Laparoscopic spleen-preserving distal pancreatectomy for pancreatic neoplasms: A retrospective study

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Abstract

AIM: To describe the clinical characteristics, technical procedures, and outcomes of patients undergoing laparoscopic spleen-preserving distal pancreatectomy (LSPDP) for benign and malignant pancreatic neoplasms.

METHODS: The clinical data of 38 patients who underwent LSPDP in the Sir Run Run Shaw Hospital between January 2003 and August 2013 were analyzed retrospectively. Surgical techniques for LSPDP included preservation of the splenic artery and vein (Kimura’s technique) and ligation of the splenic pedicle with preservation of the short gastric vessels (Warshaw’s technique).

RESULTS: There were no conversions to open surgery in the 38 patients. Splenic vessels were conserved during spleen-preserving pancreatectomy, except in two patients who underwent resection of the splenic vessels and preservation only of the short gastric vessels. The mean operation time was 123.2 ± 52.4 min, the mean intraoperative blood loss was 78.2 ± 39.5 mL, and the mean postoperative hospital stay was 7.6 ± 2.9 d. The overall rate of postoperative complications was 18.4% (7/38), and the rate of clinical pancreatic fistula was 13.2% (5/38). All postoperative complications were treated conservatively. The postoperative pathological diagnoses were 22 cases of benign pancreatic disease and 16 cases of borderline or low-grade malignant lesions. During a median follow-up of 38 mo (range: 5-133 mo), no recurrence was observed.

CONCLUSION: LSPDP is a safe, feasible and effective procedure for the treatment of benign and low-grade malignant tumors of the distal pancreas.

Site Map | WJG | www.wjgnet.com 13966 October 14, 2014 | Volume 20 | Issue 38 |
Surgical procedure

Surgical techniques for LSPDP included preservation of the splenic artery and vein (Kimura’s technique) and ligation of the splenic vein (Warshaw’s technique).

Kimura’s technique

The patient was placed in the supine position on the surgical table and then shifted into the reverse Trendelenburg position with the left side up. We used five trocars. The first one was 10 mm and was inserted into the umbilicus for location of a 30° telescope, one 12-mm and one 5-mm trocar in the right upper quadrant for the surgeon, and two 5-mm trocars in the left upper quadrant for the assistant. Port placement is depicted in Figure 1. The surgical procedure included: (1) exploration: we explored the abdominal cavity to exclude metastasis in the abdominal organs, such as the liver surface or the peritoneum. Using an ultrasonic knife, the gastrocolic and gastrosplenic ligaments were dissected, revealing the pancreatic lesion, its size and adjacent tissue. If necessary, intraoperative laparoscopic ultrasound was used to assist the positioning of the lesion; (2) dissection of the splenic artery: the upper border of the pancreas was separated to expose the splenic artery on the superior edge of the pancreas. The artery was dissected from the pancreatic border and was tied with a rubber band (Figure 1B); (3) dissection of the splenic vein: the lower pancreatic border was freed from the transverse colon by blunt dissection, thus revealing the superior mesenteric vein, splenic vein and portal vein (Figure 1C); (4) dividing the pancreas: using the endoscopic stapler (ENDO-GIA) or ultrasonic knife, the pancreas was cut at the level of the neck of the pancreas (Figure 1D); (5) resecting the pancreatic body and tail: the distal pancreas was lifted gently and the loose tissue between the pancreas and splenic vessels was separated using the ultrasonic knife, thus freeing the splenic artery and vein from the pancreatic parenchyma. Small blood vessel branches were occluded using the ultrasonic scalpel directly or using titanium clips (Figure 1E); and (6) removing the specimen: all bleeding points were stopped; the umbilical incision was extended by approximately 1.2-3 cm and the specimen was removed. A rubber drainage tube was placed at the remnant pancreas (Figure 1F).

