Surgical Atlas of Pancreatic Cancer

Ying-bin Liu
Editor

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Editor
Ying-bin Liu
Department of General Surgery
Xinhua Hospital
Shanghai Jiaotong University
School of Medicine
Shanghai
China

Co-Editors
Bai-Yong Shen
Department of Pancreatic Surgery
Ruijin Hospital
Shanghai Jiaotong University
School of Medicine
Shanghai
China

Tai-Ping Zhang
Department of Pancreatic Surgery
Peking Union Medical College Hospital
Beijing
China

Wen-Hui Lou
Department of Pancreatic Surgery
Zhongshan Hospital
Fudan University School of Medicine
Shanghai
China

De-Fei Hong
Department of General Surgery
Sir Run Run Shaw Hospital
Zhejiang University School of Medicine
Hangzhou
China

Deputy-Editor
Xu-An Wang
Department of General Surgery
Xinhua Hospital
Shanghai Jiaotong University
School of Medicine
Shanghai
China

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Preface

Pancreatic resections are complex surgical procedures requiring extensive dissection and complex reconstructive anastomoses with a strong volume-outcome relationship. The past decade has witnessed the exploding evolution of surgical approaches toward the role of pancreatic operative intervention.

The major goal of this book is to present the current surgical management of treatment of common and rare pancreatic lesions. This is a pictorial atlas with a demonstration of each surgical procedure in stepwise manner, and all the procedures are demonstrated with series of photographs.

It covers an entire spectrum of open, laparoscopic, and robotic-assisted pancreatic surgery of pancreatic head/tail adenocarcinoma, pancreatic neuroendocrine tumors, and pancreatic cystic neoplasms and also covers the surgical treatment of postoperative complications.

All the chapters included are completely new and relevant to our clinical practice. The chapter of open pancreatic surgery for pancreatic head adenocarcinoma introduces a new concept of our own which named extended total meso-pancreas excision. Other approaches such as artery-first approach, stomach-preserving approach, pylorus-preserving approach, and pancreatoduodenectomy with venous reconstruction are well illustrated. The chapter of open pancreatic surgery for pancreatic body and tail adenocarcinoma describes the distal pancreatectomy with or without splenectomy and modified Appleby techniques. Total pancreatectomy and pancreatectomy with other organ resection are also written in this atlas. Over the past decade, innovations in minimally invasive surgical technology have allowed pancreatic surgeons to perform laparoscopic and robotic-assisted pancreatic surgery, and the feasibility and safety of minimally invasive approach were confirmed. Laparoscopic pancreatoduodenectomy (LPD), robotic-assisted pancreatoduodenectomy (RPD), and laparoscopic distal pancreatectomy (LDP), with or without splenectomy, are also well provided in separated chapter. Central pancreatectomy and duodenum-preserving pancreatic head resection are introduced in the treatment of pancreatic neuroendocrine tumors chapter. Other treatment methods for pancreatic mucinous cystic neoplasms, serous cystadenomas neoplasm, and solid pseudopapillary neoplasm are included. Especially, the surgical treatment of postoperative hemorrhage, pancreatic fistula, pancreatic-enteric anastomosis stricture, binding method for pancreatojejunostomy, and pancreaticogastrostomy are provided in this atlas.

This case-based pancreatic surgery atlas is unique in that it includes typical case introduction, images, illustrative intraoperative pictures, and drawings that could reveal the details of surgical techniques of pancreatic surgery. We are so honored to have a leading group of world experts from China in conventional, laparoscopic, and robotic surgery contribute to this book. This book of current surgical treatment has been designed primarily to meet the needs of surgeons working specifically in the field of pancreatic diseases.

Shanghai, China Ying-bin Liu

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Contributors

Wei-Long Cai Huzhuo Central Hospital, Huzhou, China

Feng Cao Xuanwu Hospital, Capital Medical University, Beijing, China

Jun Cao Sun Yat-sen Memorial Hospital, Sun Yat-sen University, Guangzhou, China

Zhe Cao Peking Union Medical College Hospital, Beijing, China

Dan-Lei Chen Pancreaticobiliary Surgery Department, Changzheng Hospital, Naval Military Medical University, Shanghai, China

Wei Chen The First Affiliated Hospital, Sun Yat-sen University, Guangzhou, Guangdong, China

Wei Cheng Hunan Provincial People's Hospital, Changsha, China

Yuan Fang Zhongshan Hospital, Fudan University, Shanghai, China

Wei Gong Xinhua Hospital, Shanghai Jiaotong University, Shanghai, China

De-Xing Guo The First Affiliated Hospital of Harbin Medical University, Harbin, China

De-Fei Hong Department of General Surgery, Sir Run Run Shaw Hospital, The Medicine School of Zhejiang University, Hangzhou, China

Jia-Bin Jin Ruijin Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, China

Fei Li Xuanwu Hospital, Capital Medical University, Beijing, China

Jiang-Tao Li The Second Affiliated Hospital of Zhejiang University School of Medicine, Shanghai, China

Chang Liu The First Affiliated Hospital of Xi'an Jiaotong University, Xi'an, China

Fu-bao Liu Department of Hepatopancreatobiliary Surgery, Division of General Surgery, First Affiliated Hospital, Anhui Medical University, Hefei, China

Lei Liu Department of Hepatopancreatobiliary Surgery, Division of General Surgery, First Affiliated Hospital, Anhui Medical University, Hefei, China

Shi-Lei Liu Xinhua Hospital, Shanghai Jiaotong University, Shanghai, China

Wei-Kang Liu Peking University First Hospital, Peking University, Beijing, China

Xiao-Long Liu Department of General Surgery, Sir Run Run Shaw Hospital, The Medicine School of Zhejiang University, Hangzhou, China

Ying-Bin Liu Xinhua Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, China

Wen-Hui Lou Zhongshan Hospital, Fudan University, Shanghai, China

Xiao-Ming Ma The Second Affiliated Hospital of Soochow University, Suzhou, China

Yong-Su Ma Peking University First Hospital, Peking University, Beijing, China

Yi Miao The First Affiliated Hospital of Nanjing Medical University, Nanjing, China

Long Pan Sir Run Run Shaw Hospital, Zhejiang University, School of Medicine Hangzhou, Hangzhou, China

Cheng-Hong Peng Ruijin Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, China

Shu-You Peng The Second Affiliated Hospital of Zhejiang University School of Medicine, Shanghai, China

Ren-Yi Qin Tongji Hospital, Huazhong University of Science and Technology, Wuhan, China

Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China

Kai Qu The First Affiliated Hospital of Xi'an Jiaotong University, Xi'an, China

Cheng-Hao Shao Pancreaticobiliary Surgery Department, Changzheng Hospital, Naval Military Medical University, Shanghai, China

Bai-Yong Shen Shanghai Ruijin Hospital affiliated to Shanghai Jiaotong University, Shanghai, China

Yu-Sheng Shi Shanghai Ruijin Hospital Affiliated to Shanghai Jiaotong University, Shanghai, China

Zhi-Hao Shi Shanghai Ruijin Hospital Affiliated to Shanghai Jiaotong University, Shanghai, China

Bei Sun The First Affiliated Hospital of Harbin Medical University, Harbin, China

Hong-Tao Tan The First Affiliated Hospital of Harbin Medical University, Harbin, China

Zhi-Jian Tan Guangdong Province Traditional Medical Hospital, Guangdong, China

Rui Tian Tongji Hospital, Huazhong University of Science and Technology, Wuhan, China

Jian-Wei Wang The Second Affiliated Hospital of Zhejiang University School of Medicine, Shanghai, China

Min Wang Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China

Xu-An Wang Xinhua Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, China

The First People's Hospital of Lianyungang, Xuzhou Medical University, Jiangsu, China

Xue-Feng Wang Department of General Surgery, Xinhua Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, China

Yi-Fan Wang Sir Run Run Shaw Hospital, Zhejiang University, School of Medicine Hangzhou, Hangzhou, China

Ji-shu Wei The First Affiliated Hospital of Nanjing Medical University, Nanjing, China

Hao Weng Department of General Surgery, Xinhua Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, China

Xiang-Song Wu Xinhua Hospital, Shanghai Jiaotong University, Shanghai, China

Fang-Liang Xie Xinhua Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, China

The First People's Hospital of Lianyungang, Xuzhou Medical University, Jiangsu, China

Yin-Mo Yang Peking University First Hospital, Peking University, Beijing, China

Qing Yao The First Affiliated Hospital of Xi'an Jiaotong University, Xi'an, China

Qi-Fan Zhang Nanfang Hospital, Southern Medical University, Guangzhou, China

Tai-Ping Zhang Peking Union Medical College Hospital, Beijing, China

Yu-Hua Zhang Zhejiang Provincial People's Hospital, People's Hospital of Hangzhou Medical College, Hangzhou, China

Shi-Wei Zhao Ruijin Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, China

Xiao-Sheng Zhong Guangdong Province Traditional Medical Hospital, Guangdong, China

Part I

Adenocarcinoma of the Pancreas: Pancreatoduodenectomy

1 Pancreatoduodenectomy: Total Mesopancreas Excision Approach

Xu-An Wang and Ying-bin Liu

1.1 Introduction

In 2012, Adham et al. [1] firstly described the application of Total Mesopancreas Excision (TMpE) Approach (Figs. 1.1 and 1.2), for the carcinoma of head of pancreas, which was based on the concept of total mesorectal excision [2]. They defined the contents in the region for the excision to be formed by the superior mesenteric vein, portal vein, superior mesenteric artery, and celiac trunk of the aorta, and they called this region as the "mesopancreas triangle." Totally 52 patients using the posterior approach of total mesopancreas excision (TMpE) for pancreatic head cancer were reported by them with a very high R0 resection rate of 80.7%, and the 5-year survival rate was significantly improved [1].

However, in the following years, only few reports have demonstrated the role of TMpE for pancreatic head carcinoma. In our center, the relevant clinical study was initiated in 2010, and the findings from 75 cases were quite encouraging [3, 4]. We further divided the concepts of TMpE into the anterior and posterior mesopancreas parts (Fig. 1.3), which were included in the en bloc resection of pancreatic head carcinoma.

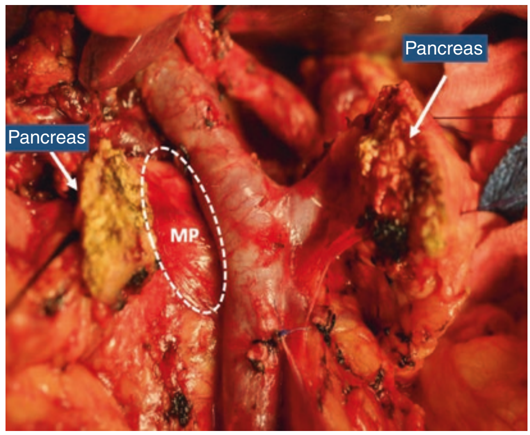

Fig. 1.1 The mesopancreas (*MP* mesopancreas)

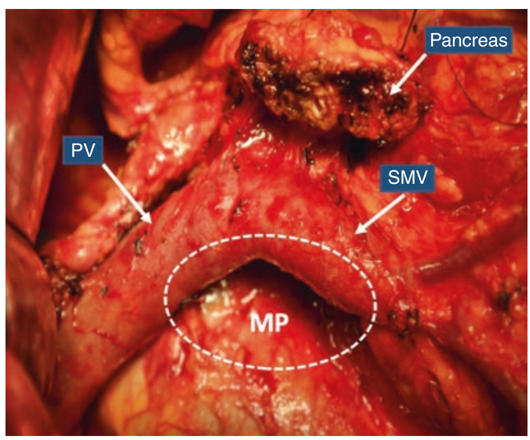

Fig. 1.2 The mesopancreas (*MP* mesopancreas, *PV* portal vein, *SMV* superior mesenteric vein)

X.-A. Wang · Y.-b. Liu (✉)
Xinhua Hospital, Shanghai Jiaotong University, Shanghai, China

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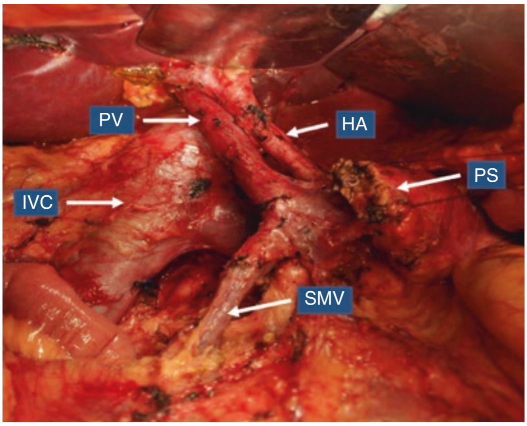

Fig. 1.3 Overview of the anterior and posterior mesopancreas parts (*HA* hepatic artery, *IVC* inferior vena cava, *PS* pancreatic stump)

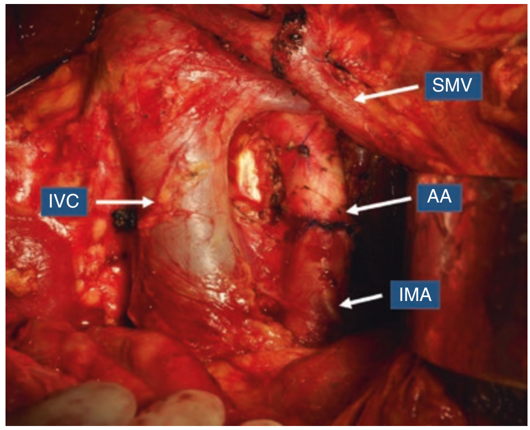

Fig. 1.4 The inferior boundary of the posterior mesopancreas (*AA* abdominal aorta, *SMA* superior mesenteric artery)

The anterior mesopancreas [3, 4] primarily consists of (1) the anterior leaf of the transverse mesocolon on the right side of the middle colic vein, (2) the greater omentum on the right side of the gastroepiploic artery, (3) the lesser omentum and portal vein to the right of the left gastric vein, (4) the region around the proper hepatic artery, (5) the lymphatic and adipose tissues around the hepatic artery, as well as (6) the antrum, duodenum, common bile duct, and their adjacent tissues. Excision of the anterior mesopancreas focuses on dissection and removal of lymphatic tissues.

The inferior mesenteric artery is used as the inferior boundary of the posterior mesopancreas [3, 4] to dissect all connective tissues around the inferior mesenteric artery (Fig. 1.4). On dissection of the abdominal aorta superiorly, a point of 2 cm above the celiac trunk forms the upper boundary of the posterior mesopancreas dissection (Fig. 1.5). All the connective tissues around the celiac trunk should be removed. Care should be taken to clear all the connective tissues between the upper and lower boundaries and between the inferior vena cava and the abdominal aorta (Fig. 1.6). The left gonadal vein is used as the left posterior boundary for excision of the mesopancreas, and the left anterior boundary is formed by the inferior mesenteric vein (Fig. 1.7). There are numerous nerve plexuses in the connective tissues behind the superior mesenteric artery and

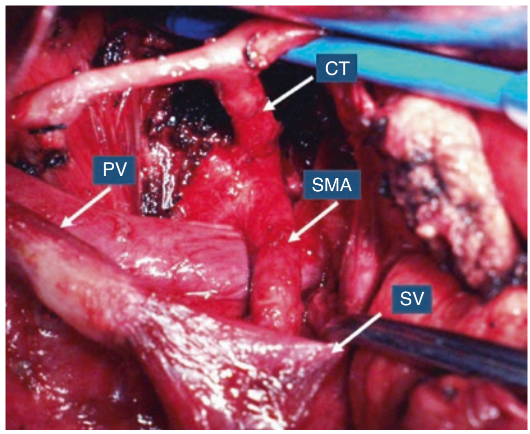

Fig. 1.5 The upper border of the posterior mesopancreas (*CT* celiac trunk, *SV* splenic vein)

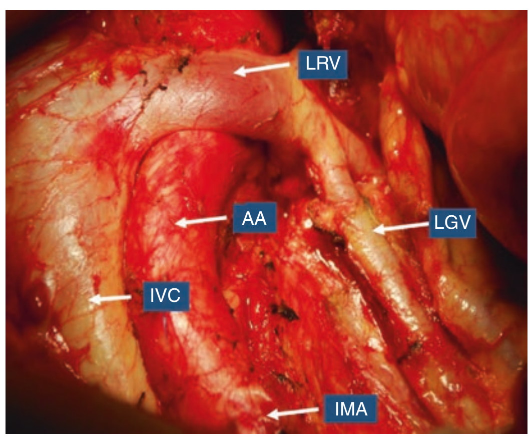

Fig. 1.6 Posterior border of posterior mesopancreas (*LGV* left gonadal vein, *LRV* left renal vein)

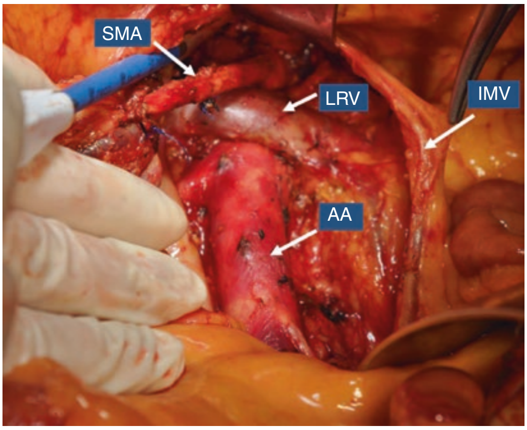

Fig. 1.7 The left anterior boundary of posterior mesopancreas (*IMV* inferior mesenteric vein)

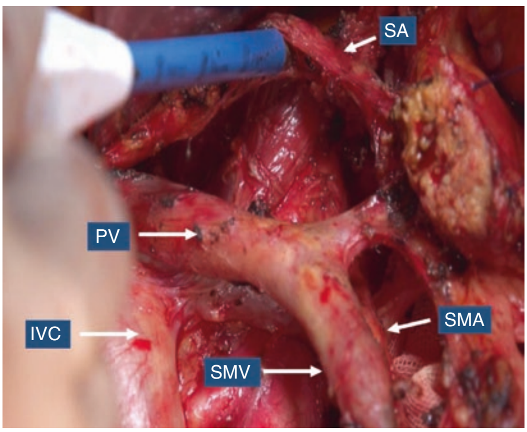

Fig. 1.8 The clearance of anterior and posterior of mesopancreas (*SA* splenic artery)

in front of the abdominal aorta and inferior vena cava [1–4]. Thus, the posterior mesopancreas excision is primarily dissection and removal of nerve plexuses.

The excision of the anterior and posterior mesopancreas targets the two primary sites of lymphatic metastasis and posterior nerve plexus invasion by pancreatic head cancer. A successful dissection of all these regions accomplishes the goal of en bloc excision of the anterior and posterior mesopancreas with clearance of all these tissues included (Figs. 1.8 and 1.9): (1) posterior to the pancreatic head, (2) posterior to the superior mesenteric vein-portal vein, (3) around the superior mesenteric artery, and (4) around the celiac trunk and the abdominal aorta.

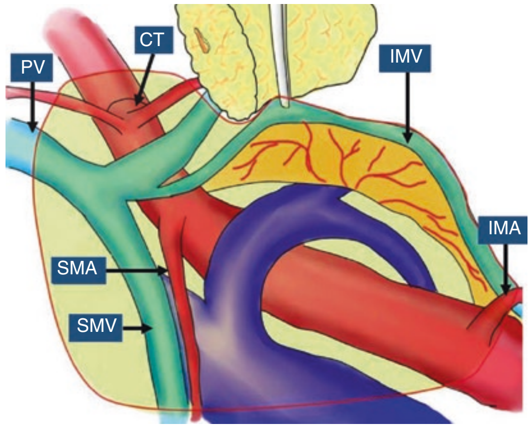

Fig. 1.9 The clearance of anterior and posterior of mesopancreas

1.2 Case

The patient was a 51-year-old man admitted to our hospital because of skin and sclera yellow stained for more than 1 month. Laboratory examinations showed an elevation of liver function tests: total bilirubin (TB) 112.7 μmol/L, direct bilirubin (DB) 88.1 μmol/L, aspartate aminotransferase (AST) 437 U/L, alanine aminotransferase (ALT) 1022 U/L, alkaline phosphatase (ALP) 254 U/L, and r-glutamyl transpeptidase (r-GTP) 1934 U/L. The tumor marker CA19-9 was increased to 183.1 kU/L, and others were normal.

The abdominal ultrasonography (US) and abdominal computed tomography (CT) showed a mass in the head of the pancreas, and a dilation of common bile duct and pancreatic duct. Pancreatic head adenocarcinoma was considered (Fig. 1.10). Same image was revealed by the abdominal magnetic resonance image. The digital reconstruction of 3D images was performed to observe the correlation of this mass and the portal vein, SMA, and SMV (Fig. 1.11).

From these findings, a diagnosis of pancreatic duct adenocarcinoma located in the head was made, and TMpE approach for pancreatoduodenectomy was performed.

Informed consent was obtained from all participating patients, and the ethics committee of Xinhua Hospital, Shanghai Jiaotong University School of Medicine approved this study.

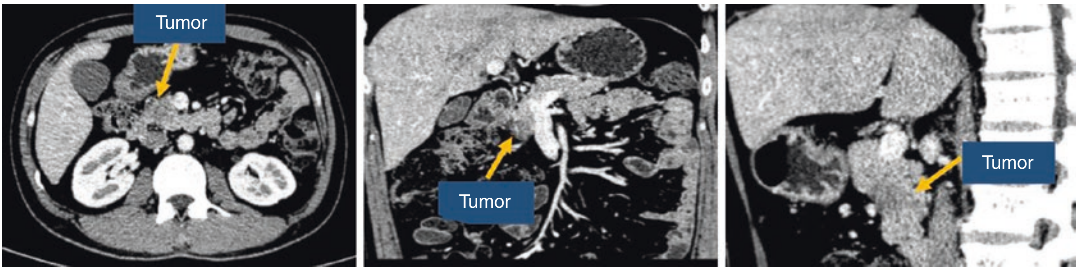

Fig. 1.10 CT image showed a mass in the head of the pancreas

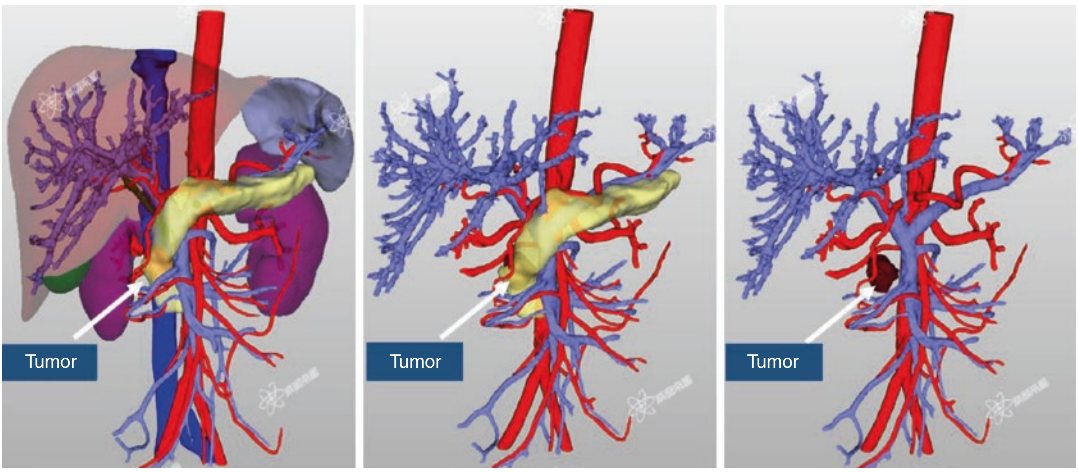

Fig. 1.11 3D reconstruction images revealed the correlation of the mass and the portal vein, SMA, and SMV

1.3 Details of Procedure

1.3.1 The Procedure Was the Same as Described in Our Previous Article [3–5]

1.3.1.1 Isolation of the Posterior Edge of the Mesopancreas Using the Kocher's Maneuver

Cut open the right anterior renal fascia along the external edge of the descendant duodenum. After the head of the pancreas and the duodenum were lifted to the left upper side by the assistant, the duodenal capsule was released and the hepatic flexure of the colon was protected (Fig. 1.12).

