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Original Article

Difficulties and countermeasures of laparoscopic pancreaticoduodenectomy: report of 18 cases

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Abstract: Objective: In this study, we aimed to investigate the difficulties and countermeasures related to laparoscopic pancreaticoduodenectomy (LP). Methods: A retrospective analysis was performed on the surgical methods and clinical data of 18 LP cases at our hospital between December 2009 and November 2013. Results: All 18 surgeries were completed successfully. The operation time was 465 ± 93 min, and the intraoperative blood loss was 380 ± 216 mL. All cases had negative surgical margins, and there were 14.3 ± 6.7 pieces of scavenged lymph nodes. Postoperative complicating pulmonary infection occurred in 1 case that resolved after enhancement of anti-infectious activity. Mal-healing of incisions occurred in 1 case, and a second-stage suture was performed. Seroperitoneum accompanied with infection occurred in 1 case, and reoperative drainage was performed. Bile leakage occurred in 2 cases that resolved after drainage, and pancreatic leakage occurred in 2 cases, presenting as secondary intra-abdominal bleeding in 1 case that was treated with reoperation for hemostasis; in the other case, pancreatic leakage resolved after drainage. Conclusions: Improvements in the surgical approach, uncinate process resection, and pancreaticojejunostomy could improve the feasibility and safety of LP.

Keywords: Laparoscopy, pancreaticoduodenectomy, surgical approach, pancreaticojejunostomy

Introduction

Since Gagner successfully performed laparoscopic pancreaticoduodenectomy (LP) in 1 patient with chronic pancreatitis for the first time in 1994 [1], many hospitals, both domestic and abroad, have performed LP. In most literature reports, the technological aspect was the focus of the study, the cases were few, and some cases were reported independently [2, 3]; moreover, the short-term effects were not ideal, the complication rate was higher than that for open surgery, and the operative time was significantly prolonged, diminishing the advantages of microinvasive surgery [4-9]. Therefore, the use of LP was controversial and developed slowly. In recent years, with the continuous advances in surgical techniques and improvement of surgical instruments, LP has greatly progressed, and recent reports have described encouraging results [10-15]. However, because the pancreas has a deep anatomical location, in addition to its complex structure and close proximity to many major blood vessels, LP remains one of the most challenging endoscopic surgeries. Currently, the major technical problems related to LP are as follows: the surgical approach still follows the traditional model of open surgery and cannot fit the requirements of endoscopic operations; the resection of the pancreatic uncinate process under laparoscope guidance is still associated with some technical difficulty and bleeding risk; and the technique for gastrointestinal reconstruction under endoscopic guidance is difficult, especially for pancreaticojejunostomy. Therefore, the key was determining how to improve laparoscopic techniques and the LP experience, thus ensuring outcomes similar to those of open surgery. Between December 2009 and November 2013, 18 patients underwent LP at our hospital with satisfactory results. These cases are reported below and were investigated in relation to the above-mentioned problems.

Clinical data and methods

General data

The 18 LP patients included 10 men and 8 women aged 39-70 years (**Table 1**). All patients

Table 1. The general information of the 18 cases

No	Gender	Age	BMI	TBIL(1) umol/L	TBIL(2) umol/L	CA19-9 U/ml	Pathology	Complications
1	M	48	22.77	205	121	316	carcinoma of CBD	Pulmonary infection and bile leakage
2	M	70	20.95	414	178	409	duodenal papilla cancer	incision mal-healing
3	F	46	23.33	133	55	901	duodenal papilla cancer	
4	M	65	19.23	136	108	2	pancreatic carcinoma	
5	F	59	19.1	22	10	12	adenocarcinoma of CBD	intra-abdominal infection
6	M	66	23.57	210	343	51	pancreatic carcinoma	
7	F	51	27.78	122	207	14	carcinoma of CBD	bile leakage
8	M	60	20.76	11	7	86	chronic calcific pancreatitis	
9	M	61	24.97	112	48	13	pancreatic carcinoma	pancreatic leakage
10	M	45	20.68	113	40	30	carcinoma of CBD	
11	F	59	31.04	114	113	1200	duodenal papilla cancer	pancreatic leakage and intra-abdominal bleeding
12	M	69	19.48	30	31	1112	duodenal papilla cancer	
13	F	39	19.15	13	4	35	duodenal papilla cancer	
14	M	64	18.47	244	152	6	duodenal papilla cancer	
15	F	60	19.81	174	28	20	pancreatic carcinoma	
16	M	52	25.31	298	126	46	duodenal papilla cancer	
17	F	44	19.04	163	36	145	pancreatic solid pseudo-papilloma	
18	F	65	20.95	279	75	13	duodenal papilla cancer	