Warshaw’s technique

The patient’s position and port placement were as in Kimura’s technique. Up to the division of the retroperitoneum along the inferior margin on the pancreas, the procedure was performed in the same way as Kimura’s technique. After the upper border of the pancreas was separated, the splenic artery was dissected and sectioned between clips. The splenic vein was sectioned after the lower pancreatic border was freed, or the pancreatic parenchyma and the splenic vein were both cut with an endoscopic stapler (Figure 2A). Finally, the distal side of the splenic vein and artery were resected between clips.
Statistical analysis
Quantitative data are presented as the mean ± SD. All statistical analyses were performed using SPSS software, version 18.0 (SPSS Inc, Chicago, United States).

RESULTS

Patient characteristics
Thirty-eight patients (29 female and 9 male), with a mean age of 53.2 ± 13.6 years (range: 31–79 years) successfully underwent LSPDP for a benign or borderline malignant tumor of the distal pancreas during the study period. Their mean BMI was 24.4 ± 2.7 kg/m² (range: 20.8–32.1 kg/m²). Less than one-third (12/38; 31.6%) of the patients had comorbidities, the most common being diabetes mellitus. Table 1 shows the patient characteristics. The mean neoplasm size was 4.5 cm (range: 1–8.5 cm) and the neoplasms were located in the body (14 cases, 36.8%) and tail (24 cases, 63.2%) of the pancreas. The pathology of the resected pancreas specimens and the tumor sizes are listed in Table 2.

Intraoperative outcomes
None of the 38 patients underwent conversion to open procedures. Thirty-six patients underwent Kimura’s technique and two patients underwent Warshaw’s technique because of the close proximity of the lesion to the vessels. This series included seven patients who underwent concomitant surgery as follows: four cases underwent cholecystectomy, one underwent case resection of a right adrenal tumor, one case underwent myomectomy and left ovarian teratoma resection, and one case underwent resection of the left lateral liver lobe and choledocholithotomy. The mean operation time was 123.2 ± 52.4 min (range: 70–320 min), the mean intraoperative blood loss was 78.2 ± 39.5 mL (range: 50–300 mL), and only one patient needed a transfusion. The intraoperative outcomes

Table 1  Patient demographics n (%)  

| Variable                  | Data   |
|---------------------------|--------|
| No. of patients           | 38     |
| Gender (Male/Female)      | 9 (23.7)/29 (76.3) |
| Mean age (yr)             | 53.2 ± 13.6 |
| ASA classification (Ⅰ/Ⅱ) | 26 (68.4)/12 (31.6) |
| BMI (kg/m²)               | 24.4 ± 2.7 |
| Comorbidities             | 12 (31.6) |
| Diabetes mellitus         | 6 (15.7) |
| Hypertension              | 3 (7.9) |
| Cardiovascular            | 2 (5.3) |
| Pulmonary                 | 2 (5.3) |
| Liver                     | 1 (2.6) |
| Others                    | 1 (2.6) |

ASA: American Society of Anesthesiologists classification; BMI: Body mass index.

or by an endoscopic stapler (Figure 2B).

Statistical analysis
Quantitative data are presented as the mean ± SD. All statistical analyses were performed using SPSS software, version 18.0 (SPSS Inc, Chicago, United States).
In 1994, Soper et al. first performed laparoscopic distal pancreatectomy in a pig model to document its safety and feasibility, and since then the use of this technique has been reported in large series and comparative studies. The body and tail of the pancreas, and the spleen, are generally regarded as one anatomical unit, as these parts of the pancreas are closely associated with the spleen. In addition, the splenic artery and vein have many branches in the pancreatic parenchyma. In the past, surgeons preferred to remove the spleen simultaneously as the intimate relationship between the splenic vessels and the pancreas made separation difficult. However, splenectomy combined with other major abdominal or-

Table 2  Histological analysis

| Histological diagnosis            | n  | Mean size (cm) |
|----------------------------------|----|----------------|
| Pancreatic retention cyst        | 2  | 5.0            |
| Pancreatic epithelial cyst       | 5  | 5.2            |
| Congenital cyst of pancreas      | 1  | 4.8            |
| Insulinoma                       | 1  | 3.8            |
| Serous cystadenoma               | 13 | 3.9            |
| Mucinous cystadenoma             | 10 | 3.1            |
| Pancreatic solid-pseudopapillary tumors | 4   | 3.0           |
| Well-differentiated neuroendocrine tumor | 1   | 2.1           |
| Intraductal papillary mucinous tumor | 1   | 2.3           |
| Total                            | 38 | 4.5            |