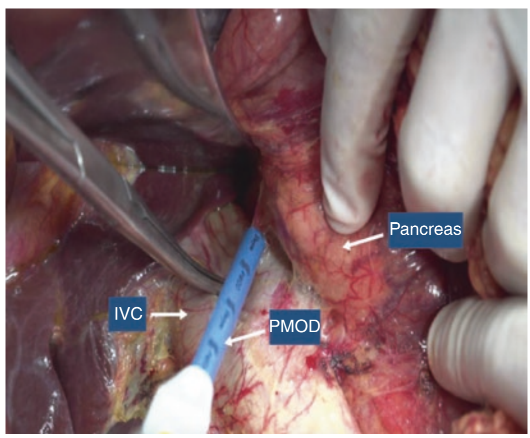

Fig. 1.12 Isolation of the posterior edge of the mesopancreas using the Kocher's maneuver (*PMOD* peng's multiple operation dissector)

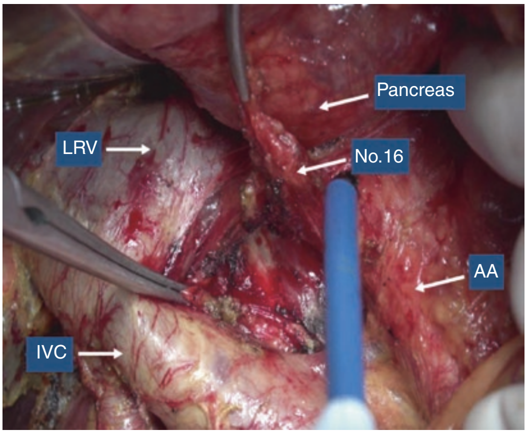

Fig. 1.13 Clearance of No.16 LN by using the Kocher's maneuver

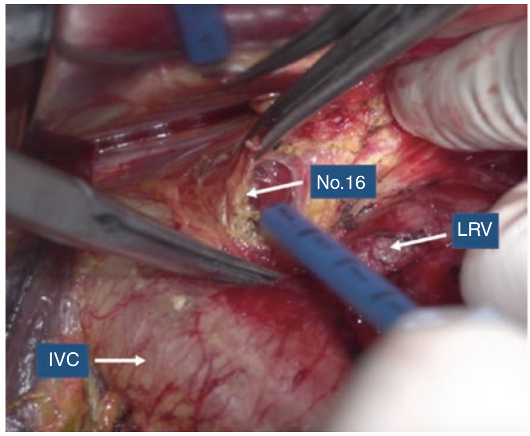

Fig. 1.14 Clearance of No.16 LN by using the Kocher's maneuver

Using the Kocher method, expose right renal vein, right genital vein, and inferior vena cava, and then leftwards expose and inspect the spaces behind the pancreatic head and portal vein (Fig. 1.13). After the exposure of the distal end of left renal vein and the abdominal aorta leftwards, expose the root of superior mesenteric artery that is located above the cephalic aorta at the distal end of left renal vein and inspect whether the superior mesenteric artery (Figs. 1.14 and 1.15) has been involved. Furthermore, expose the inferior vena cava and abdominal aorta towards the caudal (Fig. 1.16).

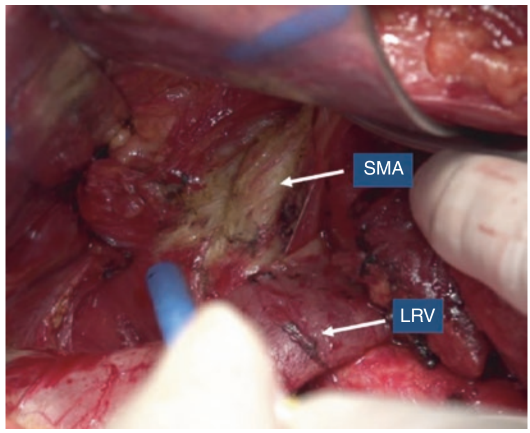

Fig. 1.15 Explore of the SMA

1.3.1.2 Resection of the Anterior Portion of the Mesopancreas

From the hepatic flexure of colon to the middle colic vein, expose and ligate the right gastroepiploic vein, dissect the greater omentum and the anterior lobe of the transverse mesocolon till the lower edge of the pancreas, expose the superior mesenteric vein beneath the pancreatic neck, dissect the adjacent adipose and lymphoid tissues, and then partially expose the space behind pancreatic neck and in front of the portal vein and superior mesenteric vein at the lower edge of the pancreatic neck (Fig. 1.17).

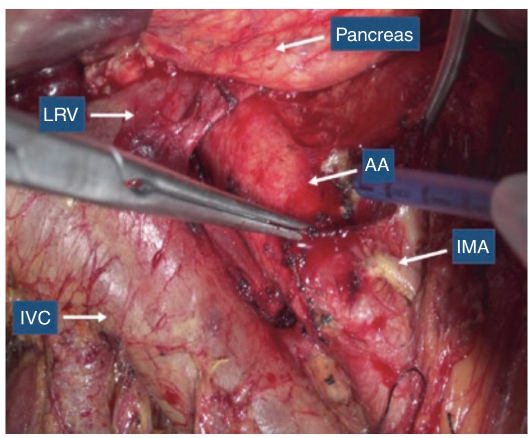

Fig. 1.16 Further expose the inferior vena cava and abdominal aorta

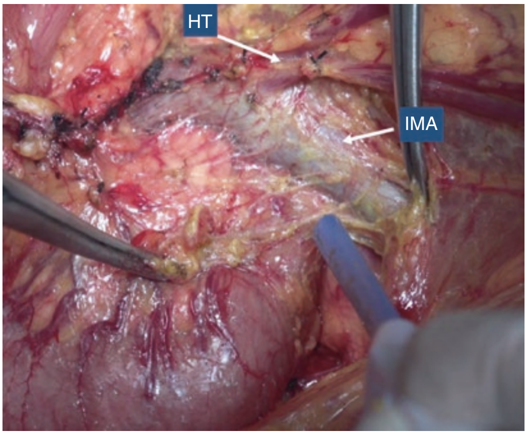

Fig. 1.17 Resection of the anterior portion of the mesopancreas (*HT* Helens trunk)

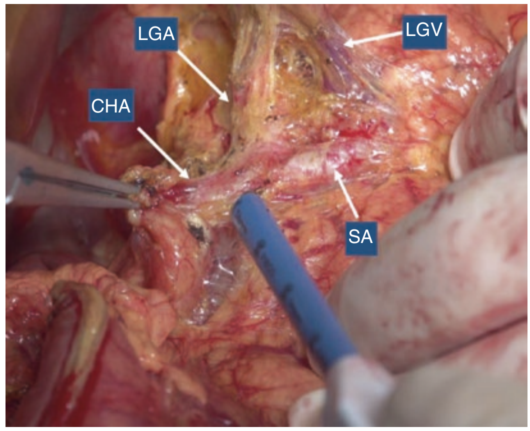

Fig. 1.19 Clearance of No.8a (*LGA* left gastric artery, *LGV* left gastric vein, *CHA* common hepatic artery)

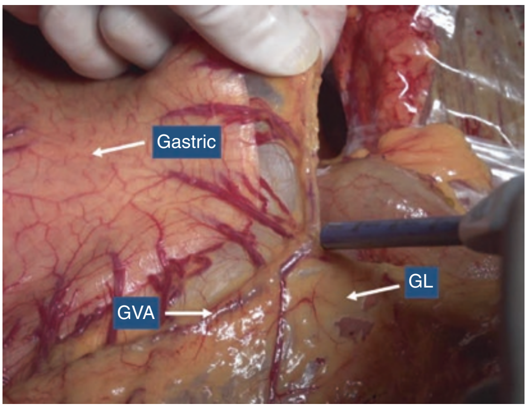

Fig. 1.18 Divide the greater omentum along the GVA (*GVA* gastroepiploic venous arch, *GL* gastric colon ligament)

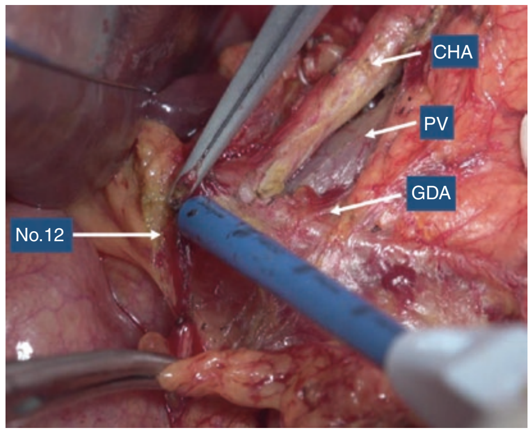

Fig. 1.20 Skeletonize the hepatoduodenal ligament (*GDA* gastric duodenum artery)

Divide the greater omentum from the middle to the right side along the external side of the gastroepiploic arterial arch till the gastric antrum (Fig. 1.18), during which the gastroepiploic arterial arch must be carefully protected. After the removal of the gallbladder, transect the common hepatic duct over the cystic duct, expose the hepatic artery and portal vein, skeletonize the hepatoduodenal ligament, and then expose and ligate the right gastric artery at the proximal end along the proper hepatic artery. Divide and ligate the gastroduodenal artery, followed by the exposure of the root of common hepatic artery and the abdominal aorta (Figs. 1.19, 1.20, 1.21).

Open the hepatogastric ligament along the lower edge of the left hepatic lobe till the distal

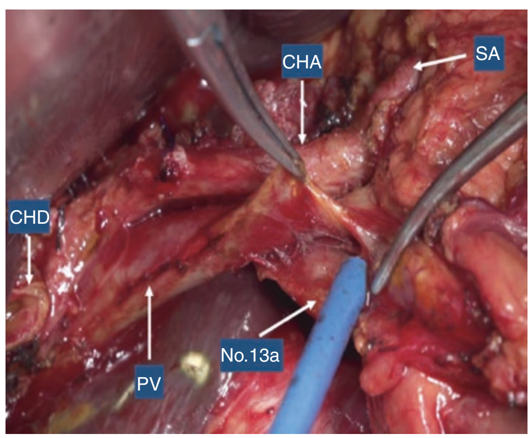

Fig. 1.21 Skeletonize the hepatoduodenal ligament and transect the common hepatic duct over the cystic duct (*CHD* common hepatic duct)

end of the left gastric vein. Remove the lesser omentum from the distal end of the left gastric vein to the gastric antrum along the external side of the vascular arch of the gastric lesser curvature (Fig. 1.22), during which the vascular arch must be carefully protected. Divide the gastric antrum using a stapler & cutter.

After the portal vein and superior mesenteric vein were exposed at the upper and lower edge of the pancreatic neck, respectively, the space behind the pancreatic neck in front of the portal vein- superior mesenteric vein was further exposed, and then the pancreas was divided. Specimen from the pancreatic stump was sent for routine frozen pathology (Fig. 1.23).

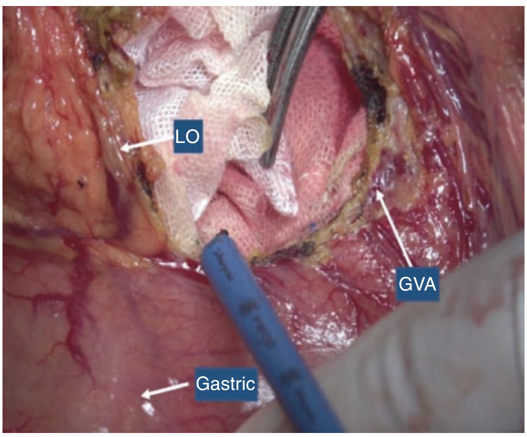

Fig. 1.22 Remove the lesser omentum along the GVA (*LO* lesser omentum)

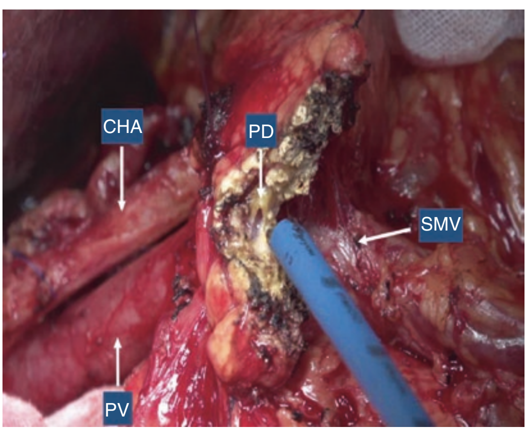

Fig. 1.23 The pancreas was divided and specimen from the pancreatic stump was sent for routine frozen pathology (*PD* pancreatic duct)

Thus, the anterior portion of the mesopancreas was completely divided, and the head of the pancreas and pancreas uncinate process were still connected with the posterior portion of the mesopancreas.

1.3.1.3 Resection of the Posterior Portion of the Mesopancreas

Lift the transverse colon upwards to expose the inferior mesenteric vein. Open the retroperitoneum along the left edge of the inferior mesenteric vein. Thus, the posterior portion of the mesopancreas became visible (Fig. 1.24).

The level of inferior mesenteric artery was defined as the lower border of the resection of the posterior portion of the mesopancreas. After the dissection of the connective tissues around the superior mesenteric artery (Fig. 1.25), the dissec-

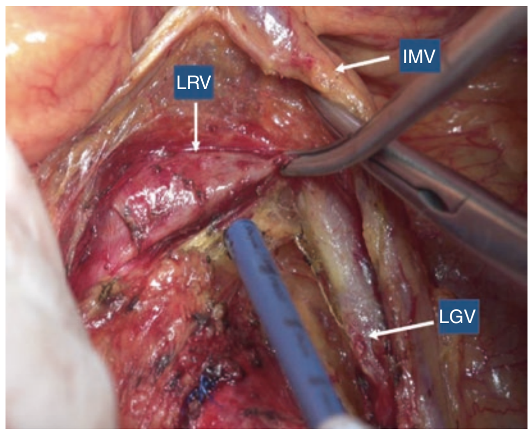

Fig. 1.24 The posterior portion of the mesopancreas

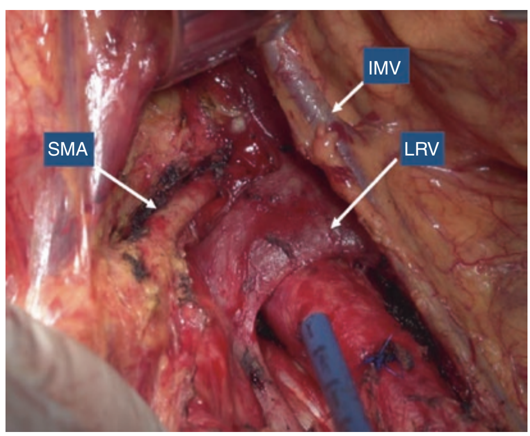

Fig. 1.25 Dissection of the connective tissues around the superior mesenteric artery

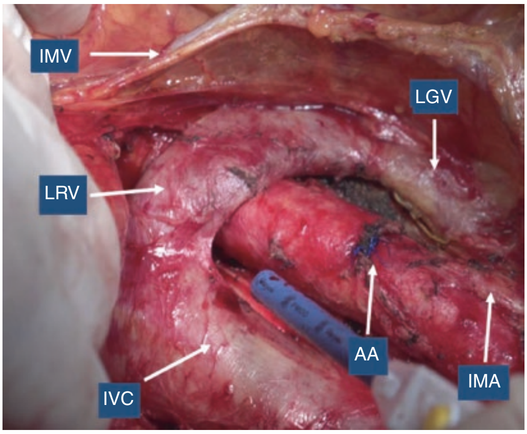

Fig. 1.26 Connective tissue between the inferior vena cava and the abdominal aorta was dissected

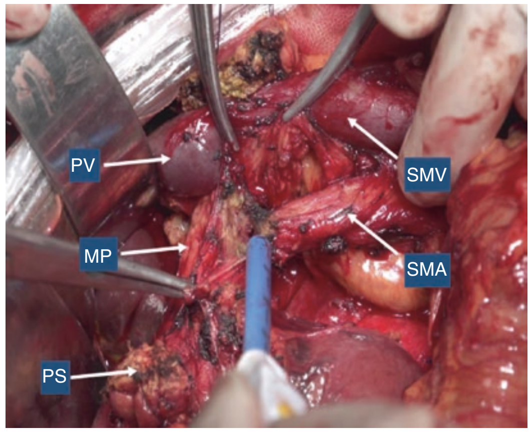

Fig. 1.27 The anterior and posterior sections of the mesopancreas had been completely divided

tion continued upwards along the anterior side of the abdominal aorta till 2 cm above the root of celiac trunk, which was defined as the upper border of resection of the posterior portion of the mesopancreas. Then, the connective tissues around the celiac trunk were dissected. The connective tissue between the inferior vena cava and the abdominal aorta should be carefully dissected (Fig. 1.26).

Furthermore, the left genital vein was set as the left posterior border for the resection of mesopancreas and the inferior mesenteric vein as the left anterior border. After the jejunum was transected 15 cm away from the ligament of Treitz, the anterior and posterior sections of the mesopancreas had been completely divided; only the junction between the anterior and posterior sections (the head of the pancreas and the uncinate process of the pancreas) was connected with the superior mesenteric artery and vein (Fig. 1.27).

Divide and ligate the vessels in the uncinate process of the pancreas and then dissociate the uncinate process. Pull away the uncinate process to expose the superior mesenteric artery at the left side of the superior mesenteric vein. Turn over the superior mesenteric artery in the first branch of jejunum to expose the right side of the superior mesenteric vein. Then, the lymphatic and nerve tissues around the superior mesenteric artery were dissected till its root (Fig. 1.28). Separate and ligate the small blood vessels in the uncinate process to complete the en bloc resection of the head of the pancreas, duodenum, and the anterior and posterior sections of the mesopancreas; if necessary, resection and reconstruction of the vessels were also performed (Figs. 1.29, 1.30, 1.31). After three-dimensional marking of the cutting edges, the surgical specimens were sent for pathology.

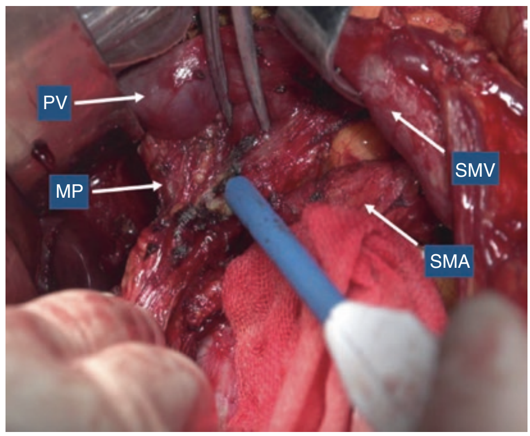

Fig. 1.28 Separate and ligate the small blood vessels in the uncinate process to complete the en bloc resection of the head of the pancreas

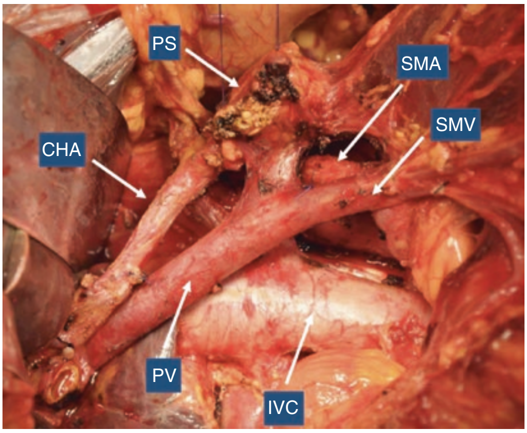

Fig. 1.29 The view after removing the specimen

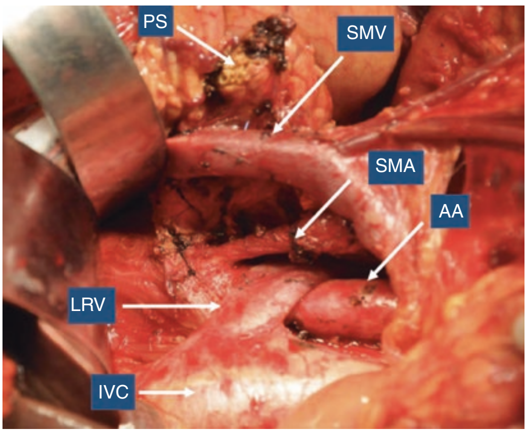

Fig. 1.30 The view after removing the specimen

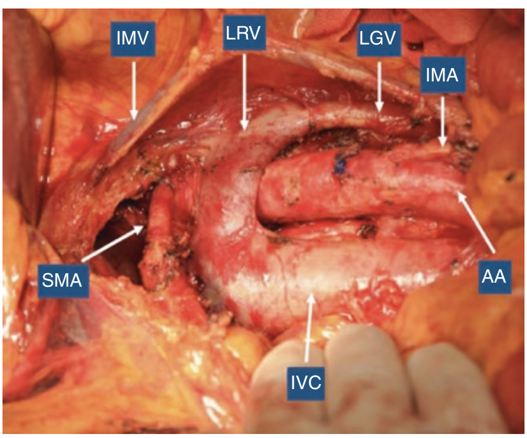

Fig. 1.31 The view after removing the specimen

Fig. 1.32 The resected specimen

1.4 Pathology and Prognosis

The resected specimen was showed as Fig. 1.32. Pathology diagnosis was poor to moderately differentiated pancreatic duct adenocarcinoma (grade II), invading the plexus, but no portal or venous infiltration was detected. The tumor also did not involve the duodenum and duodenal papilla. The cutting margin of common bile duct, pancreatic margin, stomach, and duodenal were negative; 19 lymph nodes including peri-pancreatic lymph nodes (n=5), the superior mesenteric artery/vein lymph nodes (n=5), No.16 lymph node (n=3), No.12 lymph nodes (n=4), No.8 lymph nodes (n=2) were harvasted totally, and none of them was positive.

The patient recovered uneventfully and was discharged 12 days after the operation. 6 months after surgery, follow-up CT and tumor marker revealed no recurrence.

1.5 Comment

Pancreatic duct adenocarcinoma is associated with worse prognosis, and radical resection with negative margin remains the only promising treatment. Retropancreatic margin or the medial margin is the most common site of positive resection margin [5]. Unfortunately, the R0 resection rate of traditional PD is less than 50%, and most patients cannot be cured even with PD [6]. The two main sites of residual microscopical tumor after PD are at the medial and the posterior resection margins [7, 8].

Mesopancreas concepts, which lies posterior to the pancreas and contains pancreaticoduodenal vessels, lymphatics, nerve plexus, and loose areolar tissue, were proposed to increase the rate of R0 resection [1, 2]. We had modified this concept and summarized the clinicopathological data of 120 patients with pancreatic head cancer, which demonstrated that TMpE was safe and feasible when compared with conventional PD. And the R0 resection rate, especially on the mesopancreatic margin was improved, the postoperative local recurrence rate was decreased and overall survival rate was increased in the TMpE group of patients [3–5]. As these were retrospective studies, the true role of PD with TMpE stills requires further properly conducted large-scale, multicenter, randomized comparative studies to define.