BMI: body mass index, TBIL: total bilirubin, CBD: common bile duct. TBIL(1): TBIL before operation. TBIL(2): TBIL 1 week after operation.

were preoperatively confirmed to have ampullary or pancreatic head tumors using B ultrasound, computed tomography, magnetic resonance imaging, or endoscopic retrograde cholangiopancreatography. The case selection criteria were as follows: tumor diameter < 3 cm, no signs of peripheral vascular invasion, no obvious lymphadenectasis, and no distant metastasis. This study was conducted in accordance with the declaration of Helsinki. This study was conducted with approval from the Ethics Committee of Wannan Medical College. Written informed consent was obtained from all participants.

Surgical approach

Anesthesia and position: The patient was administered general anesthesia in the supine-straddle position. The laparoscope was inserted through a small incision at the lower edge of the umbilical ring (or 3-5 cm below the umbilicus). Then, 4 incisions were made at the lower rib margin of the left and right anterior axillary lines and slightly above the umbilicus level of the left and right clavicular middle lines, as the primary and secondary operating holes. The surgeon stood on the left side of the patient, and the assistant stood on the right side.

Exploration: Conventional exploration was performed toward the liver, abdominal cavity, and omentum to investigate whether metastatic lesion(s), cholestatic liver, and bile duct dilatation existed. An ultrasound knife was used to transect the right stomach-colon ligament and flexura hepatica coli. A Kocher incision was then made, the duodenum was lifted with non-damaged grasping forceps, and the tissues were freed from Toldt's gap and leftward until the duodenal horizontal portion to assess for inferior vena cava invasion. The transverse mesocolon was then pulled leftward, and the superior mesenteric vein was exposed at the duodenal horizontal portion (**Figure 1**). The vascular sheath was opened and freed upward, anatomically transecting branch vessels such as the right gastroepiploic vein. The lower edge of the pancreas was freed and lifted, and the part behind the pancreas was resected until the intersection at the splenic vein. It could then be determined whether the tumor had invaded the superior mesenteric vein and whether LP could be performed.

Lymph node dissection of the duodenohepatic ligament: The gastroduodenal artery was anatomically transected at the "portal vein triangle" after the beginning portion of the portal vein was revealed and freed along its surface toward the porta hepatis. It was then separated from the hepatic artery and bile duct, which are located at its front. The hepatic artery sheath was cut open, and the common hepatic artery

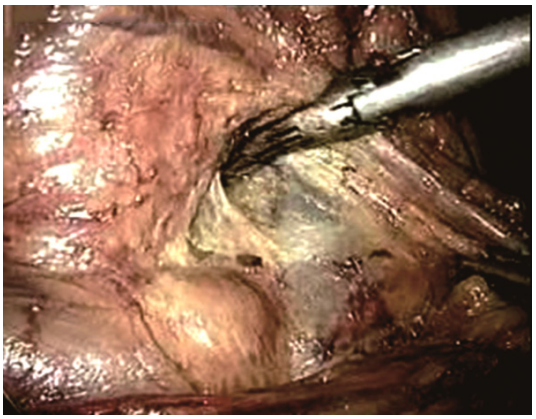

Figure 1. The superior mesenteric vein was exposed on the duodenal horizontal part.