Table 3  Intra-operative features of patients undergoing laparoscopic spleen-preserving distal pancreatectomy

|                        | LSPDP (n = 38) |
|------------------------|----------------|
| Surgical technique     |                |
| Splenic vessels preserversion (Kimura’s method) | 36 (94.7) |
| Splenic vessels resection (Warshaw’s method)     | 2 (5.3)       |
| Operative time (min)   | 123.2 ± 52.4   |
| Estimated blood loss (mL) | 78.2 ± 39.5   |
| Transfusion (cases)    | 1 (2.6)        |

LSPDP: Laparoscopic spleen-preserving distal pancreatectomy.

Table 3 shows the intra-operative features of patients undergoing laparoscopic spleen-preserving distal pancreatectomy. The mean time to resuming daily activities after surgery was 1.5 ± 0.6 d (range: 1-5 d); the mean time to first flatus was 2.2 ± 1.0 d (range: 1-4 d); the mean time to starting liquid and soft diets was 2.8 ± 0.9 d (range: 1-4 d) and 4.0 ± 1.2 d (range: 3-8 d); and the mean postoperative hospital stay was 7.6 ± 2.9 d (range: 5-19 d). The overall rate of postoperative complications was 18.4% (7/38), and the rate of clinical pancreatic fistula was 13.2% (5/38). All postoperative complications (three grade A and two grade B postoperative pancreatic fistula; one pulmonary infection; one intra-abdominal abscess) were treated conservatively. The postoperative outcomes are listed in Table 4. During a median follow-up of 38 mo (range: 5-133 mo), no recurrence was observed.

DISCUSSION

In 1994, Soper et al. first performed laparoscopic distal pancreatectomy in a pig model to document its safety and feasibility, and since then the use of this technique has been reported in large series and comparative studies. The body and tail of the pancreas, and the spleen, are generally regarded as one anatomical unit, as these parts of the pancreas are closely associated with the spleen. In addition, the splenic artery and vein have many branches in the pancreatic parenchyma. In the past, surgeons preferred to remove the spleen simultaneously as the intimate relationship between the splenic vessels and the pancreas made separation difficult. However, splenectomy combined with other major abdominal or-
Table 4 Post-operative features of patients undergoing laparoscopic spleen-preserving distal pancreatectomy (*n* = 38)

| LSPDP (*n* = 38) |  |
|------------------|---|
| Total complications | 7 (18.4) |
| Grade I          | 5 (13.2) |
| Grade II         | 2 (5.3)  |
| Grade III/III b  | 0 (0.0)  |
| Details of complications |  |
| Pancreatic fistula | 5 (13.2) |
| Grade A          | 3 (7.9)  |
| Grade B          | 2 (5.3)  |
| Grade C          | 0 (0.0)  |
| Pneumonia        | 1 (2.6)  |
| Intraperitoneal abscess | 1 (2.6) |
| Time to activities (d) | 1.5 ± 0.6 |
| Time to first flatus (d) | 2.2 ± 1.0 |
| Time to starting liquid (d) | 2.8 ± 0.9 |
| Time to starting soft diets (d) | 4.0 ± 1.2 |
| Postoperative hospital stay (d) | 7.6 ± 2.9 |
| 30-d mortality   | 0 (0.0)  |

LSPDP: Laparoscopic spleen-preserving distal pancreatectomy.

gon resection was found to be associated with increased postoperative morbidity, especially the complications of infection\(^{[10]}\). In addition, there is concern about the increased risk of subsequent hematologic complications, myocardial infarction, and even cancer in patients with elective splenectomy in later years\(^{[10,20,21]}\). With regard to the many adverse consequences reported after splenectomy, patients with benign and low-grade malignant tumors are expected to have long-term survival, thus their quality of life needs to be fully considered. Therefore, spleen preservation is desirable.