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2 Pancreatoduodenectomy: Artery First Approach

Lei Liu and Fu-bao Liu

2.1 Introduction

In 2006, the concept of Artery First Approach for pancreatic cancer surgery was first proposed by Pessaux et al. [1], then the method of Artery First Approach in pancreatoduodenectomy, which has been worldwide recognized, was proposed by Weitz in 2010 [2]. Many “Artery First Approach” have been reported currently, and the most classic of which called the posterior approach is put forward by Pessaux, namely expand Kocher incision firstly, then the free SMA including the lymphoid tissue and nerve plexus surrounding the artery are dissected at the root of the posterior SMA before the head of pancreas is anatomized, which can not only obviously increase the R0 resection rate of tumor, but also help making accurate judgment for arterial infringement cases in early stage, which avoids blindly expanding the operation range [3].

The difficulty and perioperative safety of pancreatoduodenectomy can be seriously affected by location, size, and vascular invasion of pancreatic cancer [4]. For pancreatic cancer with small tumor diameter and clear vascular relationship, the standard approach of pancreatoduodenectomy, the procedure of exploration, dissociation, and subsequent resection, can solve the problem, and then for complicated pancreatic head tumors, the Artery First approach has obvious advantages. At present, the indications suggested by scholars to adopt the Artery First approach include: (1) the pancreatic head tumor which is larger than 5 cm in diameter, (2) the tumor intrudes into some important blood vessels, such as portal vein (PV), SMV, superior mesenteric artery (SMA), etc., and may tear the blood vessels during the operation, and even cause uncontrollable massive bleeding, (3) the tumor in special position, which is located in the deep vascular space of the uncinate process, (4) in addition, peripancreatic lymph nodes and nerve plexus should be removed, and (5) location of SMA is deep, difficult to show or other special circumstances [5].

Operation area of Artery First Approach is large, and easily occur related complications like diarrhea, lymphatic leakage, and postoperative bleeding, but because pancreatic cancer can transfer through lymph nodes and nerve in an early stage, in order to improve the operation effect, treating pancreatic cancer patients who met the indications with Artery First Approach still has following advantages over the traditional approach: (1) Tumor and the nerve and vascular tissues nearby can be resected adequately on the basis of protecting SMA, and the resection rate of R0 at the incision margin can be increased. (2) Trauma to patients after surgery can be avoided by evaluating the feasibility of the surgery early.

L. Liu · F.-b. Liu (✉)
Department of Hepatopancreatobiliary Surgery, Division of General Surgery, First Affiliated Hospital, Anhui Medical University, Hefei, China

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(3) Early treatment of SMA and pancreatic head vascular branches, such as inferior pancreaticoduodenal artery (IPDA), can be beneficial to the control of bleeding. (4) Early detection of whether there are mutations in SMA or right hepatic artery of abdominal aorta, to avoid intraoperative injury [6].

Related meta-analysis on the safety and postoperative survival rate of the Artery First Approach pancreaticoduodenectomy was made by Ironside N et al. recently; 1472 patients participated in the study and 771 of whom were treated with resection of the Artery First Approach pancreaticoduodenectomy while other 701 patients underwent resection of the standard of pancreaticoduodenectomy. The bleeding amount and the number of transfused patients of Artery First Approach group are significantly lower than the control group. Although the two groups of patients have similar perioperative mortality, incidence of severe postoperative pancreatic fistula was significantly reduced in Artery First Approach group, and the R0 resection rate and total survival rate of Artery First Approach group are significantly higher than the control group; so, perioperative prognosis and survival rate can be significantly improved by Pancreatoduodenectomy in Artery First Approach group [7]. More than 40 cases of Artery First Approach pancreatoduodenectomy have been carried out in our center recently, and the results and prognosis of relevant studies after the operation are satisfied.

The related research proposes the "Artery First Approach" concept which refers to six different surgical approaches. These involved close to the SMA from the upper approach, the posterior approach, the medial uncinate approach, the mesenteric approach, the left approach, and through left posterior approach (Fig. 2.1). Specifically, such as: (1) upper approach: during the operation, hepatoduodenal ligament is separated and dissected; the common hepatic artery (CHA) and gastroduodenal artery (GDA) are freed out above the pancreas; PV and SMV are exposed and separated at the posterior surface of the pancreas; the pancreas is suspended and pulled downward, along the CHA to the left side and expose the abdominal trunk and aorta; and the origin of SMA is searched downwards along the abdominal aorta. (2) Posterior path: by expanding Kocher incision, the right colon is pushed downwards and extended to the left along the rear space of the pancreatic head; Treitz fascia is separated ahead of the left kidney. The pancreatic head and duodenum are freed from the posterior peritoneum, until the left side of inferior vena cava and the left renal vein are shown; the root of SMA is isolated from the angle above the left renal vein and abdominal aorta, judging the degree of tumor invasion and making the separation of IPDA easier. (3) The medial uncinate process path: the SMV and its branches can be found by using Kocher technique and separated in the front direction of the duodenum horizontal segment. The right Toldt line is cut to dissociate the right hemicolon and mesentery, and the right hemicolon and small intestine are turned to the left; SMV is then pulled to the left, so that the interior SMV can be isolated. If the proximal jejunum is further removed, drag it from the back of the mesenteric vessel to the right, rotate the SMA clockwise to the right of SMV, and rotate the IPDA to the right of SMA. (4) Submesenteric path: raise the transverse mesentery; follow the middle colon artery (MCA) to find the begin-

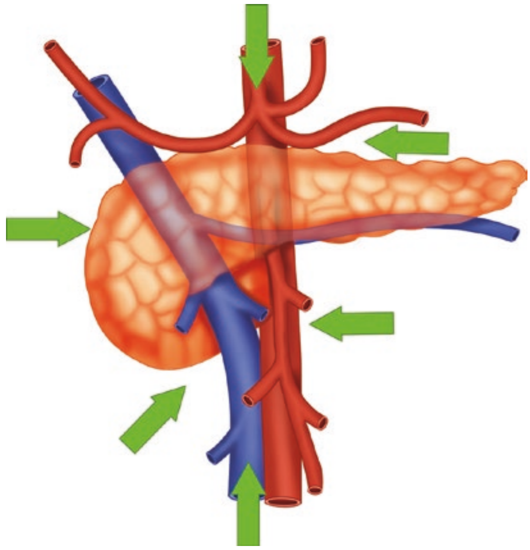

Fig. 2.1 The illustration showing the six approaches of 'Artery First Approach'

ning; cut open the mesentery at the touch of SMA pulse; expose SMA and SMV directly; and if necessary, cut off the root of MCA to get better exposure. The initial part of IPDA can be found on the right-hand side of SMA, moving backward and upward, and the uncinate process is injected from the back of SMV. (5) Left approach: pull the proximal jejunum to the left, and then cut off the first and second jejunal branches at the root; after that the left margin of SMA is exposed, further pulling the jejunum can make SMA to rotate counterclockwise, thus can make IPDA to turn to the left from SMA back, easy to be exposed, and cut off. The loosened SMA is then pulled forward to the right, exposing the rear SMV and its first jejunal branch and cutting off. Thus, the superior mesenteric vessel is separated from the proximal mesentery, and the jejunum is pulled from the back of the vessel to the right after the separation, which can fully expose the relationship between the uncinate process and the blood vessel and improve the R0 resection rate. (6) Left posterior approach: The lateral peritoneum of the duodenal jejunum curve was incised at the Treitz ligament and dissociated towards the lower right along the root of the mesentery, and then the small intestine and its mesentery can be disparted from the retroperitoneum and turned to the right front. Then aorta and the left renal artery across the aorta were exposed. Above the left renal artery, the root of SMA which was already turned up can be found. This approach that combines with the right posterior approach can dissociate SMA root completely and make it easy to find and protect the potential abnormal right hepatic artery which originates from SMA. The basic principle of all pathways is to know whether SMA is involved or not, as the primary criterion is to determine whether the resection is feasible [8].

2.2 Case

A 48-year-old male patient was hospitalized due to poor appetite and sclera stained yellow for 5 days. Laboratory examinations showed an elevation of liver function tests: total bilirubin (TB) 212.85 μmol/L, direct bilirubin (DB) 108.86 μmol/L, aspartate aminotransferase (AST) 68 U/L, alanine aminotransferase (ALT) 166 U/L, alkaline phosphatase (ALP) 262 U/L, and r-glutamyl transpeptidase (r-GTP) 575 U/L. The tumor marker CA19-9 was increased to 158.2 kU/L, and others were normal.

The magnetic resonance water imaging (MRCP) and abdominal computed tomography (CT) showed a pancreatic head lump, involving the lower segment of the common bile duct. Pancreatic head adenocarcinoma was considered (Figs. 2.2 and 2.3). The digital reconstruction of 3D images was performed to observe the correlation of this mass and the portal vein, SMA, and SMV (Fig. 2.4).

From these findings, a diagnosis of pancreatic duct adenocarcinoma located in the head was made, and Rear path Artery First Approach for pancreatoduodenectomy was performed.

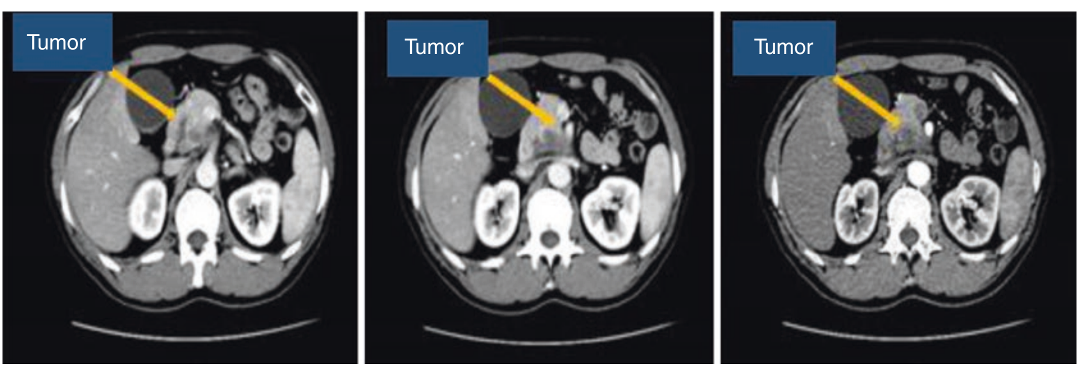

Fig. 2.2 CT images show a mass in the pancreatic head

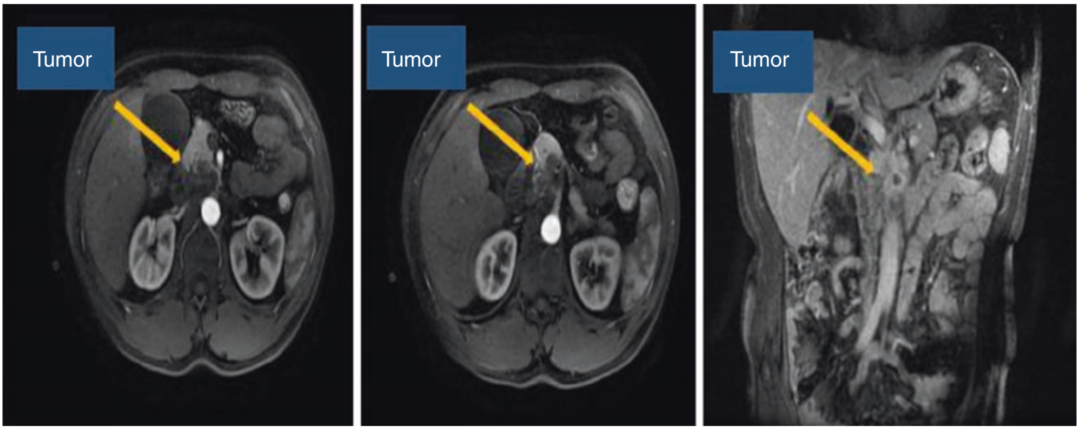

Fig. 2.3 MRI images show a mass in the pancreatic head

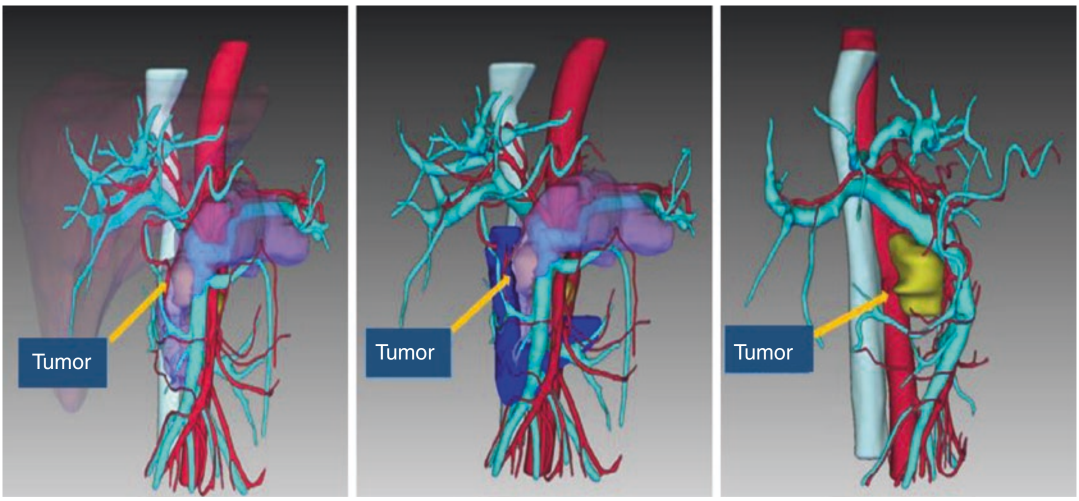

Fig. 2.4 3D reconstruction images revealed the correlation of the mass and the portal vein, SMA, and SMV

Informed consent was obtained from all participating patients, and the ethics committee of First Affiliated Hospital, Anhui Medical University, approved this study.

2.3 Details of Procedure

2.3.1 The Enlarged Kocher Incision

After intraoperative exploration of no metastases in the abdominal cavity, an expanded Kocher incision was made in the right upper abdomen (Fig. 2.5), and the duodenum, right colon, right curvature of the colon, and right transverse mesentery were

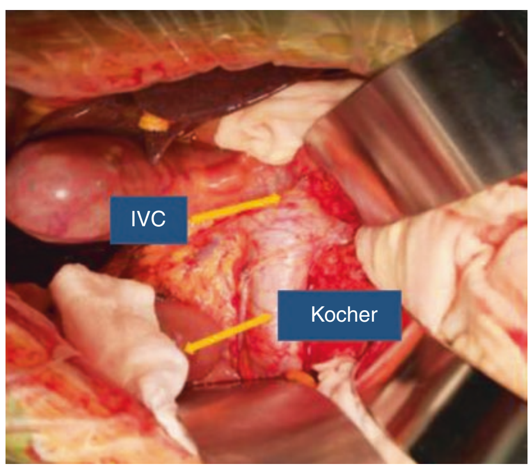

Fig. 2.5 The enlarged Kocher incision

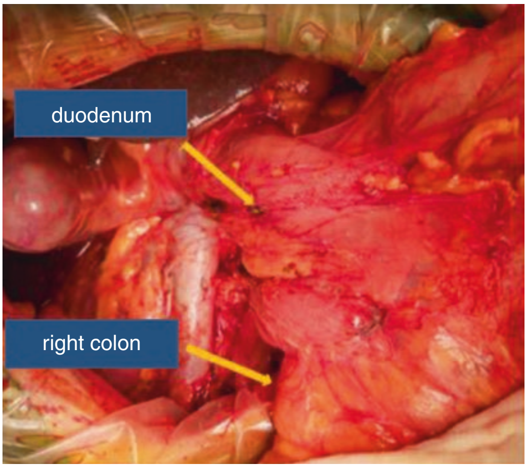

Fig. 2.6 Free duodenum, right colon, right curvature of colon

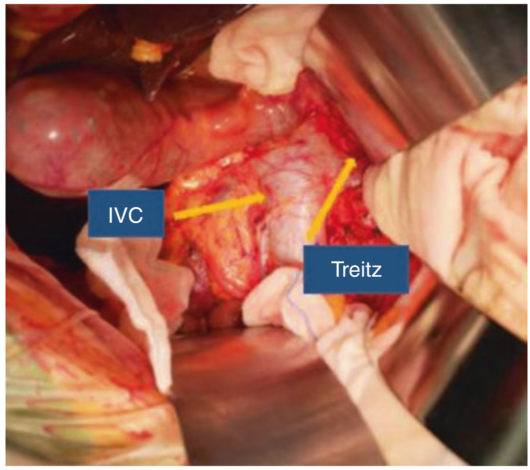

Fig. 2.7 Separate Treitz and fuse fascia to separate pancreatoduodenum

subsequently flipped into the left abdominal cavity, exposing the inferior vena cava to protect the mesentery vessels and avoid bleeding (Fig. 2.6).

2.3.2 The Duodenum of the Head of Pancreas Was Separated from the Retroperitoneum

After the Kocher incision is fully opened, continue to separate along the left side of the back of the pancreatic head until the left Treitz fuses the fascia, and then the head of the pancreas and duodenum were dissociated from the retroperitoneum (Fig. 2.7).

2.3.3 Completely Expose the Abdominal Aorta and Inferior Vena Cava

Push the pancreatoduodenum and the right mesentery to the left, free the surrounding fibrous tissue, and fully expose the abdominal aorta and inferior vena cava (Fig. 2.8).

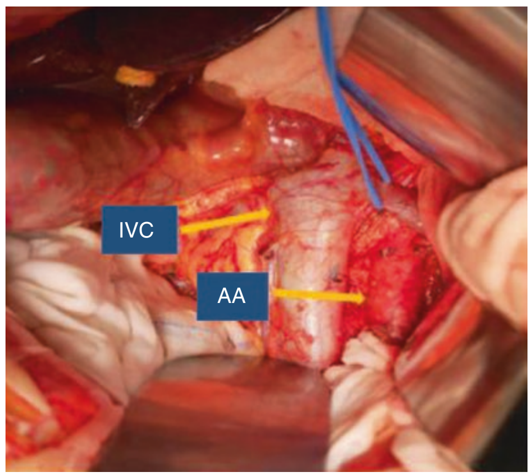

Fig. 2.8 Fully expose the abdominal aorta and inferior vena cava

2.3.4 Isolate and Suspend SMA Roots

During the operation, the SMA root was isolated from the angle between the left margin of the inferior vena cava and the upper margin of the left renal vein and was suspended and separated carefully to clear the lymph node around, and continue detecting whether there were right hepatic artery with abnormal position starting from SMA (Fig. 2.9).

2.3.5 The Pancreaticoduodenal Inferior Artery Was Isolated and Ligated

The SMA segment into the mesentery was dissected from the SMA roots downward and

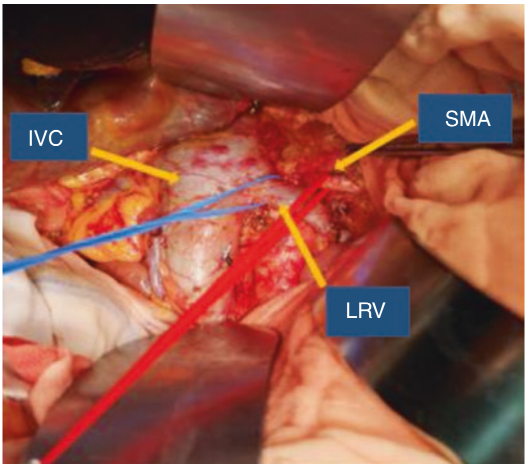

Fig. 2.9 Isolate and suspend SMA roots

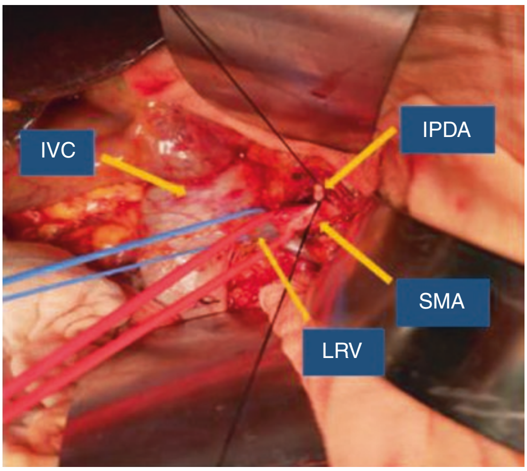

Fig. 2.10 The pancreaticoduodenal inferior artery was isolated and ligated

posterior, and the pancreaticoduodenal inferior artery was carefully separated and ligated (Fig. 2.10).

2.3.6 Complete Dissociation of SMA to the Segment Entering the Mesentery

Continue with the SMA completely free downward (Fig. 2.11), exposing the segment from the root to the mesentery, suspend, dissect the pancreatic neck, dissect the superior mesenteric vein

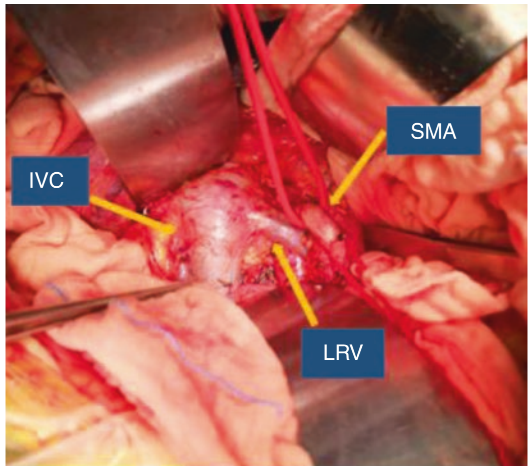

Fig. 2.11 Completely free with SMA

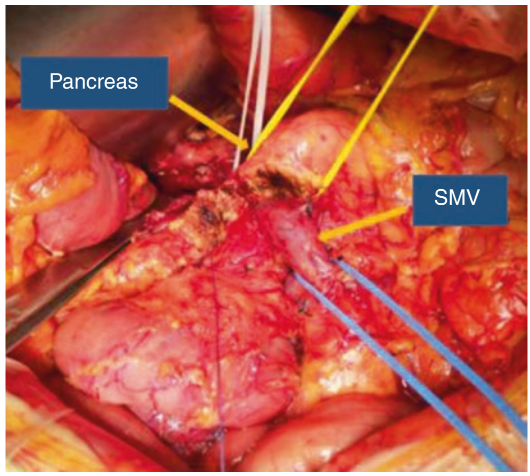

Fig. 2.12 The pancreas was severed, and the superior mesenteric vein was suspended

and portal vein from the uncinate process of the pancreas, and suspend (Fig. 2.12).

2.3.7 The Arteriovenous Vessels Were Exposed After Pancreaticoduodenal Specimen Was Excised

After the pancreatoduodenal specimen was removed, PV, SMV, and SMA were suspended to expose the abdominal aorta and inferior vena cava vessels (Fig. 2.13).

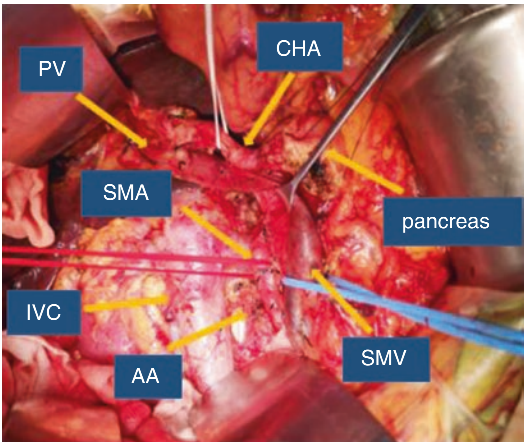

Fig. 2.13 The view after removing the specimen

Fig. 2.14 The resected specimen

2.4 Pathology and Prognosis

The resected specimen was showed in Fig. 2.14. Pathology diagnosis was poor to poorly differentiated pancreatic duct adenocarcinoma (grade II), invading the plexus and bile duct, but no portal or venous infiltration was detected. The tumor also did not involve the duodenum and duodenal papilla. The cutting margins of common bile duct, pancreatic margin, stomach, and duodenal were negative; 14 lymph nodes including peripancreatic lymph nodes (4), the superior mesenteric artery lymph nodes (3), No.16 lymph node (2), No.12 lymph nodes (3), and No.8 lymph nodes (2) were dissected totally, and none of them was positive.