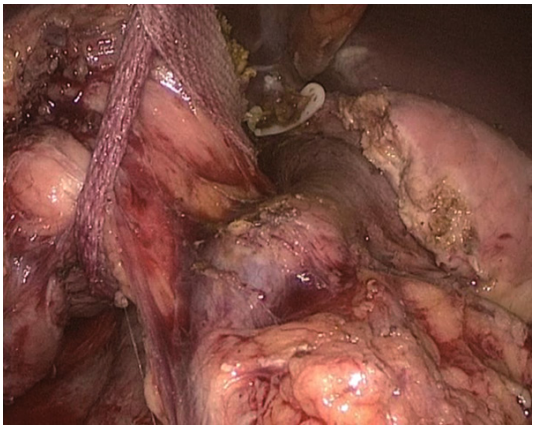

Figure 2. Pancreatic suspension method was used to resect the uncinate process.

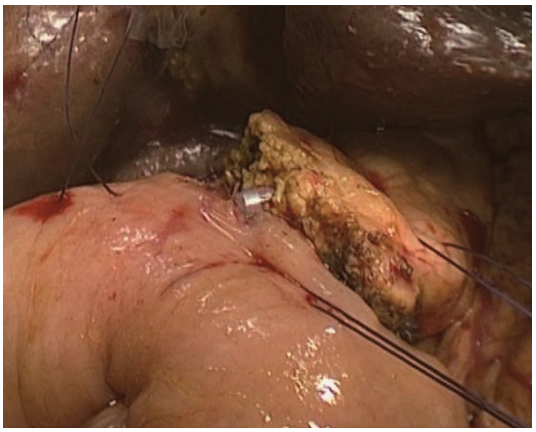

Figure 3. Penetration-suture method was performed to suture the pancreatic broken end and the intestinal wall.

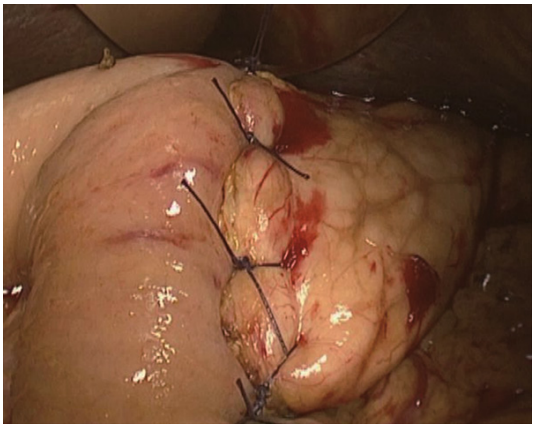

Figure 4. Completed pancreaticojejunostomy.

and proper hepatic artery were fully dissected and skeletonized. The lymph nodes in this region were scavenged.

*Specimen dissection and uncinate process resection (pancreatic head hanging method, **Figure 2**):* The surgeon freed the arcus major ventriculi and arcus minor ventriculi, transected the gastric body, opened/resected the gallbladder, and transected the common hepatic duct. Then, the surgeon transected the jejunum 15 cm to the Treitz ligament and pulled the proximal jejunum to the right through the mesenteric vessels. An electric coagulation hook or ultrasonic knife was used to transect the pancreatic neck. A "sling" protruded from the pancreatic head and the uncinate process, and was suspended and pulled to the right. The superior mesenteric vein was then pulled to the left, and the vascular branches between the superior mesenteric vein and the pancreatic head were then dissected individually from the bottom to the top. The surgeon identified the superior mesenteric artery and opened the artery sheath, and used an ultrasound knife to dissect the uncinate process from the right wall of the superior mesenteric artery. The larger branch should be dissected after being clipped; meanwhile, the surrounding lymph adipose tissues should be cleaned. Thus, the specimen was completely resected and removed through the small incision on the middle abdomen.