Carrère \(\text{et al}^{[23]}\) compared the results of 38 patients who underwent open spleen-preserving distal pancreatectomy with a matched cohort of patients undergoing open distal pancreatectomy with splenectomy, and showed that the conservative group had less postoperative morbidity. Shoup \(\text{et al}^{[24]}\) demonstrated that distal pancreatectomy with spleen preservation was associated with a reduction in perioperative infectious complications, severe complications, and the length of hospital stay, suggesting the value of spleen preservation in distal pancreatectomy.

At our hospital, we have performed laparoscopic distal pancreatectomy since 2003\(^{[9]}\). When the tumor is distant from the splenic artery and vein, and is either benign or low-grade malignant, LSPDP is recommended. This retrospective study shows a conversion rate of 0% and a high percentage (94.7%) of splenic vessel preservation; mean operative time of 123.2 min and mean operative blood loss of 78.2 mL; low overall rate of postoperative complications (18.4%), and low rate of clinical pancreatic fistula (13.2%). These findings are consistent with the best case series published to date\(^{[24-26]}\), and demonstrated that LSPDP is a feasible, safe and efficient approach for benign or low-grade malignant pancreatic neoplasms.

Surgical techniques in LSPDP include preservation of the splenic artery and vein, as well as ligation of the splenic pedicle with preservation of the short gastric vessels. The use of LSPDP has been reported from several institutes in a relatively large number of patients. However, there are relatively few reported studies of laparoscopic vessel-preserving SPDP. The highlight of this study is the high rate of splenic vessel preservation (94.7%). Whether one approach is superior to another is still a matter of debate. Although the perioperative and functional results of spleen-preserving distal pancreatectomy with splenic vessel resection seem acceptable in the short-term, concern has been raised regarding potential long-term complications, including the high incidence of left-sided portal hypertension and perigastric varices during follow-up, with a theoretical risk of gastrointestinal bleeding. Fernández-Cruz \(\text{et al}^{[5]}\) compared the outcomes of laparoscopic spleen-preserving distal pancreatectomy with either splenic vessels preservation or resection. Splenic vessels resection was faster and associated with reduced blood loss. Miura \(\text{et al}^{[21]}\) analyzed the long-term hemodynamic changes in the splenogastric circulation retrospectively in 10 patients after open spleen-preserving pancreatectomy with excision of splenic vessels (with a minimum follow-up of 52 mo). The incidence of perigastric and submucosal varices was 70% and 20%, respectively, and one patient experienced gastrointestinal bleeding from gastric varices 6.5 years after middle segment pancreatectomy. On the other hand, a recent study by Yoon \(\text{et al}^{[27]}\) evaluated the short- and long-term patency of the splenic vessel in 22 patients after LSPDP with splenic vessel preservation. Vascular obliteration in the preserved artery and vein was found in 6 (27.3%) and 17 patients (77.3%), respectively, within 1 mo of surgery, and in 3 (13.6%) and 13 patients (59.1%) 6 mo or more after surgery. Nine (90%) of ten patients with complete splenic vein occlusion developed a collateral circulation during the late postoperative phase.

In our study, some patients received computed tomography (CT) scanning during the follow-up period to evaluate the patency of the splenic vessel, while the remaining patients only received B ultrasound examination because of economic reasons. This, and the relatively short follow-up period, meant that we did not observe patients with splenic vessel occlusion after preservation of the splenic vessels. We think that splenic vessels should be preserved as far as possible during spleen-preserving pancreatectomy. For LSPDP, the key point and difficulty lie in the handling of splenic vessels and special attention should be given to the followings: (1) Gentle manipulation. The lack of direct touch and enlarged view of tissues on laparoscopy might lead to a wrong impression for the need of more strength when manipulating the vessels, which in turn leads to vascular rupture due to excessive traction. Therefore, gentle actions are needed and when required, small gauze should be used to gently move the blood vessels; (2) Pre-exposure of vessels. Pre-exposed large blood vessels will help to quickly control bleeding during vascular rupture; (3) Bleeding. For the splenic artery and vein bleeding, when the bleeding point
is clear, bleeding is first controlled with a clamp. After suction, temporary occlusion is performed with titanium clips, and then the bleeding points are sutured with 5-0 Prolene under direct vision and the titanium clips are then removed. If the bleeding point is not clear, gauze can be applied for small blood vessel bleeding, and after removal of the specimen, the bleeding point can be detected; in the setting of massive bleeding without a clear bleeding point or severe vascular rupture, timely conversion to laparotomy is mandatory; and (4) Surgical team. Highly precise laparoscopic surgery requires an understanding between the main surgeon and the assistant such that in the event of bleeding, adept, timely and accurate exposure of the bleeding point can help control the bleeding within the shortest possible time.