The patient recovered uneventfully and was discharged 2 weeks after the operation. Four months after surgery, follow-up CT and tumor marker revealed no recurrence.

2.5 Comment

Pancreatic cancer is a kind of digestive system tumor with high degree of malignancy. Due to the development of living standard and poor diet and living habits, the incidence of Pancreatic cancer has increased about sixfold in the past 20 years. Surgical resection is still the preferred treatment for pancreatic cancer. The epidemiological studies of pancreatic cancer in recent years have found that the 5-year survival rate is still low, about 8%, the most important reason is the high malignant degree, strong invasion and may associate with lymph node metastasis along with nerve vascular infiltration in an early stage, therefore many patients have been in an advanced stage when diagnosed, and can soon appear local and distant metastasis [9]. Pancreatic cancer has a poor prognosis and involves many complex mechanisms. Recent studies have shown that tumor size and lymph node metastasis are closely related to prognosis. Arterial preferential approach can not only realize early identifcation of superior mesenteric artery invasion, but also clear the peripancreatic nerve fiber tissue and lymph tissue better and improve the R0 resection rate [10].

There are many advantages in the arterial priority pathway for complex and huge pancreatic tumors, but the arterial priority technique is difficult, requiring high anatomy and strain capacity of the surgeon, and needs a relatively high vascular surgical technical foundation, and a relatively long overall learning curve. Therefore, the selection of surgical routes and methods should be based on the comprehensive evaluation of individual conditions.

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3 Pancreatoduodenectomy: Other Approach

Wei Chen

3.1 Introduction

Pancreaticoduodenectomy (PD), first reported by Codivilla and Kausch [1], is a complex and delicate surgical operation for treating the periampullary and pancreatic head tumors. This technique was finally polished and popularized by Whipple et al. [2]. To date, several versions of the Whipple's technique have been modified; however, PD is usually detected, dissociated, and removed by standard approach in most cases. It can be performed within these situations: no distant organ metastasis of tumor, no tumor invasion and fixation in transverse mesocolon root, no tumor invasion of important peripancreatic vessels, and no large number of abnormal collateral vessels in the hilum of the liver can be removed by abdominal exploration.

Although PD has reached a general consensus in terms of surgical scope and anastomotic approach, there are still many controversies in the judgment of surgical approach and resectability. The PD surgical approaches included standard approach, no-touch technique, below the transverse mesocolon approach, early ligation of the efferent arteries of the head of pancreas, artery first approach, uncinate process first approach, etc. [3].

W. Chen (✉)
The First Affiliated Hospital, Sun Yat-sen University, Guangzhou, Guangdong, China
e-mail: chenw57@mail.sysu.edu.cn

Standard approach for pancreaticoduodenectomy is currently the most effective treatment for pancreatic head cancer. This procedure includes a single resection of the pancreatic head, distal stomach, duodenum, gallbladder, and distal end of common bile duct, proximal jejunum, and focal lymph nodes, followed by pancreatic jejunostomy, jejunal common bile duct anastomosis, and gastrojejunostomy. Pancreaticojejunostomy would solve the pancreatic juice problem; biliary anastomosis could drain bile, improve the condition of jaundice, and prepare for radiotherapy and chemotherapy, while gastrointestinal anastomosis is duodenal obstruction.

The standard approach is mature and safe because it follows the classical order of exploration, dissociation, and resection. However, in case of large tumor location, tumor, invasion of peripancreatic blood vessels, needed to be jointly peripancreatic nerve plexus resection, and so on, the standard approach is difficult to perform. Then other approaches have their unique advantages.

The artery first approach is more focused on whether the artery is invaded than the standard approach, so that it can identify the invasion of SMA earlier and determine whether the operation can be radical resection. The right side and the initial part of SMA can be better boned to improve the resection rate of R0 [4]. At present, results of nonrandomized retrospective control studies showed that there was no significant

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statistical difference between the arterial anterior approach and the conventional approach in intraoperative bleeding, operation time, complications, incisal margin, and other aspects, but the local recurrence rate of the arterial anterior approach is lower and the postoperative survival time is longer than that of the conventional approach. The arterial leading technique needs a high technical foundation and a long learning curve because of its high difficulty.

The uncinate process first approach was reported that it improves the surgical safety and R0 resection rate of the incisional margin. However, for large uncinate tumors, SMV and SMA were raised forward by tumors, making it difficult to break the uncinate mesangium and easy to damage important branches of the mesangium root. If the tumor is large enough to compress and invade the inferior vena cava, it is difficult to use the uncinate process approach to dissect the pancreas and neck before dissection, and it is difficult to control hemostasis when vascular injury occurs. This approach requires high basic skills and careful performance of the surgeons.

The early ligation of the efferent arteries of the head of pancreas can effectively reduce the amount of intraoperative blood loss and the number of blood transfusions. However, because the dissection of the pancreatic duodenal artery requires rich surgical experience and a longer learning curve, many related studies have reported that this approach will prolong the operation time.

No-touch technique reduces intraoperative compression and contact of tumor lesions. Studies have shown that intraoperative peritoneal lavage and PV flow detection in the no-touch technique group indicated that the incidence of tumor cell metastasis was significantly lower than that in the conventional surgical approach group [5]. However, for the patients with larger tumor and PV-SMV invasion, since the pancreatic head cannot be pulled and raised as the conventional approach, once the blood vessel is damaged and bleeding, it is difficult for hemostasis, and operation time is significantly prolonged. At present, reports of no-touch technology in PD are still limited, so that the long-term efficacy still needs to be further studied and evaluated.

The isolated pancreatectomy is suitable for the large pancreatic head uncinate tumors, which invades SMA and SMV, because it reduces damage of SMA and SMV and avoids the blindness of separation, leading to improve the R0 resection rate of SMA cutting edge.

If left SMA plexus tissue can be retained, the risk of postoperative refractory diarrhea is relatively low [6].

The choice of surgical approach should be based on individual comprehensive consideration of patients, tumor location and size, vascular invasion, and technical experience of the surgeons. Here, we focus on the standard approach. The standard approach is usually detected, dissociated, and removed in most cases.

3.2 Case

A 53-year-old female with history of vague epigastric pain for 2 weeks.

Laboratory examinations showed an elevation of liver function tests: total bilirubin (TB) 106.6 mmol/L, direct bilirubin (DB) 85.3 3 mmol/L, aspartate aminotransferase (AST) 428 U/L, and alanine aminotransferase (ALT) 695 U/L. The tumor marker CA19-9 was increased to 1180.84 u/ml.

Computer tomography (CT) images demonstrate an infiltrative, low attenuation mass involving the head of pancreas causing obstruction of the distal pancreatic duct and atrophy of the pancreatic parenchyma. Pancreatic head adenocarcinoma was considered (Fig. 3.1).

Informed consent was obtained from all participating patients, and the ethics committee of the First Affiliated Hospital, Sun Yat-sen University, approved this study.

3.3 Details of Procedure

3.3.1 Standard Approach for Pancreaticoduodenectomy

A vertical midline incision and a cambered retractor would be used for our preference.

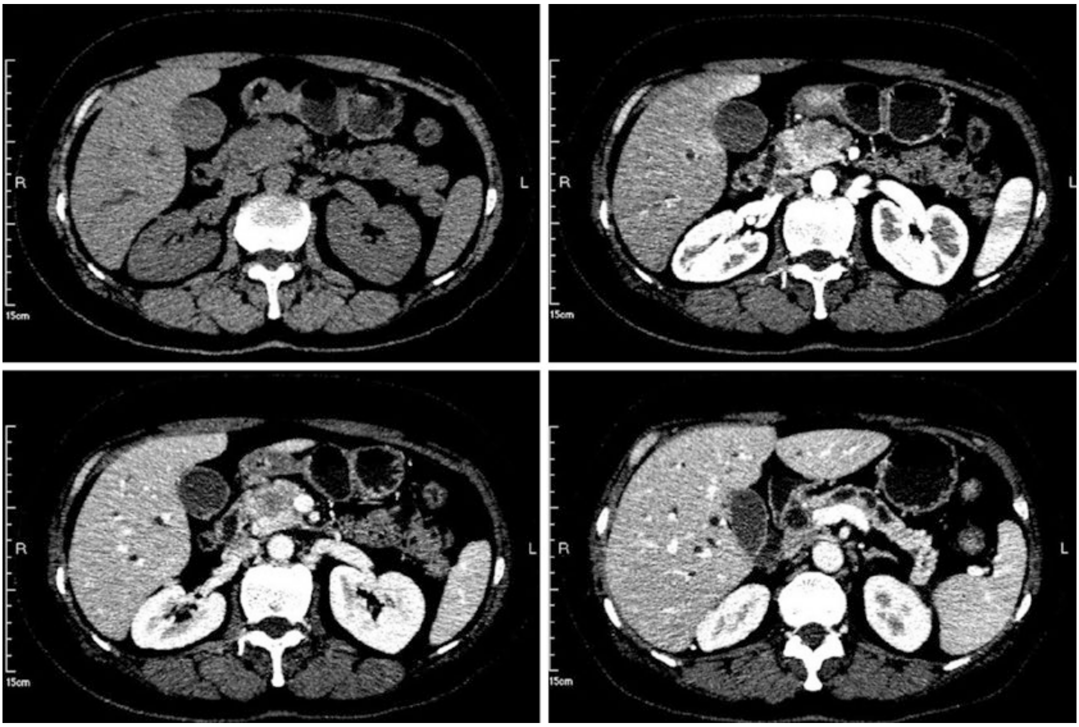

Fig. 3.1 CT images demonstrate an infiltrative, low attenuation mass involving the head of pancreas causing obstruction of the distal pancreatic duct and atrophy of the pancreatic parenchyma

Unexpected extrapancreatic metastases, including the liver and peritoneal surfaces, are examined. Suspicious lesions and enlarged lymph nodes outside the planned field of dissection should be biopsied and examined by frozen section, and the resection should be aborted if positive for metastatic cancer.

2. Kocher dissociated the duodenal bulb into the retroperitoneum, exposing the inferior vena cava (IVC) and dissecting lymph nodes behind the pancreatic head (Fig. 3.2).

3. Extensive exposure to IVC ensures a dissection surface at the back of the pancreas. Attention points confirm the ureter line and avoid damaging the ureter (Fig. 3.3).

4. Dissociating the descending and horizontal part of duodenum. To dissociate the anal side of the duodenum free (Fig. 3.4).

5. Dissociating the pancreatic uncinate process, exposing the superior mesenteric vein (Fig. 3.5).

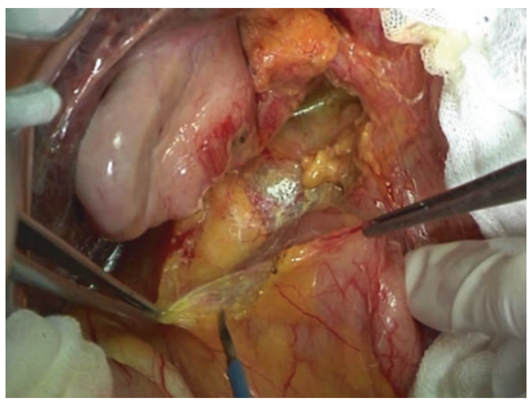

Fig. 3.2 Liberal Kocherization of the duodenum

6. Between the pancreatic neck and superior mesenteric vein, a vessel forceps was used to explore and confirm the tumor not encroaching mesenteric vessel (Fig. 3.6).
7. Calot's triangle was anatomized (Fig. 3.7).
8. The cystic artery was ligated and dissected (Fig. 3.8).

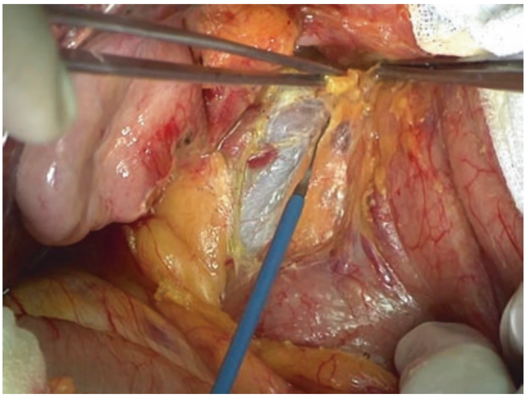

Fig. 3.3 Extensive exposure to IVC

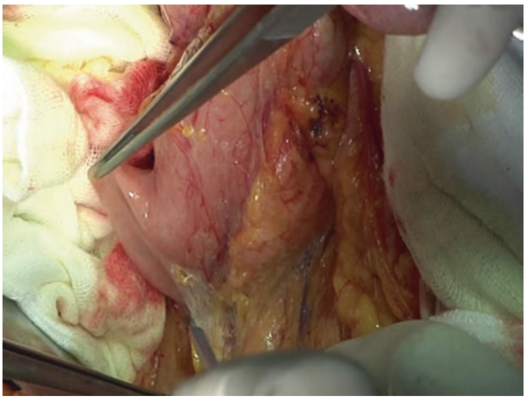

Fig. 3.4 Dissociating the descending and horizontal part of duodenum

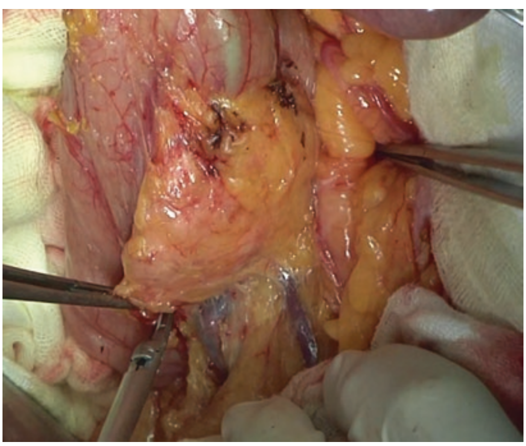

Fig. 3.5 To expose the superior mesenteric vein

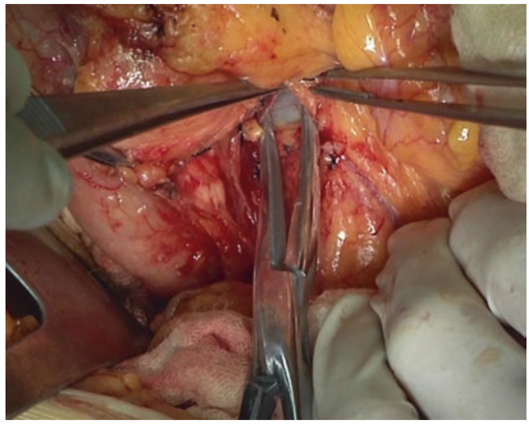

Fig. 3.6 To confirm the tumor not encroaching mesenteric vessel

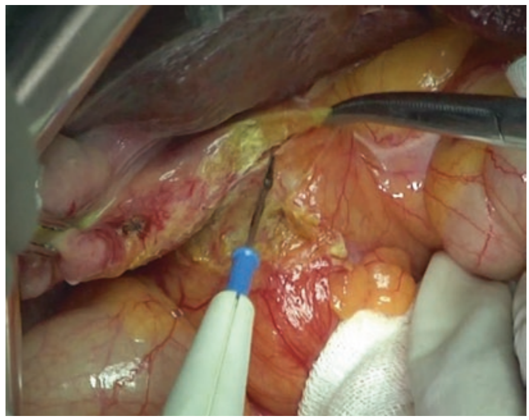

Fig. 3.7 Calot's triangle was anatomized

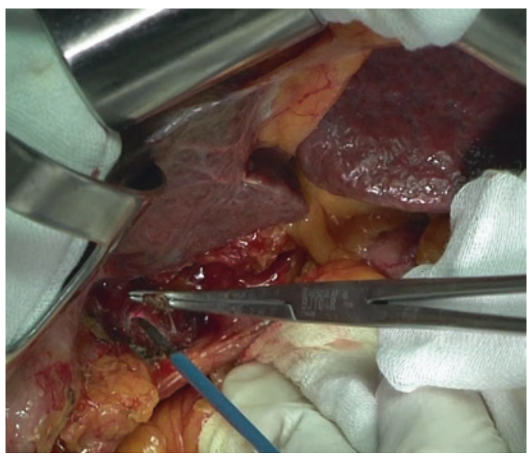

Fig. 3.8 The cystic artery was ligated and dissected

9. The gallbladder is dissected from the bottom in order to identify the common hepatic duct (Fig. 3.9).
10. The common hepatic duct was ligated and dissected (Fig. 3.10).
11. Dissociating the right hepatic artery, this patient's right hepatic artery arises from superior mesenteric artery (Fig. 3.11a, b).
12. Dissecting hilar hepatic lymph nodes (Fig. 3.12).
13. Dissociating portal vein, right hepatic artery, left hepatic artery, common hepatic artery, and gastric duodenal artery (Fig. 3.13).
14. The gastric duodenal artery was ligated and dissected (Fig. 3.14).
15. Between the pancreatic neck and superior mesenteric vein, a vessel forceps was used to explore and confirm the tumor not encroaching the portal vein (Fig. 3.15).
16. Dissociated gastric omentum and dissecting stomach (Fig. 3.16a, b).
17. Dissecting the pancreas from the neck of the pancreas (Fig. 3.17).
18. Dissociated and dissected pancreatic duct (Fig. 3.18).
19. A drainage tube was inserted into pancreatic duct and was fixed by suture (Fig. 3.19).
20. Dissected the sheath of superior mesenteric artery, exposing right hepatic artery and superior mesenteric artery (Fig. 3.20).
21. Dissecting the whole uncinate process of pancreas (Fig. 3.21).
22. Break the Treiz ligament, pull the duodenum, and remove the upper jejunum from the right side of the superior mesenteric vein. Jejunum was dissected at 15 cm from the Treitz ligament, suturing the end of the jejunum segment (Fig. 3.22a, b).

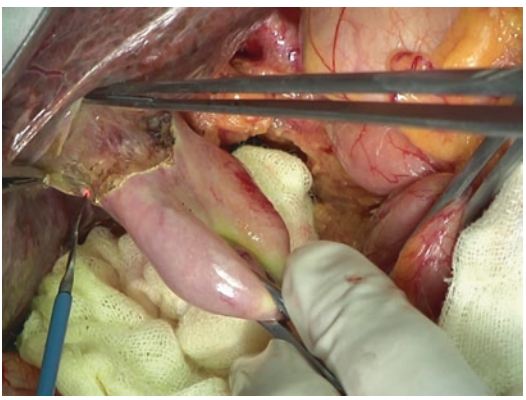

Fig. 3.9 The gallbladder was dissected

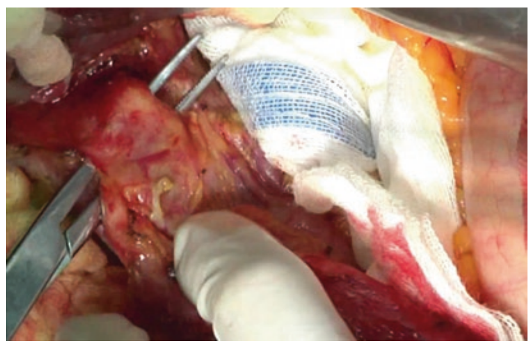

Fig. 3.10 The common hepatic duct was ligated and dissected

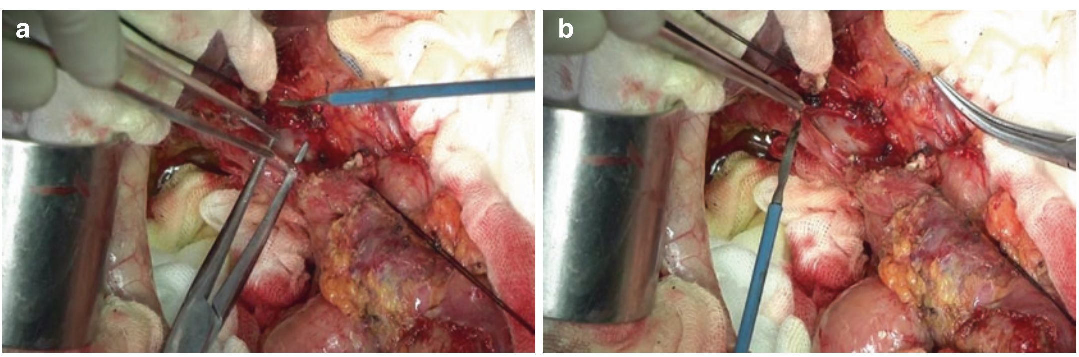

Fig. 3.11 (**a**) Dissociating the right hepatic artery; (**b**) the right hepatic artery aroused from the superior mesenteric artery

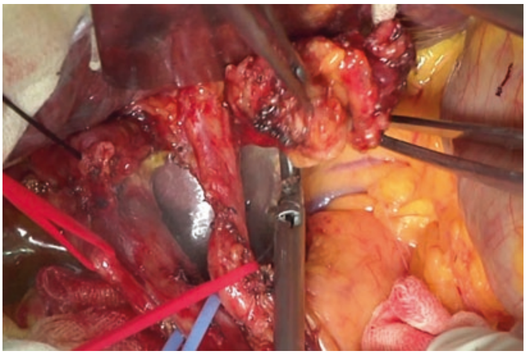

Fig. 3.12 Dissecting hilar hepatic lymph nodes

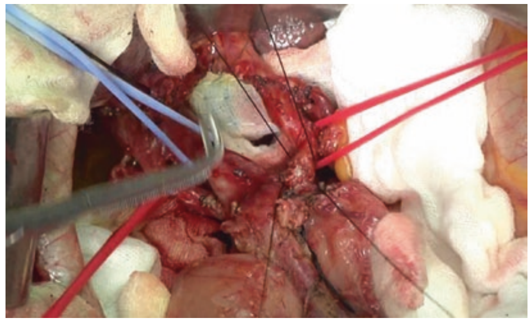

Fig. 3.14 The gastric duodenal artery was ligated and dissected

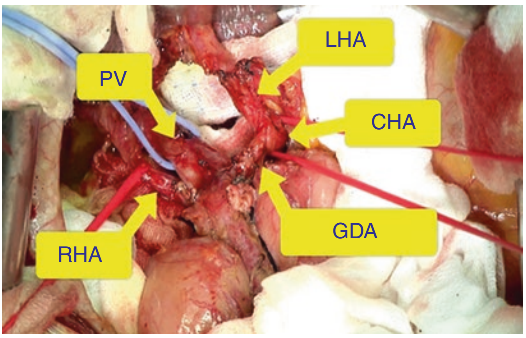

Fig. 3.13 Dissociating portal vein (PV), right hepatic artery (RHA), left hepatic artery (LHA), common hepatic artery (CHA), and gastric duodenal artery (GDA)

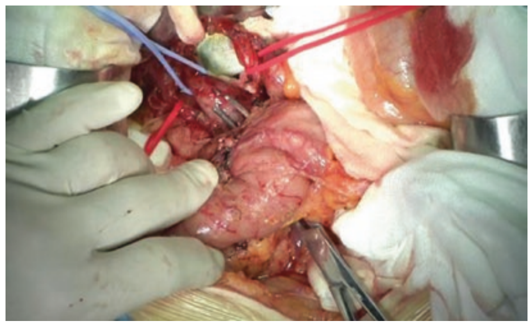

Fig. 3.15 To confirm the tumor not encroaching the portal vein

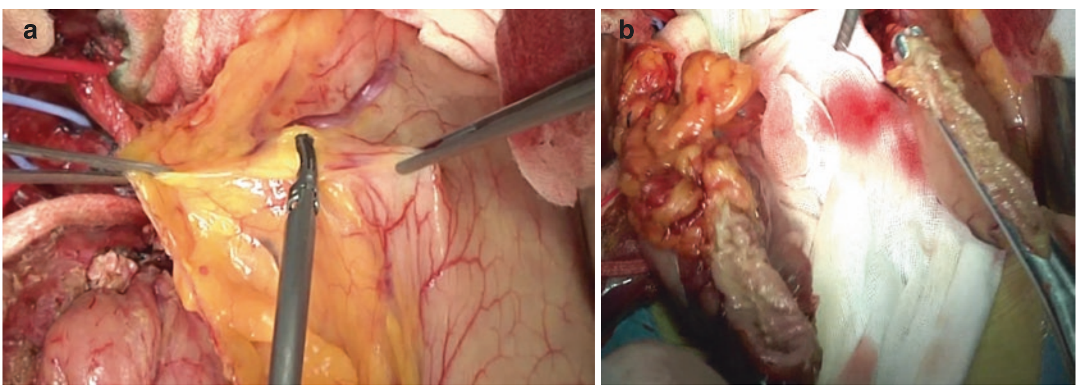

Fig. 3.16 (**a**) Dissociating the gastric omentum; (**b**) dissecting the stomach

