving splenic hilum LN dissection is different from that in previous reports in the literature. The hand-assisted technique was adopted by Uyama *et al.*<sup>[17]</sup>, taping the SA was applied by Hur *et al.*<sup>[19]</sup>, and Hyung stood at the patient's right side and skeletonized the distal portion of the SA as soon as completing division of the gastro-splenic ligament<sup>[18]</sup>. To our knowledge, all these surgeons adopted the suprapancreatic approach. However, one similarity we noted was that when approaching the splenic hilum, meticulous manipulation was required to avoid injury. In Hyung's report, preoperative assessment of the splenic vascular anatomy was conducted with CT in collaboration with radiologists<sup>[18]</sup>. In our study, we experienced an episode of major intraoperative bleeding during dissection of the inferior branch of the SA in one of our patients. We applied endoscopic gauze to compress the bleeding area and identified the bleeding point. A hemo-lock was then used to clip onto the artery surface, involving the bleeding point without fully clamping the whole artery. Successfully, the bleeding was finally controlled after some maneuvers. In retrospect, even if this attempt was not successful, splenectomy could be safely conducted because the splenic pedicle was freed. Given these aspects, the average operating time was increased to 268.4 min, and the time was especially longer for the first three cases; nevertheless, our average operating time was still in congruent with that in the previous reports<sup>[17-19]</sup>. Although the patients in our study suffered from a more advanced stage of gastric carcinoma, the early follow-up results showed satisfactory survival.

In our study, only one out of 12 patients had splenic hilum LN metastasis. Interestingly, this patient had an overall high percentage of positive LNs, experienced peritoneal metastasis at 12 mo after surgery and died 6 mo later. This finding might suggest that splenic hilum LN involvement is always associated with highly advanced proximal gastric cancers, and poorer prognosis in these patients might be predicted. Similarly, Shin *et al.*<sup>[4]</sup> found that splenic hilum LN metastasis had a poor prognosis. However, due to the limitation of our relatively small sample size, the correlation between splenic hilum LN metastasis and oncological outcomes needs to be further confirmed.

Our retrospective study also had several limitations, including patient selection bias and relatively small sample size. However, to the best of our knowledge, this is a modified approach for conducting laparoscopic pancreas-

and spleen-preserving splenic hilum LN dissection. The detailed procedure might be useful for surgeons who wish to conduct similar laparoscopic surgery.

In conclusion, using the strategy of combining supra- and infra-pancreatic approach to extend the retropancreatic space in experienced hands, laparoscopic total gastrectomy with pancreas- and spleen-preserving splenic hilum lymph nodes dissection for the treatment of advanced proximal gastric cancer in selected patients could be safe and feasible. However, long-term follow-up and randomized clinical trials to evaluate its surgical safety and oncological efficacy are needed.

## ACKNOWLEDGMENTS

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## COMMENTS

### Background

Laparoscopic gastrectomy, as a minimally invasive alternative treatment to traditional open surgery in treating gastric cancer, is gaining popularity worldwide. For advanced gastric cancer, radical surgery should accomplish adequate lymph node (LN) dissection (D2 lymphadenectomy) according to oncological principles. Splenic hilum LN dissection should be included in the D2 lymphadenectomy when treating advanced proximal gastric cancer.

### Research frontiers

Traditional removal of splenic hilum LNs was achieved through combined resection of the pancreas and/or spleen. However, it has been suggested that combined resection would increase postoperative morbidity and mortality and not significantly benefit patient survival. Thus, pancreas- and spleen-preserving total gastrectomy was subsequently attempted in open and laparoscopic surgery.

### Innovations and breakthroughs

In laparoscopic total gastrectomy, pancreas- and spleen-preserving splenic hilum LN dissection is challenging because of the tortuous splenic vessels and possibility of parenchymal injury to the spleen or pancreas. To date, only a small number of skilled laparoscopic surgeons in high-volume specialized centers can achieve splenic hilum LN dissection in pancreas- and spleen-preserving total gastrectomy, and most of them only adopt the suprapancreatic approach. This method might not facilitate the dissection of LNs posterior to the splenic hilum and might cause unpredicted injury to splenic vessels. Thus, they modified this strategy by combining both supra- and infra-pancreatic approaches to better expose the posterior splenic artery LNs at the splenic hilum, and dissect more safely.

### Applications

Using the strategy of combining supra- and infra-pancreatic approach to extend the retropancreatic space in experienced hands, laparoscopic total gastrectomy with pancreas- and spleen-preserving splenic hilum lymph nodes dissection for the treatment of advanced proximal gastric cancer in selected patients could be safe and feasible. The indications for laparoscopic surgery could be extended to advanced proximal gastric cancer. The detailed procedure described here might be useful for laparoscopic surgeons. However, due to the limited sample size, further long-term follow-up results and randomized controlled trials are needed to ascertain its surgical safety and oncological efficacy.

### Terminology

In advanced gastric cancer, the tumor penetrates the mucosal layer of the stomach wall. In advanced proximal gastric cancer, the tumor is located in the upper or middle third of the stomach. Splenic hilum LNs are the LNs located adjacent to the splenic artery distal to the pancreatic tail, those on the roots of the short gastric arteries, and those along the left gastroepiploic artery proximal to its first gastric branch, according to the Japanese Classification of Gastric Carcinoma guidelines.

**Peer review**

The authors described of clinical impact of laparoscopic splenic hilum lymph node dissection for advanced proximal gastric cancer based on the strategy combining supra- and infra-pancreatic approach for pancreas- and spleen-preserving total gastrectomy. It is well written.

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