Digestive tract reconstruction with the child surgical method: Before the pancreaticojejunostomy, 10 patients underwent traditional pancreatic duct-mucosal side anastomosis, and the remaining 8 patients underwent a self-designed single-layer penetrative pancreas–intestinal side anastomosis. The specific procedures were as follows (**Figures 3** and **4**): (i) Penetrative suture-with the pancreatic duct as

the center, 2-3 sutures were applied at the top and the bottom, with about a 1 cm margin; each suture was inserted with the needle from the anterior wall of the pancreatic broken end and withdrawn from the rear wall, which then penetrated the seromuscular layer of the jejunal mesentery edge from the back to the front and was not tied temporarily. For anastomosis of the pancreatic duct and jejunal mucosa, holes were made in the corresponding lateral intestinal wall of the pancreatic duct and then interruptedly sutured with 0/5 absorbable threads. The frame was placed in the pancreatic duct, and the other end was inserted into the intestine. (ii) The detained suture was tied into a knot, while attention was paid to cover the pancreatic broken end with the jejunal wall. (iii) Strengthening the suture-one suture was strengthened on the corresponding anterior and posterior pancreatic wall of the pancreatic duct.

Results

Surgical results

The operations were successful in all 18 patients. The operation time was 465 ± 93 min, and the intraoperative blood loss was 380 ± 216 mL.

Postoperative pathology

There were 4 cases of lower adenocarcinoma of the common bile duct, 8 cases of duodenal papilla cancer, 4 cases of pancreatic adenocarcinoma, 1 case of chronic calcific pancreatitis accompanied by cyst formation, and 1 case of pancreatic solid pseudo-papilloma; the tumor diameter was < 3 cm, and the edges of all samples were negative. There were 14.3 ± 6.7 pieces of scavenged lymph nodes.

Postoperative complications

There was 1 case of postoperative pulmonary *Staphylococcus aureus* infection, which resolved after enhancement of anti-infection activity; 1 case of incision mal-healing, for which a second-stage suture was performed; 1 case of seroperitoneum, due to poor drainage, accompanied by infection, for which surgical drainage was performed again; and 2 cases of bile leakage that resolved after drainage. There were 2 cases of pancreatic leakage (both were treated with conventional anastomosis), 1 of which was accompanied by secondary intra-abdominal bleeding and found to have dehiscence in the anterior wall of the pancreatic anastomosis; the patient in this case underwent resuturing and double-catheter washing after which the condition resolved. In the other case, pancreatic leakage resolved after drainage.

Discussion

Currently, the surgical approaches of LP mostly follow those of open surgery. However, because of the limits associated with the operating hole and viewing angles, application of the surgical approach followed in laparotomy to laparoscopic surgery is difficult. Therefore, the first challenge while performing the surgery was the method of LP. Recently, some scholars have reported the superior mesenteric artery first approach [16-19]. In this study, we used the superior mesenteric vein-portal vein sequential approach, as we believe that exploration toward the superior mesenteric vein-portal vein caused difficulties in LP, and, to some extent, because the superior mesenteric vein-portal vein would ensure a successful LP. This is because (i) exploration toward the superior mesenteric vein was an important basis in determining whether the lesion could be removed; (ii) the major risk of "dangerous triangle" resection, namely, the uncinate process resection, was to dissect the uncinate process and anterior mesenteric vessels; and (iii) the scavenging of lymph nodes was expanded with the superior mesenteric vein-portal vein as the axis. The superior mesenteric vein in traditional LP is explored from the uncinate process of the blood vessels, as follows: the lower edge of the pancreas is exposed with the middle colic vein or the right gastroepiploic vein, and then the branch vessels and the superior mesenteric vein are identified. However, the superior mesenteric vein in this section was the shortest and had the most branches; in addition to the right gastroepiploic vein, the anterior pancreaticoduodenal vein and other branches still existed. These vessels were imported into the superior mesenteric vein with different stems and planes; thus, it would be difficult to grasp the anatomical structure during the separation, and, any damage would cause uncontrolled bleeding. Therefore, it was one of the intraop-

erative steps with the highest bleeding risk. In this study, according to the segment characteristics of the superior mesenteric vein-portal vein, the exploration of blood vessels began from the horizontal segment of the duodenum. This section was longer and entirely within the mesentery, had no association with the vessels in the horizontal portion of the duodenum, and would be convenient and safe for exposure. The vascular sheath was opened from this site and freed upward along the intrathecal space, and the vascular branches within the uncinate process segment could be quickly located and processed; meanwhile, the posterior pancreatic vascular segment could be explored. This surgical approach progressed sequentially from the bottom up, which not only made the laparoscopic operation convenient but also allowed the exploration and separation to be finished at the same time, shortened the operation time, reduced bleeding, and produced good outcomes.