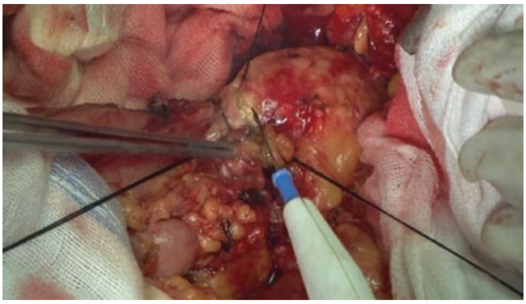

Fig. 3.17 Transecting the pancreas

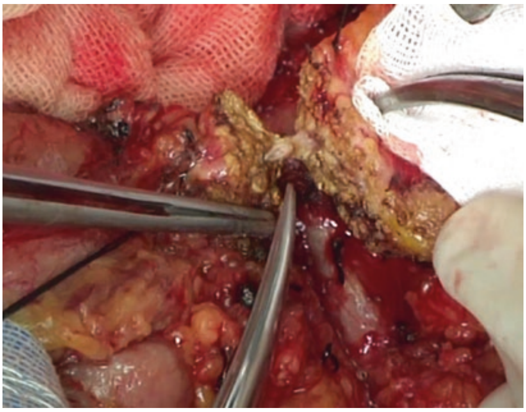

Fig. 3.18 Dissecting the pancreatic duct

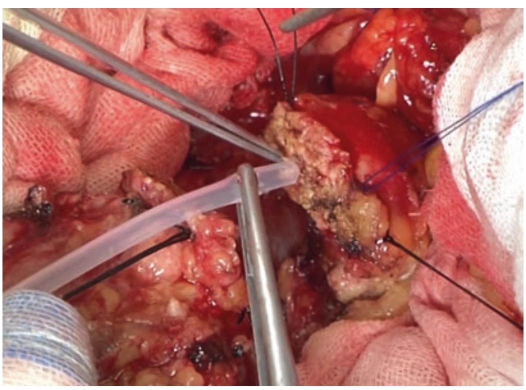

Fig. 3.19 Placing a stent to the pancreatic duct

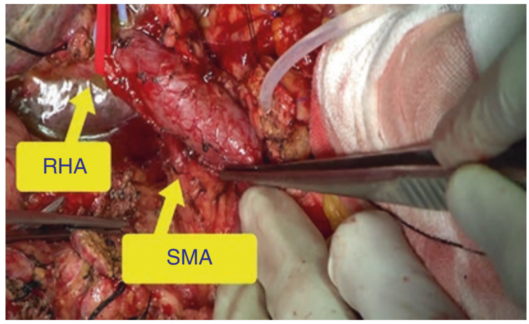

Fig. 3.20 Exposing right hepatic artery (RHA) and superior mesenteric artery (SMA)

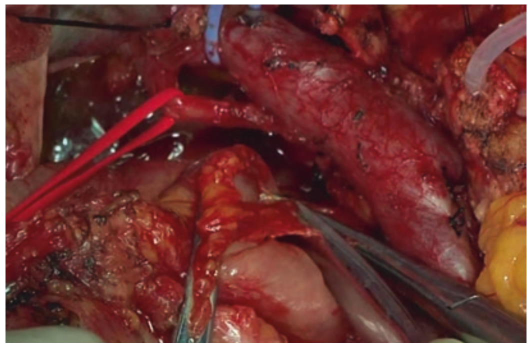

Fig. 3.21 Dissecting the uncinate process

23. Pancreaticojejunostomy was performed. First, implemented continuous suture of the jejunal seromuscular layer with the dorsal pancreas envelope (Fig. 3.23).
24. Implemented continuous suture of the jejunal seromuscular layer with the end of dorsal pancreas segment with 4-0 Prolene (Fig. 3.24).
25. Implemented continuous suture of the jejunal seromuscular layer with the end of ventral pancreas segment (Fig. 3.25).
26. Implemented continuous suture of the jejunal seromuscular layer with the end of ventral pancreas envelope (Fig. 3.26).

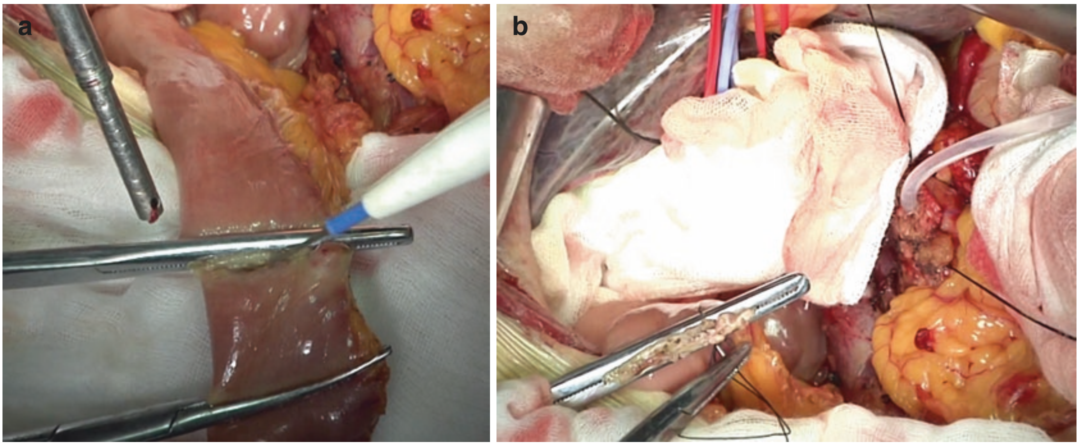

Fig. 3.22 (**a**) Cutting off the jejunum; (**b**) Suturing the end of the jejunum

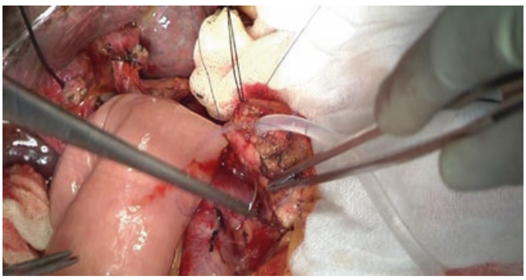

Fig. 3.23 Pancreaticojejunostomy was performed

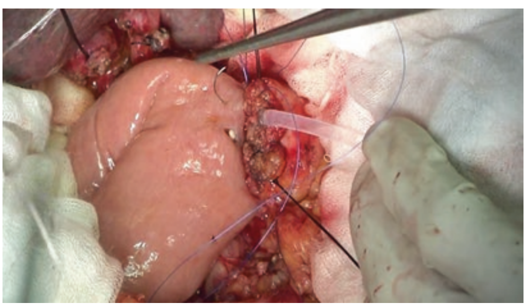

Fig. 3.24 Suturing the jejunal seromuscular layer with the pancreatic stump

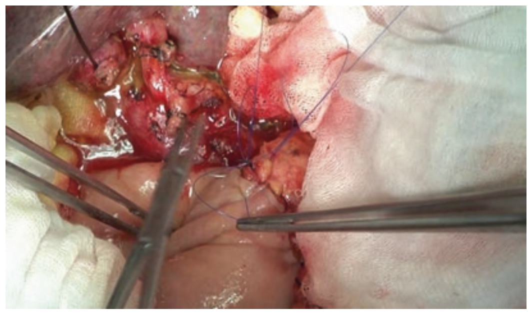

Fig. 3.25 Continue suturing the jejunal seromuscular layer with the pancreatic stump

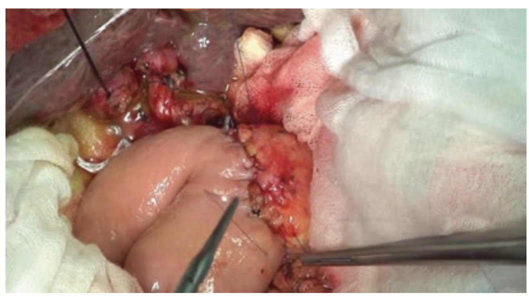

Fig. 3.26 Pancreaticojejunostomy was finished

27. Implemented choleenterostomy 10 cm from pancreatoenteric anastomosis (Fig. 3.27).
28. Implemented continuous suture of the posterior jejunal seromuscular layer with the end of bile duct segment (Fig. 3.28).
29. Implemented interrupted suture of the anterior jejunal seromuscular layer with the end of bile duct segment (Fig. 3.29).
30. Implemented gastrojejunostomy 45 cm from the pancreatoenteric anastomosis (Fig. 3.30).
31. Cut the jejunum, implemented purse-string suture, and fixed the anvil. Opened the stomach and placed the joystick to perform gastroenterostomy (Fig. 3.31a–d).
32. Used endovascular gastrointestinal anastomosis stapler to cut and close the stomach segment (Fig. 3.32a, b).
33. Postoperative exploration of abdominal cavity (Fig. 3.33a–c).

Informed consent was obtained from all participating patients, and the ethics committee of the first affiliated hospital of Sun Yat-sen university approved this study.

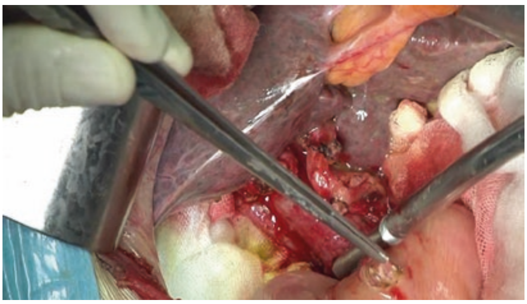

Fig. 3.27 Choledochojejunostomy was performed

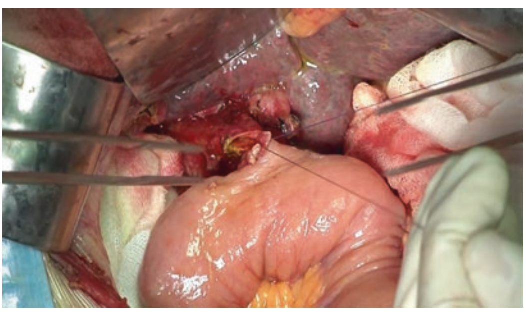

Fig. 3.28 Suturing the posterior jejunal seromuscular layer with the end of bile duct

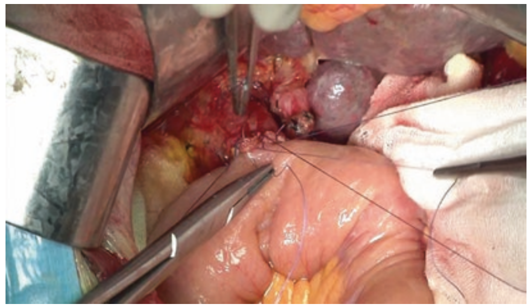

Fig. 3.29 Suturing the anterior jejunal seromuscular layer with the end of bile duct

Fig. 3.30 Gastrojejunostomy was performed

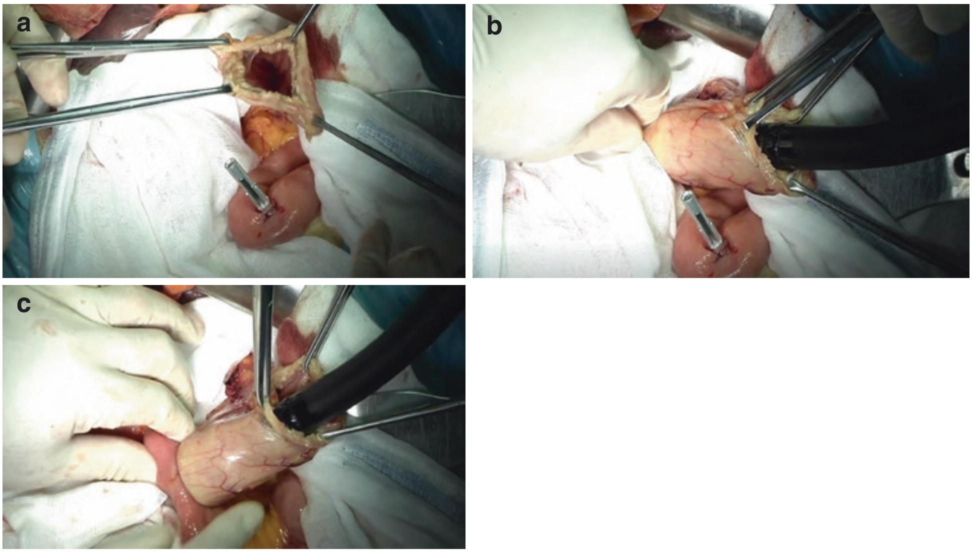

Fig. 3.31 (**a**) Cut the jejunum; (**b**) fixed the anvil; (**c**) to perform gastroenterostomy

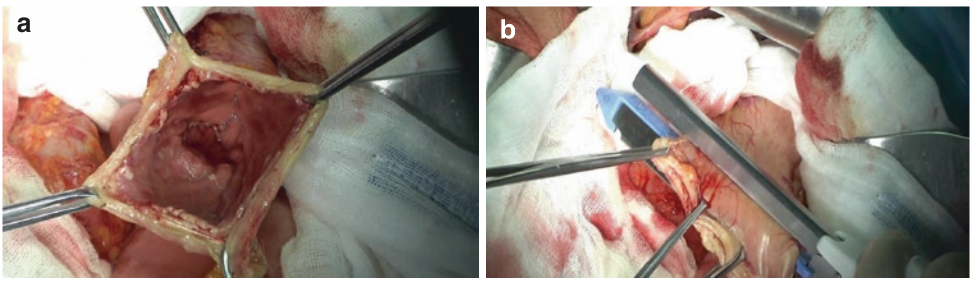

Fig. 3.32 (**a**) To check the gastrointestinal anastomosis; (**b**) To close the stomach

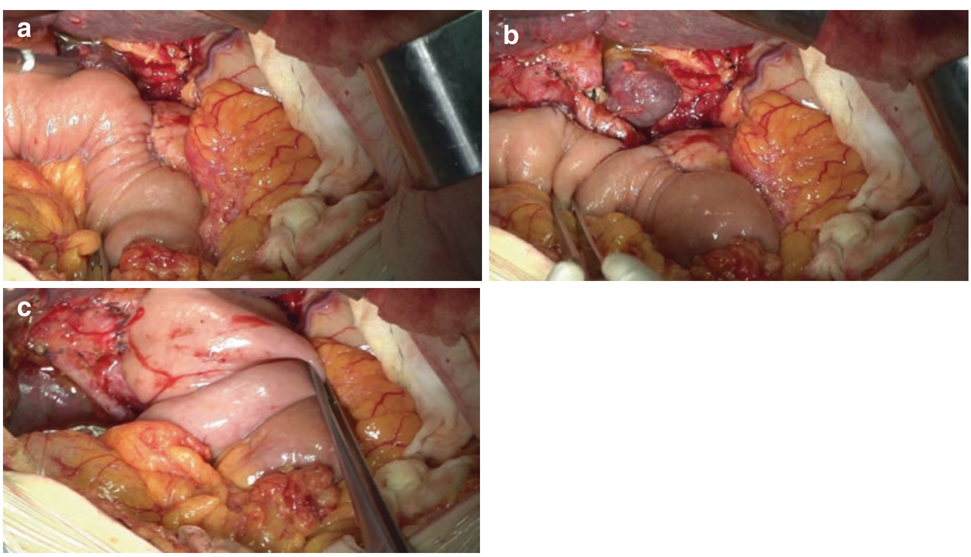

Fig. 3.33 (**a**) To expose the pancreaticojejunostomy; (**b**) To expose the pancreaticojejunostomy; (**c**) To expose the choledochojejunostomy

3.4 Comment

Since its invention, Whipple's procedure for PD has always been the standard operation for treating the tumors arising from the periampullary area or the pancreatic head. Although many versions of the original Whipple's procedure have been modified, PD is still detected, dissociated, and removed by standard approach in most cases. The standard approach follows the classical order of exploration, dissociation, and resection, and the approach is mature and safe. However, in case of large tumor location, tumor, invasion of peripancreatic blood vessels, needed to be jointly peripancreatic nerve plexus resection, and so on, the standard approach is difficult to perform. Then other approaches may have their unique advantages for the situations.

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4 Pylorus-Preserving Pancreatoduodenectomy

Rui Tian and Ren-Yi Qin

4.1 Introduction

Pancreaticoduodenectomy (PD) is the treatment of choice for various benign and malignant tumors of the pancreatic head or the periampullary region. However, because of its retroperitoneal location in an area of complex vascular anatomy and because of the inherent difficulty with anastomosis, technical progress with resective operations on the pancreas has been slowed. However, recent improvements in technique have reduced the mortality rate, making pancreatoduodenectomy the last major abdominal operative procedure to achieve a postoperative mortality rate of 5% or less.

In 1978, pancreatoduodenectomy entered the current era of pylorus preservation. Traverso and Longmire [1] reasoned that preservation of an intact stomach would eliminate the complications of a reduced gastric reservoir and improve the nutritional status of patients. Furthermore, they believed that this modification of the PD operation would decrease the postoperative incidence of jejunal ulceration, perforation, and bile reflux. Since then, differences in perioperative parameters and postoperative outcomes of classic PD compared to pylorus-preserving PD (PPPD) have been investigated in numerous studies [2–4].

R. Tian · R.-Y. Qin (✉)
Tongji Hospital, Huazhong University of Science and Technology, Wuhan, China
e-mail: ryqin@tjh.tjmu.edu.cn

The conventional pancreaticoduodenectomy, often referred to as a classic PD, includes the pancreatic head, the duodenum, the common bile duct, the gallbladder, and the distal portion of the stomach, together with adjacent lymph nodes. For the classic PD, a distal gastrectomy varying from 20 to 40% was performed. This operation can lead to special complications such as early and late dumping (rapid emptying of the stomach), postoperative weight loss, and postoperative reflux. In comparison, a PPPD involved division of the duodenum 2 cm distal to the pylorus with resection of all of the duodenum distal to the transection site, removal of the gallbladder and common bile duct (proximal to the level of the cystic duct junction), resection of the head, neck, and uncinate process of the pancreas (underneath the superior mesenteric vein, lateral from the mesenteric–portal vein axis, push with the superior mesenteric artery), and removal of the periampullary tumor. Instead of a gastrojejunostomy for gastric continuity, the duodenum is anastomosed directly to the jejunum. This might lead to a more physiologic gastrointestinal passage and also might lead to higher rates of specific complications such as delayed gastric emptying (DGE).

4.2 Case

A 54-year-old woman was admitted to our hospital with a 1 month history of jaundice. The physical examination was unremarkable, with the

Y.-b. Liu (ed.), *Surgical Atlas of Pancreatic Cancer*, https://doi.org/10.1007/978-981-32-9864-4_4

exception of skin and sclera jaundice. Laboratory results showed a total bilirubin (TB) level of 280.3 μmol/L, a direct bilirubin (DBIL) level of 168.2 μmol/L, a carbohydrate antigen 19-9 level of 65.45 U/ml, and a normal coagulation test result. Upper abdominal computed tomography scans showed dilation of the intrahepatic and common bile ducts. An arterial enhanced 2.0 × 1.8 cm mass was detected in the head of pancreas, without evidence of superior mesenteric vessel invasion (Fig. 4.1). A malignant tumor of the pancreatic head, with obstructive jaundice, was diagnosed preoperatively. Then, a laparoscopic pylorus preserving pancreatoduodenectomy (LPPPD) was performed.

Informed consent was obtained from all participating patients, and the ethics committee of Tongji Hospital, Huazhong University of Science and Technology, approved this study.

4.3 Details of Procedure

For LPPPD, the patient was placed in supine position with an anti-Trendelenburg (10–30 cm) position. Abdominal pressure using CO_2 gas insufflation was maintained at 12 mmHg, and four trocars were placed under a direct vision scope. Typically, a total of 5 (5 or 12 mm) trocars are used for the procedure, placed in a semicircle in the lower and lateral aspects of the abdomen (Fig. 4.2). Then resection and reconstruction began. After extensive Kocherization of the duodenum and mobilization of the hepatic colonic flexure, the entire duodenum was inspected. The

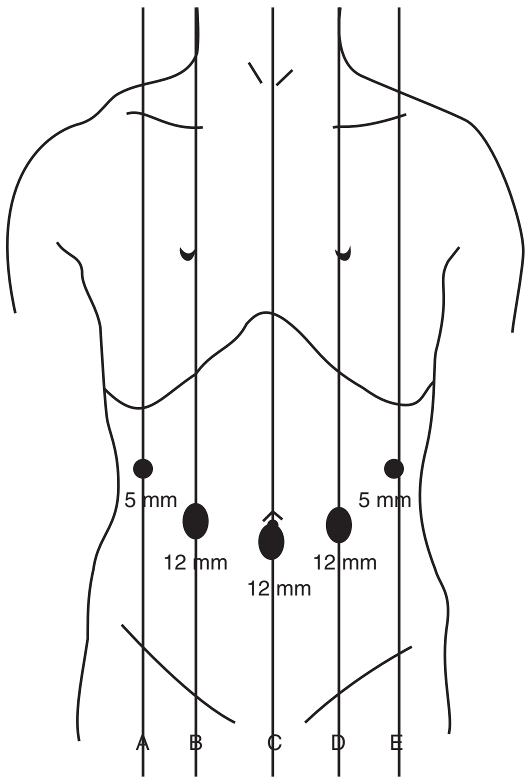

Fig. 4.2 (**a**) The right anterior axillary line; (**b**) The right midclavicular line; (**c**) The midsternal line; (**d**) The left midclavicular line; (**e**) The left anterior axillary line

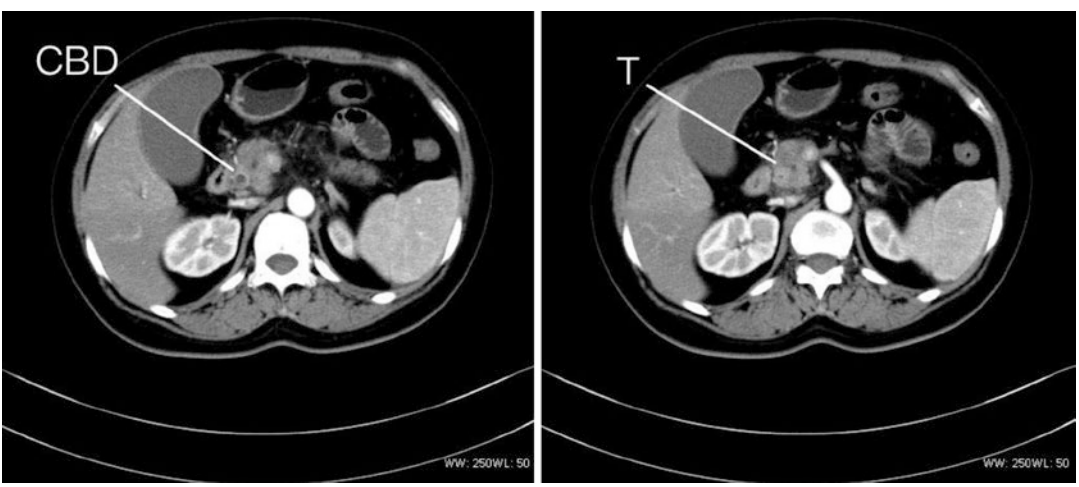

Fig. 4.1 CT scan showed an arterial enhanced 2.0 × 1.8 cm mass, detected in the head of pancreas, and thickening and enhancement of the common bile duct wall. CBD, common bile duct; T, tumor

gastrocolic omentum was dissected to allow entry into the lesser sac. The right gastroepiploic vessels were transected, and the superior mesenteric portal vein was identified at the inferior border of the pancreas. The duodenum was severed with an endoscopic linear stapler 2–3 cm distal to the pylorus (Figs. 4.3 and 4.4).