Pancreatic fistula, the most common complication after distal pancreatectomy, is still a major challenge in laparoscopic pancreatic surgery, as well as in LSPDP.\(^2,3,29\) Encompassing all grades of fistula, we observed a fistula rate of 13.2% in our study, which is comparable to that reported by others. In our experience, the best technique to cut the pancreas is to use the linear stapler: an appropriate ENDO-GIA is selected according to the size and thickness of the pancreas. Usually, a 3.5 mm staple is used. For thickening pancreas and chronic pancreatitis, a 3.8 mm staple is selected.

In conclusion, this study demonstrated the detailed procedure for LSPDP used in our department. It is worth attempting LSPDP in patients with a presumed benign or low-grade malignant tumor of the pancreatic body and tail, and preserving both splenic vessels. This was a retrospective study based on a relatively small population. The surgical approach for spleen preservation or splenic vessel preservation was not chosen on an intention-to-treat basis. Therefore, prospective comparative studies are warranted to better elucidate the short- and long-term outcomes of LSPDP with or without splenic vessel resection.

**COMMENTS**

**Background**

Laparoscopic distal pancreatectomy has become a widely accepted surgical technique for benign and low-grade tumors of the pancreas. The spleen is traditionally removed when performing distal pancreatectomy, mainly because of its anatomical intimacy to the distal pancreas and for the sake of technical simplicity. However, growing interest in the immunological role of the spleen, along with a tendency towards healthy organ preservation whenever possible, have led surgeons to avoid splenectomy during pancreatectomy for benign and low-grade malignant tumors. Unlike those with pancreatic cancer, these patients are expected to survive for a long time, thus, their quality of life should be considered when choosing surgical techniques. Function-preserving minimally-invasive pancreatectomy is an ideal surgical technique for these patients. Therefore, laparoscopic spleen-preserving distal pancreatectomy (LSPDP) should be recommended for the treatment of benign and low-grade malignant tumors in the distal pancreas.

**Research frontiers**

LSPDP is a desirable treatment for benign and low-grade malignant tumors in the distal pancreas. LSPDP includes two techniques: preservation of the splenic artery and vein (Kimura’s technique) and ligation of the splenic pedicle with preservation of the short gastric vessels (Warshaw’s technique). A research hotspot is how to modify the surgical procedure of LSPDP and compare the outcomes between the two techniques. Whether one approach is superior to another is still a matter of debate.

**Innovations and breakthroughs**

Surgical techniques for LSPDP include Kimura’s technique and Warshaw’s technique. The use of LSPDP has been reported from several institutes in a relatively large number of patients. However, there are relatively few studies of laparoscopic spleen-preserving SPDP. The highlight of this study is the high rate of splenic vessel preservation (94.7%). Although the perioperative and functional results of spleen-preserving distal pancreatectomy with splenic vessel resection seem acceptable in the short-term, concern has been raised regarding potential long-term complications, including the high incidence of left-sided portal hypertension and perigastric varices, with a theoretical risk of gastrointestinal bleeding. The authors suggested that splenic vessels should be preserved as far as possible during spleen-preserving pancreatectomy.

**Applications**

LSPDP is a safe, feasible and effective procedure for the treatment of benign and low-grade malignant tumors of the distal pancreas.

**Peer review**

This manuscript describes a complex laparoscopic procedure. This is a good descriptive study in which the authors outline one institution’s experience with 38 LSPDPs performed by the same surgical team. The results are interesting and suggest that LSPDP is a safe, feasible and effective procedure for the treatment of benign and low-grade malignant tumors of the distal pancreas.

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Laparoscopic distal pancreatectomy for pancreatic neoplasms

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