One focus of the LP debate was whether full resection of the uncinate process could be achieved; if the endoscopy could not fully resect the uncinate process, radical effects would result. Anatomically, the pancreatic uncinate process often has partial tissues surrounding the rear of the superior mesenteric vein and is difficult to expose, making resection difficult and increasing the possibility of bleeding; thus, it was called a "dangerous triangle". It was once reported that the pancreatic uncinate process was resected with the endoscopic resection closer, which was a simple procedure; however, there might exist pancreatic tissue residue, and lymph node dissection could not be realized. In this study, the "pancreatic head suspension method" was used to complete the resection of the uncinate process [20, 21] and achieved good results. This method had the following advantages: (i) It exposed the portal vein and superior mesenteric vein during the whole procedure, significantly reducing the chances of injuring the minor vessels, and improving surgical safety. (ii) It increased the distance between the pancreatic head uncinate process with the portal vein and the superior mesenteric vein and obtained the best exposure. (iii) It made the seemingly wide and thick uncinate process mesenterium appear narrow and thin, as indicated in the manner of a complete plane and improved surgical outcomes. (iv) It simplified the operation and ensured appropriate exposure, which originally required multiple equipment, by using a single suspension; meanwhile, the sling position could be adjusted at any time, thus ensuring the tension between the uncinate process and mesenteric vessels. (v) Tightening the sling could play a role in pressure-hemostasis toward the pancreatic broken end, thus reducing bleeding.

The laparoscopic technique has been widely used in various fields of abdominal surgeries; however, LP was still in the exploratory stage, and one of the most important reasons is that there is no ideal method for pancreaticojejunostomy. Currently, endoscopic pancreaticojejunostomy can be performed by using various methods [22-26]; however, regardless of end-end anastomosis or end-lateral side anastomosis, the pancreas was considered a hollow organ, and the pancreatic broken end was divided into the anterior and posterior walls for ring anastomosis with the jejunum. Therefore, it would inevitably lead to the following issues: (i) The suture levels would be increased, resulting in a time-consuming suture procedure. (ii) Each suture could tie less tissue and be prone to cutting and tearing. (iii) Suturing the posterior wall was difficult and was prone to bleeding. In fact, the pancreaticojejunostomy was the anastomosis of 1 parenchymal organ and a hollow organ. The key factor to ensure the success of pancreaticojejunostomy is that the pancreatic broken ends should be firmly anastomosed to the jejunal wall, allowing the pancreatic juice inside the main pancreatic duct to enter the intestine. According to this concept, we modified the traditional end-lateral anastomosis and designed a new anastomotic approach-single-layer penetrative pancreaticojejunal anastomosis, which greatly simplified the procedures of pancreaticojejunostomy and is especially suitable for endoscopy. This method had the following characteristics: (i) it has a single-layer suture and no requirement for suturing the posterior pancreatic wall separately, making the operation easy; (ii) the penetrative suture ties more tissues, which would not cause pancreatic tearing or anastomotic dehiscence, thus strengthening the suture; (iii) there is no need to excessively free the pancreatic ends, thus reducing the risk of bleeding; and (iv) the pancreatic broken end is closely attached to the intestinal wall after knotting

the suture, reducing the dead space between them and becoming more conducive to healing with the pancreatic broken end. In this study, this approach significantly shortened the operation time and reduced the incidence of pancreatic fistula.

Although LP has some risks, the application of a more appropriate surgical approach-a suspension method of uncinate process resection and single-layer penetrative pancreaticojejunostomy aimed at the difficulties of this surgery-could make the surgery much safer.

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Disclosure of conflict of interest

None.

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