The neurovascular supply of stomach, pylorus, and duodenum were preserved. The gastroduodenal artery was divided at its junction with the hepatic artery; the right gastric artery, if present, was also divided. This approach allowed adequate dissection of the hepatoduodenal ligament in malignant diseases. The gastroepiploic artery was divided at its origin from the pancreaticoduodenal artery, and the corresponding vein was divided at its entrance into the gastroepiploic trunk (Figs. 4.5 and 4.6). The gastroepiploic vessels were thus preserved along the greater gastric curvature.

A cholecystectomy was performed separately and the common bile duct and common hepatic artery were dissected. The pancreas was divided

Fig. 4.3 The duodenum was mobilized

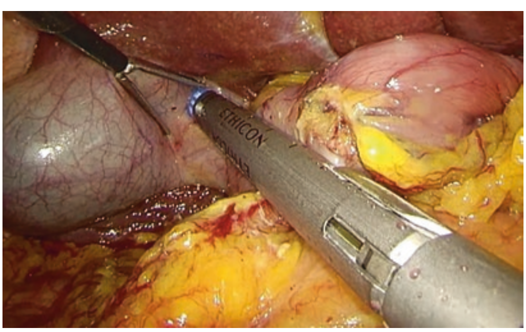

Fig. 4.4 The duodenum was severed with an endoscopic linear stapler 2–3 cm distal to the pylorus

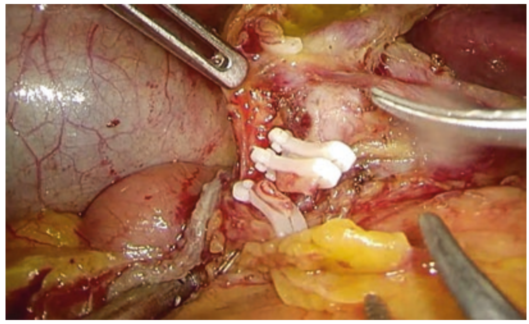

Fig. 4.5 The gastroepiploic artery was divided

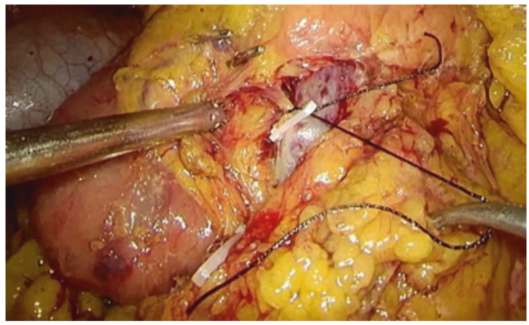

Fig. 4.6 The gastroepiploic trunk was divided

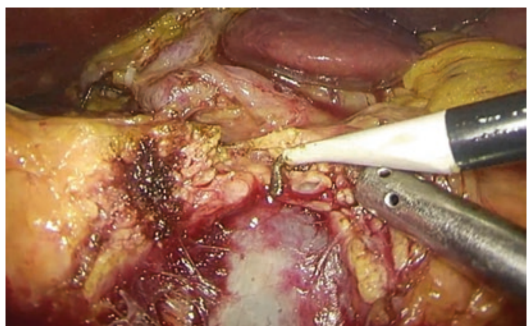

Fig. 4.7 The pancreas was divided at the neck

at the neck, while the pancreatic duct was identified for reconstruction (Fig. 4.7). Frozen section was performed routinely at the transection site of the pancreatic remnant. The jejunum was severed with an endoscopic linear stapler 10–15 cm distal to the ligament of Treitz, and the proximal jejunum passed back underneath the superior mesenteric vessels to the right upper quadrant (Fig. 4.8). The head and the neck of the pancreas, main portion of the duodenum, and distal bile duct were excised from their connection by small veins

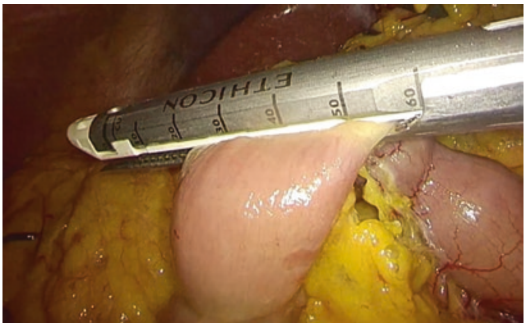

Fig. 4.8 The jejunum was severed 10–15 cm distal to the ligament of Treitz

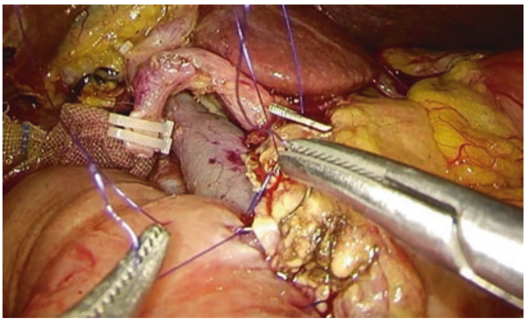

Fig. 4.9 An end-to-side, pancreaticojejunostomy, duct-to-mucosa anastomosis

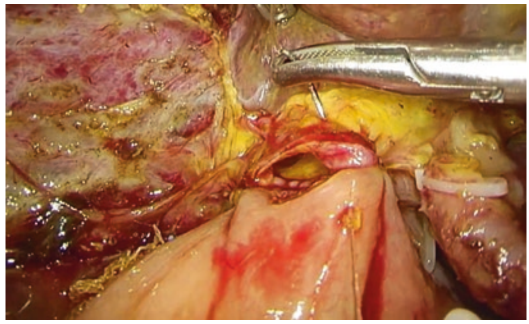

Fig. 4.10 Hepaticojejunostomy

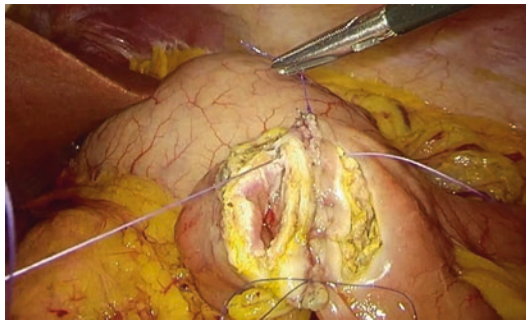

Fig. 4.11 Duodenojejunostomy

directly to the portal vein and superior mesenteric vein and by arteries to the posterior pancreatoduodenal arcade.

The first anastomosis, an end-to-side, pancreaticojejunostomy, duct-to-mucosa anastomosis, is performed over an 8-cm Silastic tube with an inner layer of 5-0 Vicryl sutures and an outer layer of interrupted 3-0 silk sutures (Fig. 4.9). Next the hepaticojejunostomy (end to side) was performed distal to the first anastomosis with running suturing (Fig. 4.10).

The duodenojejunostomy was performed using a double layer of running sutures Maxon/PDS 4/0 (Fig. 4.11). The jejunal loop(s) were fixed to the irrespective openings in the transverse mesocolon in order to avoid internal herniation and gastric outlet obstruction.

4.4 Pathology and Prognosis

At postoperative day 1 (POD 1), the laboratory results showed a TB level of 181.7 μmol/L and a DBIL level of 136.2 μmol/L. The drainage was 50 ml, and the drainage amylase test was 20 U/L at POD 2. The TB level had decreased to a normal level of 75.2 μmol/L at POD 7, with a low level of drainage amylase of 16 U/L at POD 4. No fatal complications, including heart failure, pulmonary infection, hemorrhage, pancreatic leakage, and bile leakage, were observed. The patient was discharged 13 days after the operation. During 1 year of follow-up, abdominal enhanced magnetic resonance imaging and blood tumor markers revealed that the patient had no tumor recurrence or metastasis.

Pathologic diagnosis was poor to moderately differentiated pancreatic duct adenocarcinoma, invading the plexus and the full-thickness of common bile duct, but no portal or venous infiltration was detected. The tumor also did not involve the duodenum and duodenal papilla; the cutting margin of common bile duct, pancreatic margin, stomach, and duodenal were negative. 5 of 9 peripancreatic lymph nodes dissected were found positive. Other lymph nodes including No. 8 lymph node (1), superior mesenteric artery lymph nodes (2), and No.12 lymph nodes (3) were negative.

4.5 Comment

Huttner et al. [5] included eight randomized controlled trials with a total of 512 participants comparing of PPPD with the classic PD operation for patients with cancer of the pancreas or the periampullary region. They concluded that current evidence on the basis of existing RCTs suggests no difference between the PPPD and the classic PD operation in terms of survival, postoperative mortality, and main morbidity. Pylorus-preserving resection offers the advantage of a shorter operating time, less blood loss, decreased need for blood replacement, and an increased ability to work at 6 months after surgery.

Despite the risk of peripyloric lymphatic tumor spread and continuous tumor invasion of the duodenum, it is of major clinical relevance whether the PPPD and PD show differences regarding mortality, morbidity, and postoperative survival of patients with cancer of the head of the pancreas. However, several randomized clinical trial researches showed that the morbidity and mortality were similar in both procedures. Long-term results showed no differences in terms of overall survival, tumor recurrence, or quality of life [3, 6]. The meta-analysis of randomized studies revealed a balanced distribution of R0/R1 resections (mean R0 resection: 91.1% PPPD, 90.4% PD) and lymph node status (mean positive lymph node status: 58.5% PPPD, 66.5% PD) [5]. The PPPD appears to be just as radical compared with the classic PD procedure.

The reported incidence of DGE ranges from 5 to 70% because of variations in the definition of this entity [7, 8]. The classic PD procedure is deemed to be superior to pylorus-preserving PD regarding DGE. In this context, pylorus-resecting PD has become popular especially in Japan with the aim to prevent DGE by removal of the pylorus but preservation of the stomach. In contrast to positive results from early studies, latest high-quality randomized controlled trial (RCT) data show that pylorus resection does not reduce DGE compared to the pylorus-preserving operation [9]. Nonsuperiority of pylorus resection was also confirmed in current meta-analysis on this topic [10]. However, these studies were relatively small and heterogeneous; therefore, additional well-designed trials are still necessary to delineate the differences between these surgical options.

Thus, the classical PD resection and the pylorus-preserving technique are equally effective, with comparable and acceptable perioperative risks. Both procedures are equally effective for treatment of pancreatic cancer.

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5 Stomach-Preserving Pancreaticoduodenectomy

Min Wang and Ren-Yi Qin

5.1 Introduction

Whipple first reported pancreaticoduodenectomy with resection of the distal stomach in 1941 [1]. Soon afterwards, the first pylorus-preserving pancreaticoduodenectomy (PPPD) (Fig. 5.1) was performed in 1944 [2]. Classic Whipple's and PPPD are now the most widely used surgical procedures for pancreatic head and periampullary tumors [3]. Whereas the classic Whipple's procedure includes resection of the pancreatic head, duodenum, gallbladder, distal common bile duct, partial jejunum, and distal stomach, in PPPD, the proximal duodenum is transected 3–4 cm distal to the pyloric ring [3]. Delayed gastric emptying (DGE) is one of the most common postoperative complications following PD. The mechanisms underlying DGE remain unclear but may result from the extent of gastric resection, loss of the pylorus, interrupted gastrointestinal neural connections, diabetes, local ischemia, or loss of gastrointestinal hormonal production causing gastroparesis [4]. DGE after PPPD has been attributed to devascularization and denervation of the pylorus with subsequent pylorospasm. Although DGE is not life-threatening, it leads to prolonged hospital stays, which increases hospital costs and decreases patients' quality of life. Decreasing the occurrence of DGE is important in patients undergoing any type of PD [5].

Subtotal stomach-preserving pancreaticoduodenectomy (SSPPD) (Fig. 5.1) was developed to prevent DGE, and several clinical studies have demonstrated that the procedure leads to a reduction in DGE. SSPPD was initially described during the 1990s in Japan [6] and involves dividing the stomach 2–3 cm proximal to the pyloric ring and resecting the entire duodenum distal to the site of transection, thereby removing the pylorus but retaining much of the body of the stomach, which differs from the classic Whipple's procedure [7]. Two different gastrojejunostomies can

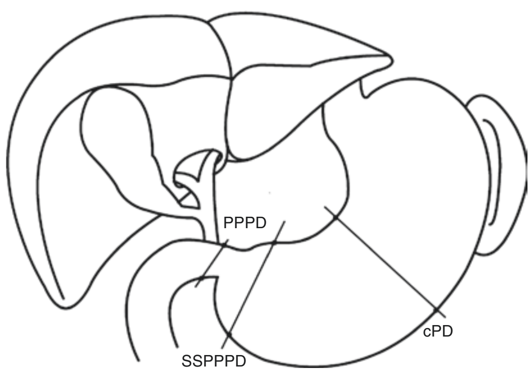

Fig. 5.1 Schematic illustration of the three types of pancreaticoduodenectomy (PD): conventional PD (cPD), SSPPD, and PPPD. In SSPPD, the stomach is resected 2–3 cm proximal to the pyloric ring. cPD, subtotal stomach-preserving pancreaticoduodenectomy; PPPD, pylorus-preserving pancreaticoduodenectomy

M. Wang · R.-Y. Qin (✉)
Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China
e-mail: ryqin@tjh.tjmu.edu.cn

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then be performed: end-to-side and side-to-side. The gastric stump is anastomosed to the jejunal loop end-to-side, whereas with side-to-side, the jejunal loop is anastomosed to the greater curvature of the stomach 5–10 cm proximal to the closed gastric stump, and the anastomosis involves only the greater curvature and not the anterior or posterior stomach wall [8].

Several studies have compared SSPPD with PPPD. Kawai et al. in a prospective, randomized, controlled trial of pylorus-resecting versus pylorus-preserving pancreaticoduodenectomy showed that pyloric ring resection decreased the incidence of DGE in patients undergoing pancreaticoduodenectomy [9]. However, another randomized, controlled trial showed that SSPPD was equally effective in decreasing the incidence of DGE and preserving long-term nutritional status compared with PPPD [10]. Huang et al. performed a meta-analysis and reported that patients undergoing SSPPD had a lower incidence of DGE compared with those undergoing PPPD, and that the duration of nasogastric intubation was shorter with SSPPD. Furthermore, there was a tendency towards shorter times to liquid and solid diets, as well as shorter hospital stays, although this tendency did not reach statistical significance [11].

Because SSPPD is a recent development, it is not yet widely used. SSPPD has the theoretical advantage of reducing the incidence of DGE by retaining most of the gastric body but resecting the pyloric complex [11]. Several studies suggested that SSPPD is as safe as PPPD and may be superior to PPPD regarding DGE. However, there is still a need for well-designed randomized, controlled trials comparing SSPPD and PPPD with regard to patients' quality of life and survival outcomes [5].

5.2 Case

The patient was a 55-year-old man admitted to our hospital because of upper abdominal pain for more than 3 months. His skin and sclera had been colored yellow for 2 weeks. Laboratory examinations showed increased liver function tests: total bilirubin: 192.2 μmol/L, direct bilirubin: 153.6 μmol/L, aspartate aminotransferase: 321 U/L, alanine aminotransferase: 754 U/L, alkaline phosphatase: 1093 U/L, and r-glutamyl transpeptidase: 3328 U/L. Levels of the tumor marker CA19-9 were increased at 572 kU/L; CA125 levels were also increased at 83 kU/L, and all other tumor marker levels were within normal reference limits.

Abdominal ultrasonography and abdominal computed tomography showed a mass in the ampullary region, and dilation of the common bile duct and pancreatic duct (Fig. 5.2 a, b). The same findings were found in abdominal magnetic resonance images (Fig. 5.3). Ampullary adenocarcinoma was confirmed by duodenal endoscopy and biopsy.

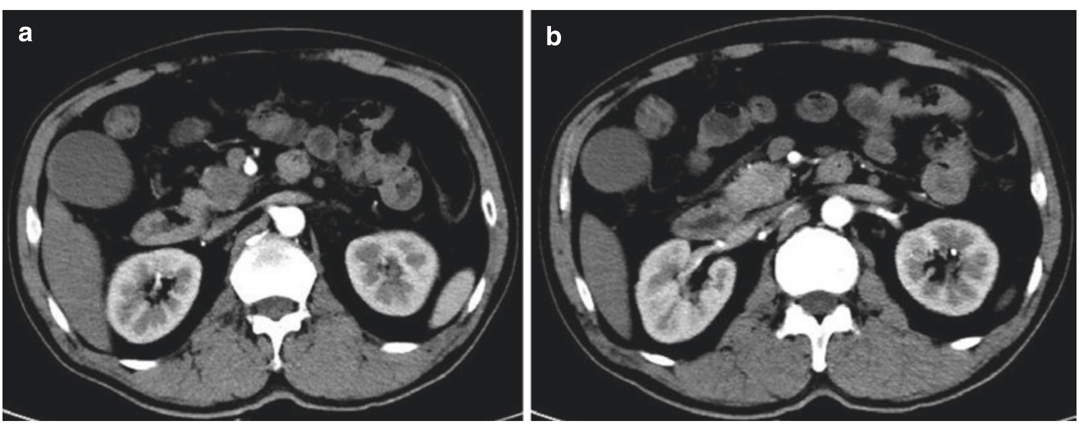

Fig. 5.2 (**a**, **b**) CT image showed a mass in the ampullar region

Fig. 5.3 MRI image also showed a mass in the ampullar region

Based on these findings, a diagnosis of ampullary adenocarcinoma was made, and SSPPD was performed.

Informed consent was obtained from all participating patients, and the ethics committee of Tongji Hospital, Huazhong University of Science and Technology, approved this study.

5.3 Details of the Surgical Procedure

The key steps in the surgery included the approach, lymphadenectomy, transecting the pancreas and jejunum, dividing the uncinate process, and pancreaticojejunal anastomosis, hepaticojejunostomy, or cholecystojejunostomy as described in the classic Whipple's and PPPD procedures.

SSPPD involved dividing the stomach 2 cm proximal to the pyloric ring and resecting the entire duodenum distal to the transection site, as well as excising the gallbladder, distal common bile duct, and pancreatic head. The pyloric ring was carefully identified and clearly isolated. Then, a dividing line was marked using an electrotome. All of the blood vessels to the stomach were carefully preserved. Following the marked line, the gastric antrum was divided using a surgical stapler and cutter.

We chose side-to-side gastrojejunostomy for this patient. The stomach stump was closed, and the jejunal loop was anastomosed to the greater curvature 5–10 cm proximal to the closed gastric stump. The anastomosis involved only the greater curvature and not the anterior or posterior stomach wall. The gastrojejunostomy was performed with a two-layer anastomosis using the Gambee technique with 4-0 monofilament absorbable sutures followed by antecolic reconstruction. The opening of the anastomosis was approximately 5 cm in length, and a nasogastric tube was maintained, intraoperatively. The nasogastric tube was removed when the drainage volume decreased to <400 mL on postoperative day 1. A clear liquid diet was introduced on postoperative day 1, and solid food intake was introduced on postoperative day 3. Octreotide (Sandostatin®, Novartis Pharmaceuticals Corp., East Hanover, NJ) and proton-pump inhibitors were used perioperatively.

5.4 Pathology and Prognosis

The patient's pathological diagnosis was well to moderately differentiated duodenal papillary adenocarcinoma. The mass measured 2 cm in diameter and had not invaded the plexus, portal, or venous systems. Neither did the tumor involve the pancreatic head, cut margin of the common bile duct, pancreatic margin, stomach, or duodenum. Twelve lymph nodes, including three peripancreatic lymph nodes, three superior mesenteric artery lymph nodes, one No.16 lymph node, and five No.12 lymph nodes were totally excised, and none were positive.

The patient recovered uneventfully, was discharged 12 days after the operation, and experienced no DGE. Six months after surgery, follow-up computed tomography and tumor marker examinations revealed no recurrence.

5.5 Comment

DGE is one of the most common complications after pancreaticoduodenectomy and has been reported to occur in 1–6% of patients [4]. SSPPD was introduced more recently as an alternative to PPPD to maintain the pooling ability of the stomach and to reduce the incidence of DGE by retaining most of the gastric body but resecting the pyloric complex [11]. Most studies report that SSPPD is associated with a lower incidence of DGE compared with PPPD. However, considering the studies' designs, the results might not have completely elucidated the correlation between DGE and other perioperative complications. Therefore, standardized, randomized, prospective studies would help determine whether DGE is associated with other risk factors and postoperative complications, or whether this complication results from a specific surgical technique [5].

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6 Pancreatoduodenectomy with Venous Reconstruction

Ji-shu Wei and Yi Miao

6.1 Introduction

Even in the ear of neoadjuvant therapy being in the spotlight, surgical resection still remains the only hope for cure of pancreatic cancer, while other treatment options were considered with the surgery as the mainstay. The most important goal of surgery was to achieve an R0 resection because R0 resection can provide unique benefit to patient. *En bloc* resection with combined vessels is an important technique to achieve an R0 resection and could attain reportedly an R0 resection rate of over 90% [1]. Due to the close position to venous axis, adenocarcinoma of the pancreatic head is easily with infiltration of portal vein (PV) and superior mesenteric vein (SMV). Therefore, it is inevitable for pancreatic surgeons to encounter PV and SMV resection and reconstruction (during the resection of pancreatic cancer), which was challenging decades ago. In 1951, Moore et al. [2] reported the first case of a pancreatoduodenectomy (PD) with superior mesenteric vein resection and reconstruction. In 1973, Fortner [3] reported the first case of a "regional pancreatectomy" involving portal vein resection. However, these procedures were later abandoned due to the high morbidity and mortality in the first decades after their introduction, with the improvement of surgical techniques, vascular suture material and critical care support, the morbidity, mortality, and survival outcome after PD are comparable in patients with and without venous resection.

Nowadays, PD with venous resection and reconstruction has become the standard procedure for patients with infiltration of the portomesenteric venous axis at high-volume center, accounting approximately 20–40% of all cases undergoing PD. It can be concluded from published data that PD combined with venous resection is a safe and effective surgical approach for pancreatic head cancer in high-volume centers, some of which even without vascular surgeon's assistance.

Due to the existence of abnormal confluence of the inferior mesenteric vein and the left gastric vein, there are many anatomical abnormalities in the portal venous system. Nevertheless, venous resection during the PD could be mainly categorized into **two major types**: partial resection of venous wall (Fig. 6.1a) and segmental venous resection. According to the resection position, the segmental resection could be further divided **into four subtypes** (Fig. 6.2b–e): (1) simple portal vein resection; (2) simple SMV trunk resection; (3) T-shaped resection of confluence SMV/SV/PV; and (4) resection of trunk and branch SMV.

It is of importance to acquire a tension-free anastomosis during venous reconstruction, which demands careful/cautious preoperative and intraoperative assessment. After adequate mobilization

J.-s. Wei (✉) · Y. Miao
The First Affiliated Hospital of Nanjing Medical University, Nanjing, China
e-mail: weijishu@njmu.edu.cn

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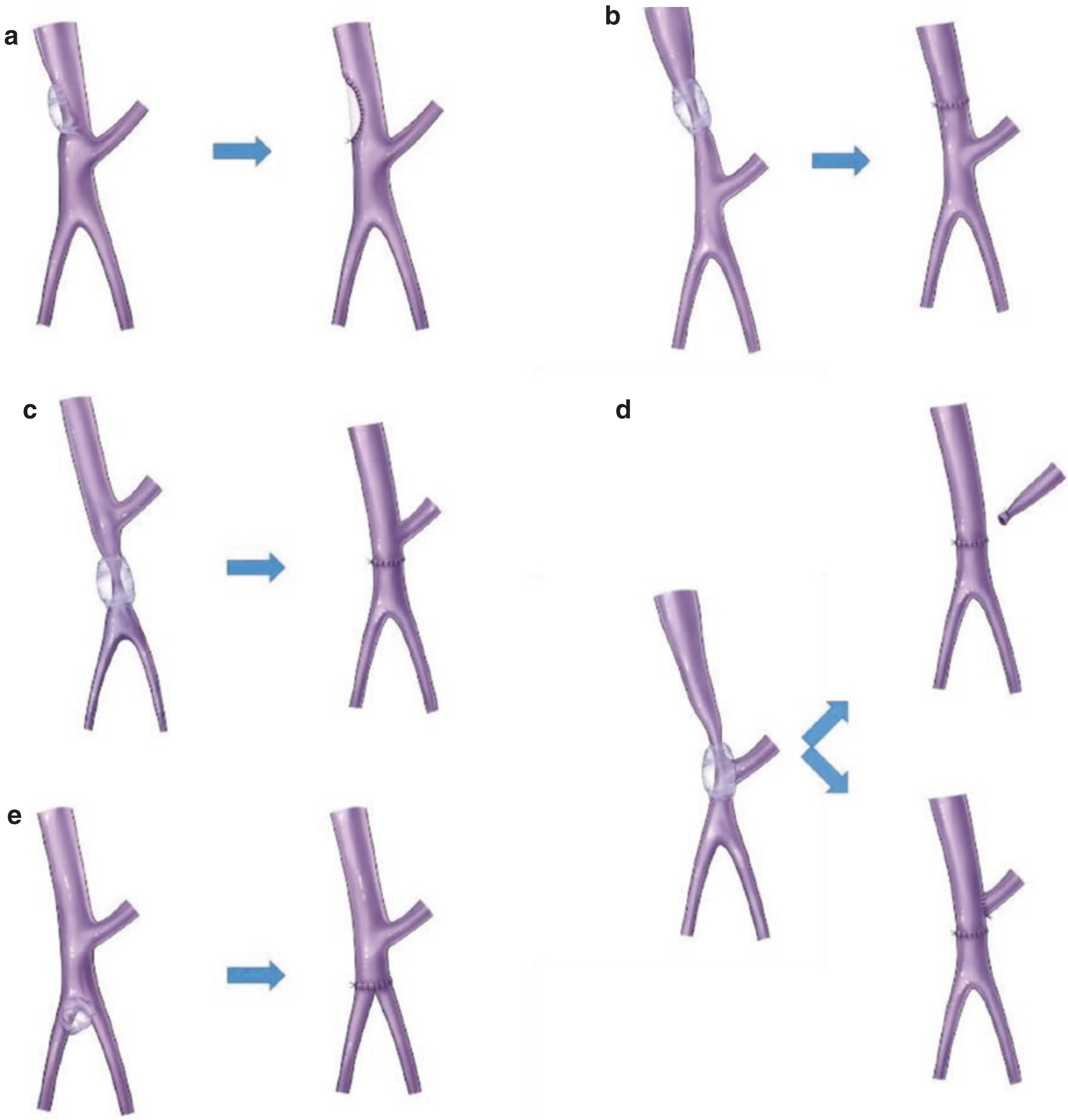

Fig. 6.1 Types of venous resection and reconstruction during PD. (**a**) Partial resection of venous wall; (**b**) simple portal vein resection; (**c**) simple SMV trunk resection; (**d**) T-shaped resection of confluence SMV/SV/PV; (**e**) resection of trunk and branch SMV

of liver, bowel, and SMV, especially the full dissociation between the SMV and the SMA, a tension-free anastomosis could be obtained when the resected vein was less than 3 cm. If the resected vein was longer than 3 cm, an artificial or an autologous vein is usually needed to avoid a tension anastomosis. It is also reported that after adequate mobilization of liver, portal vein, superior mesenteric vein, and mesentery of the small intestine, a tension-free end-to-end anastomosis could be achieved without using an interposition graft when the resected vein was less than 5 cm. In addition, it is also important to avoid local stenosis and vascular distortion after anastomosis, which are important causes of venous thrombosis.

Depending on if an interposition graft is needed, venous reconstruction could be divided into 2 types: (1) requiring interposition graft, which included autologous vessel graft and synthetic vascular graft; (2) no requiring interposi-

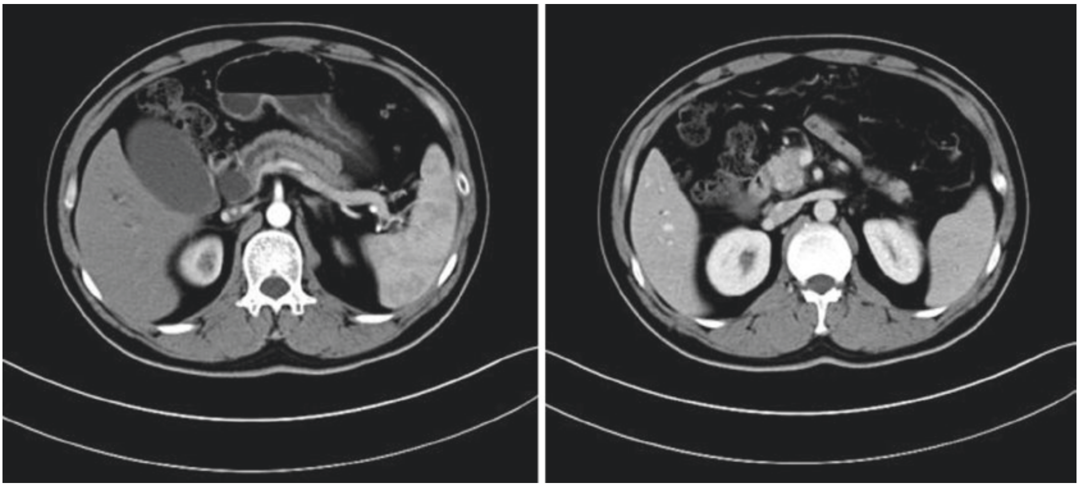

Fig. 6.2 CT images showed a mass in the head of the pancreas with infiltration of the portal vein

tion graft, which included (i) primary end-to-end anastomosis, (ii) venorrhaphy. Currently the application of synthetic vascular graft remains controversial, and autologous vein was used in most situations, such as the great saphenous vein, internal jugular vein, and renal vein. The most commonly reported reconstruction methods were primary end-to-end portal vein and/or SMV anastomosis, except the rarely reported end-to-side SMV-inferior vena cava anastomosis. The suture method of venous anastomosis can be divided into continuous suture, interrupted suture, and mixed suture. The outcomes of these suturing methods are not different, and the choice is up to the comfortable level of the surgeon.

In next section, we presented a case of Whipple procedure combined with segmental SMV resection and reconstruction with primary end-to-end anastomosis.

6.1.1 Case

The patient was a 39-year-old man admitted to our center due to a 3-month history of abdominal pain and a 10-day history of jaundice.

Laboratory examinations showed an elevation of liver function tests: total bilirubin (TB) 124.3 μmol/L, direct bilirubin (DB) 73.6 μmol/L, alanine aminotransferase (ALT) 534.6 U/L, aspartate aminotransferase (AST) 259.1 U/L, alkaline phosphatase (ALP) 366 U/L, and r-glutamyl transpeptidase (r-GTP) 1126 U/L. Serum CA19-9 was increased 138.6 kU/L, and others were normal.

The abdominal computed tomography (CT) confirmed the mass in the head of the pancreas, and a dilation of common bile duct and pancreatic main duct (Fig. 6.2). The superior mesenteric vein was involved. Pancreatic head adenocarcinoma was considered.

Based on these findings, a diagnosis of pancreatic head adenocarcinoma with venous invasion was made, and artery first approach PD with venous reconstruction and extended lymphadenectomy was performed.

Informed consent was obtained from all participating patients, and the ethics committee of the First Affiliated Hospital of Nanjing Medical University approved this study.

6.2 Details of Procedure

The Whipple surgery team of the First Affiliated Hospital of Nanjing Medical University usually has 8 medical staffs, including 2 anesthesiologists, 1 scrub nurse, and 1 circulating nurse, the 4-surgeon team consists of 1 professor of surgery, 1 senior surgeon, 1 resident, and 1 intern.

After the successful induction of general endotracheal anesthesia, the abdomen, perineum were then both prepared and draped in routine method by using iodophor. A Foley catheter was inserted in sterile fashion into the bladder, and urine drainage bag was hanged on the right side of operation bed.

A vertical midline incision from the xiphoid to 3 cm below the umbilicus was made byskin knife, and the abdomen was entered by electrocautery. After entering the abdomen, a thorough exploration of abdominal cavity was performed. The sequence of exploration is pelvis, the various peritoneal surfaces, liver, omentum, and the mesentery. There were no evidences of metastasis or implants, and then a lap-protector and abdominal wall retractors were placed for good exposure.

6.2.1 Extensive Kocher Maneuver

Mostly, extirpative phase started with the extensive Kocher maneuver, elevating the head of the pancreas and the duodenum up out of the retroperitoneum. Lymphadenectomy was performed if the interaortocaval lymph nodes enlarge (group 16), and the harvested lymph nodes were sent for frozen section. After dissecting the right mesocolon mesentery from the hepatorenal ligament, the Kocher maneuver could be extended well beyond the IVC, aortocaval window, and reached the right side of root of CA and SMA (Fig. 6.3).

The second process was to dissect the transverse mesocolon from the omentum majus. Normally, the surgical assistant hold the stomach and the surgeon hold the transverse colon, dissect along the plane between the colon mesentery and omentum. The posterior wall of stomach and the anterior of pancreas will be well exposed.

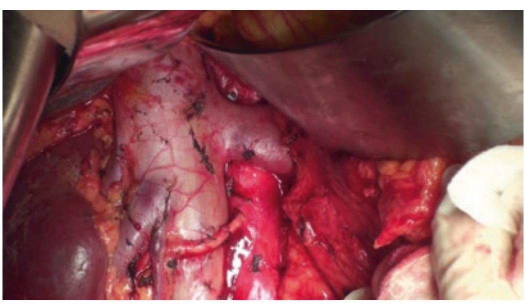

Fig. 6.3 The Kocher maneuver

Carefully dissect the Henle trunk along with the middle colon vein, ligate the Henle trunk with 2/0 silk, and divide. Along the plane between the uncinate process of the pancreas and the transverse mesocolon, identify and dissect out the proximal of the superior mesenteric vein. Carefully identify and dissect out the superior mesenteric vein inferior to the pancreatic neck, then elevate the inferior border of the pancreatic neck, and were able to complete the dissection of the tissues around the pancreatic neck at the level of the SMV-portal vein confluence. Because the tumor invades the SMV segment, it is unable to completely dissect the pancreatic head and uncinate process from the SMV wall, en bloc resection by removing the SMV combined with the whole specimen were performed.

After confirming the resectability carefully, the operation moved to the resection phase. The sequence of standard Whipple procedure combined with SMV resection at our center is dividing doudenum, resecting gallbladder, dividing hepatic duct, dividing pancreas neck, dividing jejunum and SMV/PV resection.

6.2.2 Transection of the Jejunum

Take the adhesions posterior to the distal stomach off the anterior aspect of the pancreas. Identify the right gastroepiploic artery (downstream GDA) as it tethered the stomach, ligate, and divide this vascular bundle with 2-0 silk in its retained, caudal aspect. The right gastric artery and vein were ligated with 2-0 silk and divided. The duodenum was dissected off from the anterior aspect of the pancreatic head and neck approximately 3 cm below the pylorus. Two Kocher forceps clamped the dissected distal duodenum and divided by scalpel. Then put the stomach in the left side of abdominal cavity with one Kocher clamping the duodenal stump.

6.2.3 Resection of the Gallbladder

After dividing the jejunum, resect the gallbladder using the electrocautery and the fundus up

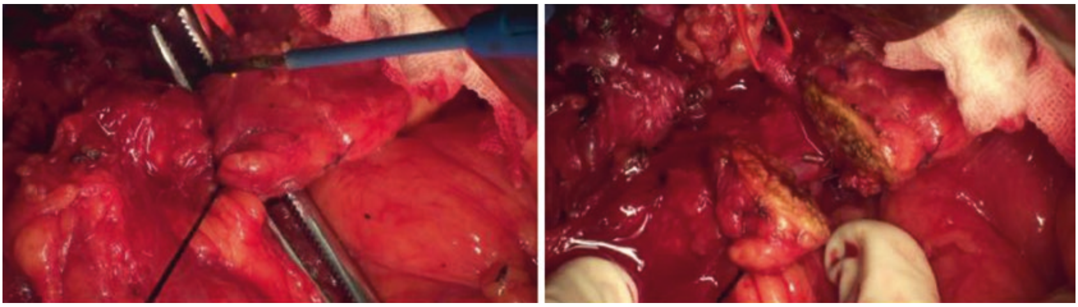

Fig. 6.4 To ligate and transect the neck of pancreas

technique. The cystic duct was dissected out and identified first, and then the cystic artery was dissected. These two tracts were identified and divided only after the hepatic duct and right hepatic artery was confirmed. The cystic artery was ligated with 2-0 silk and divided. The gallbladder was dissected from the gallbladder fossa by electrocautery. Dissect out the extrahepatic biliary tree from the hepatoduodenal ligament. Identify the hepatic duct, elevated it off the portal vein and right hepatic artery. Ligate the hepatic duct by 1-0 silk two times spacing about 1cm, and divide the duct with the scissor between the 2 ligated site. The proximal bile duct was controlled with a silk ligation, thereby preventing the intraperitoneal contamination from ongoing bile drainage. Grasp the distal bile duct with the ligation silk stich, elevate it ventrally, and then work on the anterior aspect of the portal vein, dissecting this behind the bile duct and behind the superior aspect of the pancreatic neck. At this point, the gastroduodenal artery was identified and test-clamped. After confirming the palpable pulses in both the common hepatic artery and the proper hepatic artery, the gastroduodenal artery was then doubly tied by 2-0 silk, suture-ligated on the cephalad aspect, and divided by scalpel.

6.2.4 Transection of the Pancreas

Curved clamps were used to pass between the inferior aspect of the pancreatic neck and the plane anterior to PV-SMV; 1-0 silk was used to ligate the head side of the pancreas neck tightly in case of hemorrhage from the resected side of pancreas stump after dividing the pancreas neck. Four stay sutures were placed, two along the inferior aspect of the pancreatic neck, and two along the superior aspect of the pancreatic neck by 4-0 vicryl. A forcep was then used as the chopping board under the pancreatic neck, and the neck of pancreas was divided with electrocautery without incident in the vertical plane of the SMV-portal vein axis. Hemostasis was obtained by using the electrocautery and suture ligatures by 5/0 proline (Fig. 6.4).

6.2.5 Transection of Jejunum

After transecting the pancreas, move to the ligament of Treitz and take down the ligament using the Harmonic. The proximal jejunum was divided about 20 cm distal to the Treitz ligament using GIA stapler. The short jejunal vessels to the proximal-most jejunum were taken over clamps and 4-0 silk ties. The retained jejunum had its stapled end ironed by electrocautery. The duodenojejunal junction was then mobilized behind the mesenteric vessels to the patient's right side, thereby allowing us to work carefully to separate the specimen from the SMA combined SMV resection.

6.2.6 Vein Resection and Reconstruction

Hold the second segment of duodenum with sponge clamps and pull the Whipple specimen to the right side of patient. Dissect carefully the tissue between the SMV and SMA; normally there are no artery branches form the SMA. Then dissect the right side of the SMA through the tissue, which was sometimes referred to as the mesopancreas. The IPDA was tied by 2/0 silk and divided. The first jejunum artery was preserved when possible. Skeletonize the SMA routinely on its right side, and no tissue is attached to the right lateral aspect of the SMA. When this step was completed, the Whipple specimen was found bound to the SMV. Divide carefully the superior mesenteric vein till the invaded section by the tumor.

Clamp the invaded SMV trunk with two Baby-Satinsky Anastomosis (Vena Cava) Clamps. The two clamps were 0.5 cm apart from each side of predetermined resection line. Divide the SMV using fine tissue scissor and remove the Whipple specimen. Then put the two clamps together to assess the tension and if a primary end-to-end anastomosis was suitable. If the answer was yes, then anastomose the superior mesenteric vein with 5-0 monofilament proline. The first stitch was in a “tunica externa-tunica intima-tunica intima-tunica externa”endothelium-endothelium-adventitia” at the right edge of the vein. Then the anterior venous wall was sutured first and was followed by the anterior venous wall by running suture with a distance of 1 mm between the stiches. Before tying the last knot, loose the distal clamp first and tie the knot with blood flowing. Next, loosen the Baby-Satinsky clamps, and check that there was no bleeding, stenosis of the superior vein, and intestinal congestion (Fig. 6.5). Depending on the length of resected vein, when the tension was too high, an interposed graft may be necessary. Record how long the blood flow to the liver was stopped, and make sure it was shorter than 15 min. In the present case, the anastomsis time was 9 min. Heparin was not routinely used for anticoagulation before portal vein or SMV resection and reconstruction.

So far, the tumor was removed en bloc with head of the pancreas, duodenum, and the invaded section of the superior vein. Mark the cutting edges and send the resected specimens for pathology.

6.2.7 Pancreaticojejunostomy

Gastrointestinal reconstruction was performed with Child method and began with an end-to-side pancreaticojejunostomy. Mobilize the pancreatic remnant for approximately 2 cm. Identify the main pancreatic duct. If the main pancreatic duct was smaller than 3 mm, insert an internal pancretic stent and fix it with purse-string suture. Then lift the transverse colon and make an opening at the avascular area to the right of the middle colic vessels in the transverse mesocolon. Bring the retained jejunum up through the small opening in the transverse mesocolon. At around 4 cm distal to the jejunal end, make an incision equal to the diameter of the pancreatic stump on the jujunal wall opposite to the jejunal mesentery. The pancreaticojejunostomy was then performed with one-layer interrupted technique with 3-0 Vicryl. The anastomosis began with the posterior layer and followed by the anterior layer.

Sutures in the posterior layer are placed through the pancreas from the cutting face to posterior pancras capsule then through the full-layer jejunum

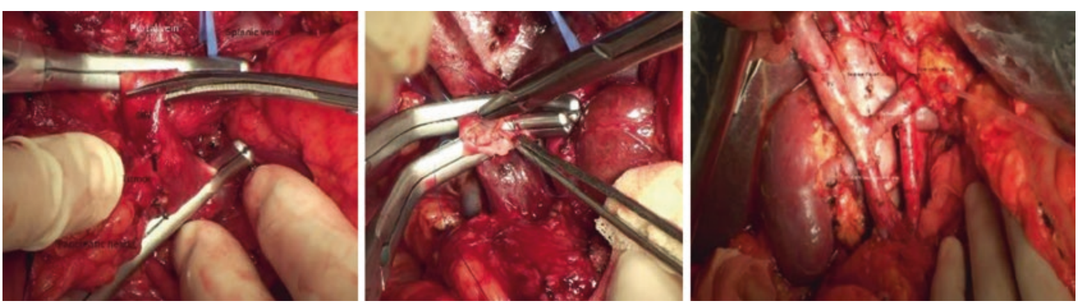

Fig. 6.5 To resect and reconstruct the invaded SMV

(serosa to mucosa). The entry point of the suture at the cutting face of the pancreas should be close to the main pancreatic duct (but not injuring the main pancreatic duct), and the exit point of the suture in posterior pancreas capsule should be at least 1 cm away from the edge of the remnant, make a **wide** bite of the pancreas. Sutures placed in the posterior layer were not tied at first but instead are secured in mosquito clamp at first and were tied father all sutures have been placed and secured.

Sutures in the anterior layer are placed through the pancreas from posterior pancras capsule to the cutting face then through the full-layer jejunum (mucosa to serosa). These sutures were tied one by one with the knots on the outside (Fig. 6.6). These stiches are placed **sparsely** with a distance between adjacent stiches around 1 cm. futures were tied **loosely** with pancreas tissue and jejunal wall touching each other and knots on the inside.

6.2.8 Hepaticojejunostomy

Approximately 8 cm distal to the pancreaticojejunostomy, perform a standard biliary-enteric reconstruction as an end-to-side hepaticojejunostomy. Trim the common hepatic duct and cut an opening in the jejunum opposite to the jejunal mesentary. The length of the opening corresponds to the size of the common hepatic duct. Then perform the hepaticojejunostomy using single-layer 4-0 Vicryl with running sutures. Suture the posterior wall first and the anterior wall second. The anastomosis was checked watertight and without undue tension (Fig. 6.7).

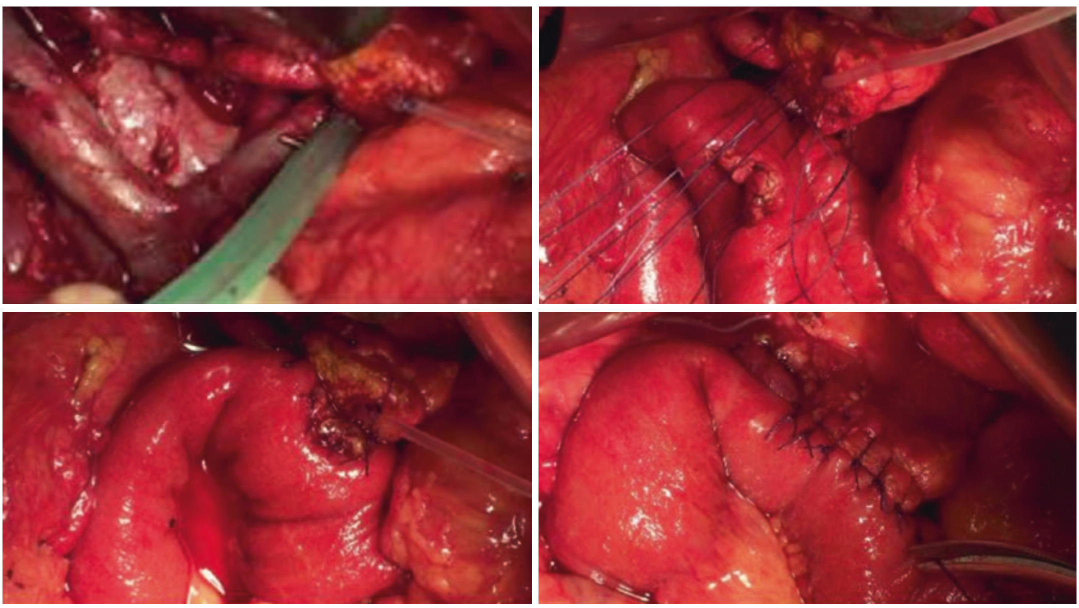

Fig. 6.6 To perform the pancreaticojejunostomy

Fig. 6.7 To perform the hepaticojejunostomy

6.2.9 Duodeneojejunostomy

Approximately 50 cm distal to the hepaticojejunostomy, perform an antecolic side-to-side isoperistaltic end-to-side duodenojejunostomy. Take out the stomach from the left side of the abdominal cavity and take the Kocher clamp off the duodenal stump, leaving the edge of the stump being compressed to be 3 mm in thickness. Immediately electrocoagulate the compressed edge of the stump by electrocautery, so that the serosa, muscularis, submucosa, and mucosa of the duodenum were merged to be one single layer. Separate the anterior and posterior walls of the duodenum using tissue forceps. Then cut a 3 cm longitudinal incision in the jejunum opposite to the mesentery. The anastomosis was done in a continuous one-layer fashion with 4-0 Vicryl. The bites of the intestinal wall were 3 mm and between the stiches were also 3 mm (Fig. 6.8). The anastomosis palpated to be patent and normal. Suture the opening in the transverse mesocolon to the jejunum.

6.2.10 Close of Abdomen

At this point, check for hemostasis thoroughly throughout the operative field, then irrigate the abdominal cavity with warm saline. Then place two flat drains through separate stab incisions in the right flank with one drain posterior to the pancreaticojejunostomy and the other one anterior to the pancreaticojejunostomy. The abdomen abdominal fascia was then closed in running fashion using 0-PDS-II, taking 1 cm bites of the fascia, and having each stitch be approximately 1 cm apart. The subcutaneous tissue was irrigated with saline, and the skin was then closed with skin stapler.

6.2.11 Pathology and Prognosis

Pathological diagnosis confirmed the preoperative diagnosis with a moderately to poorly differentiated pancreatic ductal adenocarcinoma (grade II-III). The tumor was 2.5 cm in diameter with infiltration of the intrapancreatic nerve and

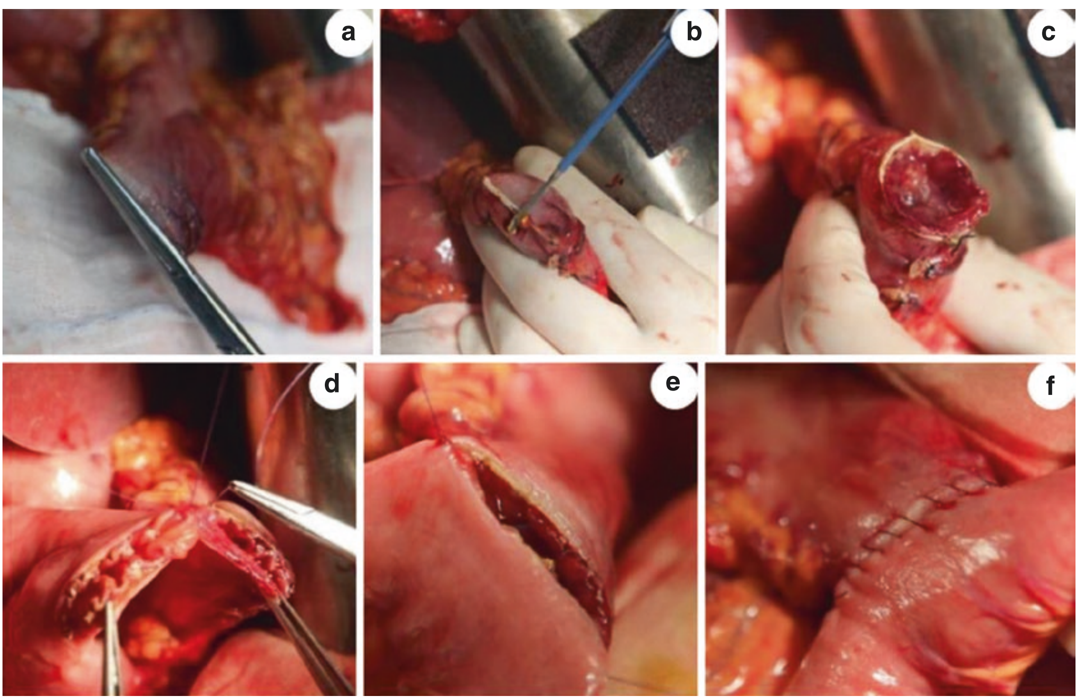

Fig. 6.8 To perform the duodeneojejunostomy

invasion of the peripancreatic fat tissue, invasion, full layer of common bile duct, the muscle layer of the duodenum, and superior mesenteric vein. Out of 17 examined lymph nodes, 3 were positive. The resection margin of common bile duct, pancreatic margin, stomach, and duodenal was tumor negative.

The patient had a smooth postoperative course and was discharged on postoperative day 13. The patient received six courses of adjuvant therapy consisting of gemcitabine and tegafur-gimeracil-oteracil potassium capsule. The reconstructed vein was without stenosis 12 months after the operation. The patient had a recurrence-free survival of 12 months and deceased 21 months after the operation. The wound was disinfected with iodophor and covered with dry dressing.

The operation time lasts 480 min, and the estimated intraoperative blood loss was 300 mL. The patient tolerated the procedure well and sent back to the ward in satisfactory condition.

6.2.12 Comment

Pancreatic duct adenocarcinoma has a dismal prognosis. While resection was the only chance to offer long-term survival, only 20% of the patients present with a resectable tumor at the time of diagnosis. Due to the aggressive tumor biology and the anatomical proximity to the portal/superior mesenteric veins, about 30% of patients were diagnosed with locally advanced disease. The en bloc resection of the for locally advanced pancreatic cancer with SMV, PV, and/or splenic vein (SV) might shed light on this group of patients.

Early studies showed when compared to standard pancreatectomy pancreatic resection with PV-SMV resection is associated with increased postoperative mortality, higher rates of nonradical surgery, and worse survival [4, 5]. However, more recent studies showed that pancreatectomy with SMV-PV resection has similar overall morbidity and mortality rates [6, 7]. Previous studies showed type of venous reconstruction did not significantly affect short-term morbidity and long-term survival, therefore it is recommended to employ appropriate complex type of reconstruction as long as a radical resection can be achieved [8, 9]. As all the previous studies were of retrospective design, well-designed, randomized comparative studies define the true role of pancreaticoduodenectomy with venous reconstruction and the best type of venous reconstruction.

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Part II

Adenocarcinoma of the Pancreas: Distal Pancreatectomy

7 Distal Pancreatectomy with Splenectomy

Long Pan and Yi-Fan Wang

7.1 Introduction

The common indications of distal pancreatectomy include localized adenocarcinoma in this area, islet cell adenomas, cysts, and chronic calcific pancreatitis. With the popularization of laparoscopic technique in pancreatic surgery, there is no significant difference in the perioperative safety between minimally invasive distal pancreatectomy (MIDP) and open procedure distal pancreatectomy (ODP) [1, 2]. However, the long-term survival benefit of MIDP for pancreatic malignancy needs to be further confirmed by more research [3]. Therefore, the ODP is still a standard procedure for the resection of pancreatic adenocarcinoma located in the body and tail of pancreas.

7.2 Case

The patient was a 65-year-old woman admitted to our hospital due to left middle abdomen pain for more than 2 months. Laboratory examinations showed an elevation of the tumor marker: CA19-9 1779.0 kU/L. Liver function tests and others were normal.

The abdominal computed tomography showed a mass in the body and tail of the pancreas, and invasion of spleen artery and vein. Pancreatic adenocarcinoma was considered (Fig. 7.1a). Similar image was revealed by the abdominal magnetic resonance image (Fig. 7.1b). Informed consent was obtained from all participating patients, and the ethics committee of Sir Run Run Shaw Hospital, Zhejiang University School of Medicine, approved this study.

7.3 Details of Procedure

7.3.1 Exposure of the Pancreas

A long vertical midline incision was performed, and a thorough exploration of the abdomen, particularly with regard to the liver and the gastrohepatic ligament in the region of the celiac plexus, was made for excluding the possibility of metastasis. After the abdomen has been explored, the greater omentum was separated by sharp dissection. Subsequently, pancreas was exposed and thoroughly inspected to determine the location, size, and the extent of local invasion of the tumor.

L. Pan · Y.-F. Wang (✉)
Sir Run Run Shaw Hospital, Zhejiang University, School of Medicine Hangzhou, Hangzhou, China
e-mail: anwyf@zju.edu.cn

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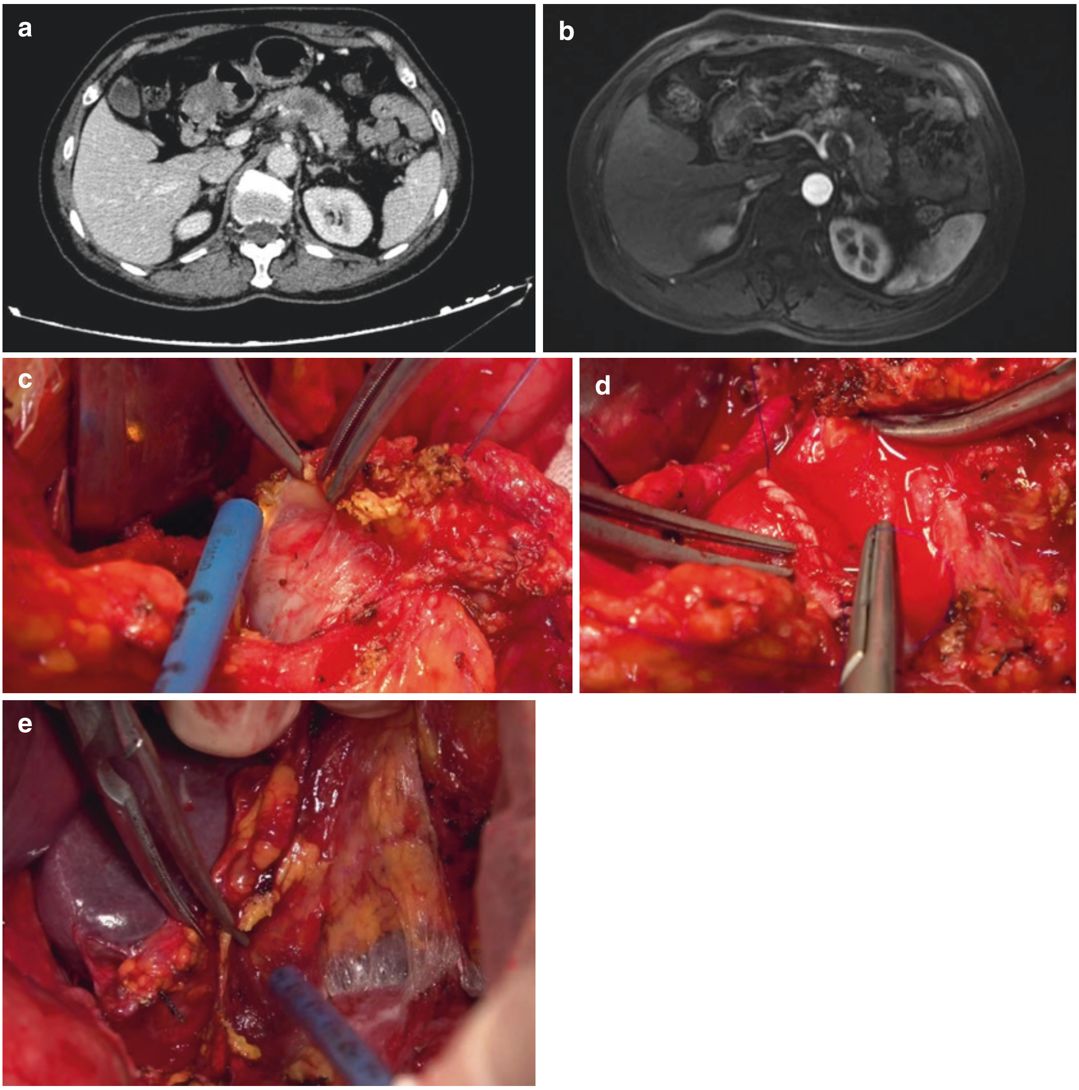

Fig. 7.1 (**a**) CT image showed a mass in the body and tail of the pancreas; (**b**) MRI image showed a mass in the body and tail of the pancreas; (**c**) the pancreas was divided; (**d**) the splenic vein was divided at the point where it connects to inferior mesenteric vein and was sutured; (**e**) the spleen was lifted and pulled medially with the surgeon's hand. The spleen and the body and tail of the pancreas were resected

7.3.2 Isolation and Division of the Body of the Pancreas

The body of pancreas was dissected and was freed along the anterior wall of superior mesenteric vein, and the pancreas was divided and secured with staples using a linear stapler (Fig. 7.1c). The pancreatic duct was identified and closed with nonabsorbable monofilament sutures alone. The cut end of the pancreas was examined and closed with interrupted overlapping U-shaped sutures.

7.3.3 Combined Resection of the Distal Pancreas with Spleen

Splenic artery was divided near its point of origin, while splenic vein was cleared and separated from the posterior surface of the pancreas, and was divided at the point where it connects to inferior mesenteric vein and was sutured (Fig. 7.1d). Then, the vessel was ligated before the junction. Divide the perisplenic ligaments, and separate and coagulate the short gastric vessels. The spleen was lifted and pulled medially with the surgeon's hand. The spleen and the distal pancreas were resected (Fig. 7.1e).

7.4 Pathology and Prognosis

Pathologic diagnosis was poor to moderately differentiated pancreatic duct adenocarcinoma (grade II), invading the nerve, but the cutting margin was negative. 21 lymph nodes including paraneoplastic lymph nodes (1+/5), peripancreatic lymph nodes (0/2), No.7, 8, 9 lymph nodes (0/4), No.16 lymph node (0/8), and phrenic horn lymph nodes (0/2) were dissected totally, one of which was positive.

The patient recovered uneventfully and was discharged 7 days after the operation. 6 months after surgery, follow-up CT and tumor marker revealed no recurrence.

7.5 Comment

Although ODP is a conventional procedure in pancreatic surgery, the following points are worth noting. Firstly, there are two procedures in ODP. The surgical procedure from the proximal to the distal (from the right to left) may be safer than from the distal to the proximal due to better exposures after the resection of the pancreas. Secondly, in respect of the closure of pancreatic stump, the rate of pancreatic fistula is still high although lots of methods were created and applied. The pancreatic duct should be identified and closed properly. 8-shaped sutures may be a good method that can be selected. Thirdly, in order to prevent major bleeding caused by pancreatic leakage, the greater omentum or transverse mesorectum can be used to cover the spleen vessel in the posterior part of the pancreatic stump.

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8 Distal Pancreatectomy with Splenic Preservation

Shi-Lei Liu and Wei Gong

8.1 Introduction

Distal pancreatectomy (resection of the pancreatic body and tail) can be operated with or without splenic preservation. The significance of preserving the spleen has been shown for lesions confined to the pancreas or in situ lesions. Splenic preservation offers various advantages as: fewer postoperative complications [1], shorter length of hospitalization, delayed onset of diabetes, and reduction of the long-term risk of postsplenectomy sepsis and overwhelming postsplenectomy infection (OPSI) [2–5].

Distal pancreatectomy with splenic preservation can be accomplished in either of the two ways: the Warshaw procedure [6] which sacrifices the splenic vessels but carefully preserving the splenic collateral blood supply from the short gastric and left gastroepiploic vessels, or the Kimura procedure [7] which preserves the splenic vessels.

Many studies were carried out with the aim of analyzing the postoperative clinical outcomes of patients who underwent either of these two procedures [8–10]. The Warshaw procedure is easier to perform than Kimura procedure with a shorter operation time, less loss of blood, and higher success rate. However, the risk of splenic ischemia as well as splenectomy resulting from splenic infraction and chronic pain was greater in the Warshaw procedure. Therefore, in most situations, the Kimura procedure is more favorable in turns of patients' outcomes. However, the Kimura procedure is technically more challenging, and when it fails, the Warshaw procedure might be the choice to carry out the operation without sacrificing the spleen. Thus, it is important to maintain the blood supply from short gastric vessels and left gastroepiploic vessels when mobilizing the body and tail of the pancreas.

8.2 Case

The patient was a 51-year-old woman admitted to Xinhua hospital because of left upper quadrant dull pain. No abnormal results were found in lab workup. The abdominal computed tomography (CT) showed a mass in the tail of the pancreas (Fig. 8.1), indicating the diagnosis of pancreatic cystadenoma.

Combining with all the findings, the patient was diagnosed with pancreatic cystadenoma located in the tail of the pancreas. Therefore, we planned to perform the spleen-preserving distal pancreatectomy with preserving of the splenic artery and vein.

Informed consent was obtained from all participating patients, and the ethics committee of Xinhua Hospital approved this study.

S.-L. Liu · W. Gong (✉)
Xinhua Hospital, Shanghai Jiaotong University, Shanghai, China

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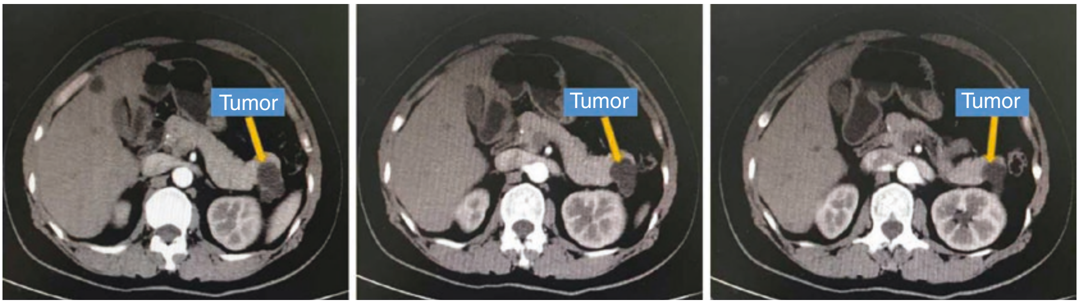

Fig. 8.1 CT image showed a mass in the tail of the pancreas

8.3 Details of Procedure (Access: An Upper Midline Incision)

8.3.1 Exploration

After exposing the abdomen, follow with a careful and systematic exploration of the abdomen. The gastrocolic ligament is dissected to approach lesser sac, so that the ventral surface of the pancreas can be exposed medially from the gastroduodenal artery to the splenic hilum. Then mobilizing the great curvature of the stomach, splenic flexure of colon, cephalad pulling of the stomach, and caudad pulling of transverse colon to expose the pancreatic bed. All the vessels along the stomach are divided and ligated with ties or harmonized scalpel.

8.3.2 Dissociation of Pancreas

To deliver the retroperitoneum from the pancreas, the peritoneum along the inferior margin of the pancreas is incised sharply or with electrocautery. Then carefully divide the splenocolic ligament to avoid damaging the splenic flexure of the colon. The hilum of the spleen is carefully divided and preserved. To assess the mobility of the mass, a thorough bimanual palpation of the pancreas is performed. Then anteromedially mobilize the pancreas from the retroperitoneum using either sharp or blunt dissection depending on tumor extension.

8.3.3 Isolation of the Splenic Vessels and Pancreas

To preserve the spleen during the procedure of distal pancreatectomy, it is key to isolate and secure the vasculature of the spleen. The splenic artery is recognized as it passes along the posterosuperior margin of the pancreatic body and tail. The splenic vein is generally found inferior and inferior to the splenic artery, where both of the vessels are isolated and preserved.

8.3.4 Dissection of the Pancreatic Body and Tail

Once the pancreatic body and tail are divided and mobilized, stay sutures are placed through the inferior and superior borders of the pancreas on both sides of the transverse section. The pancreas is dissected sharply using scalpel to avoid the artifact effects of cautery on the frozen section. Alternatively, a linear stapler can be used to divide the pancreas at the designated resection margin of the pancreatic remnant. Frozen section is mandatory for all removed specimen for pathology evaluation.

Finally, the remnant pancreatic duct is carefully closed either with figure-of-eight or U-stitch polypropylene suture proximal to the open end of the duct. Interrupted, partially overlapping mattress sutures using 3-0 polypropylene is performed to close the divided end of the c-remnant pancreas (Fig. 8.2).

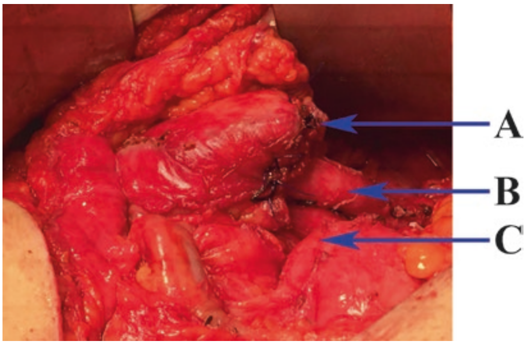

Fig. 8.2 Spleen-preserving distal pancreatectomy (Kimura procedure). A. The remnant pancreatic stunt. B. Splenic artery. C. Splenic vein

If the pancreas is divided using a linear stapler, the additional suture closure of pancreas is not necessary. However, some surgeons still prefer continuous suture rather than reinforcing the staple suture.

8.4 Pathology and Prognosis

Pathologic diagnosis was serous cystadenoma in the tail of pancreas. Immunohistochemistry results were as follow: CK7(+), CK20(−), CEA(−), WT1(−), Caretin(−), CK5/6(+), KI67(1%+), P53(−), ER(−), PR(−), VIM(−), CD34(−), CD31(−), D2–40(−), and CD10(−).

The patient successfully recovered and was discharged 8 days postoperatively. During the 3-year follow-up period, the patient had a good living quality without recurrence.

8.5 Comment

Splenectomy at distal pancreatectomy used to be thought natural due to its technical simplicity. However, the significance of splenic preservation has been widely recognized for its numerous advantages and long-term benefits, particularly for benign lesions.

The spleen can be preserved by removing the splenic artery and vein (Warshaw procedure) or with conservation of the splenic artery and vein (Kimura procedure). Both the procedures have their advantages and shortcomings in a distal pancreatectomy with splenic preservation. It is important for surgeons to master and continuously improve the technique of both procedures and choose the appropriate one according to the actual situation of patients.

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9 Modified Appleby Operation for Advanced Malignant Tumors of the Body and Tail of the Pancreas

Qi-Fan Zhang

9.1 Introduction

Malignant tumors of the body and tail of the pancreas account for about 20% of all malignant tumors of the pancreas. The early clinical symptoms of the tumors are mainly abdominal and back pain and weight loss. The symptoms and signs are not obvious or specific. At the time of consultation, the tumors often metastasize and invade the main peripancreatic vessels, which mainly include the abdominal trunk, the common hepatic artery, and the splenic artery and vein, etc. The resectability rate of these tumors is low. The 2-year survival rate was only 10%, the median survival time was 9.8 months, and the prognosis was very poor [1]. In the past, it was considered that the tumors invaded the abdominal trunk could not be resected. But with the advancement of pancreatic surgery technology, the modified Appleby operation was applied to the treatment of pancreatic body and tail malignant tumors invading the common hepatic artery and abdominal trunk, which provided patients with the opportunity of operation, improved the resection rate of R0, effectively prolonged the survival time of patients, and improved the quality of life of patients.

Q.-F. Zhang (✉)
Nanfang Hospital, Southern Medical University, Guangzhou, China

The Development Course: In 1953, when Canadian surgeon Lyon H. Appleby performed radical gastrectomy for advanced gastric cancer, he first attempted to remove the whole stomach, the tail of the pancreas, the spleen, and the abdominal trunk together with the common hepatic artery for a more thorough removal of the tumors and lymph nodes. The operation was named "Appleby Operation" [2]. In 1976, Nimura et al. first applied the operation to patients with tumors in the body and tail of the pancreas to thoroughly clean the posterior peritoneal area. In 1991, Japanese surgeon Hishinuma et al. improved the Appleby operation by preserving the whole stomach in order to improve the nutritional status and quality of life of patients after radical resection of pancreatic body and tail cancer combined with abdominal trunk resection, which is also known as the "Modified Appleby Operation" [3].

"Modified Appleby Operation" has been increasingly used in the treatment of pancreatic body and tail tumors invading the abdominal trunk. Kondo et al. formally named "Modified Appleby Operation" as "distal pancreatreatectomy with en bloc celiac axis resection, DP-CAR" [4]. With the rapid development of minimally invasive surgery, laparoscopic and robotic techniques have also been applied to DP-CAR with satisfactory results [5, 6].

The Anatomy Basis: The celiac trunk is a short and thick artery trunk Fig. 9.1, which is

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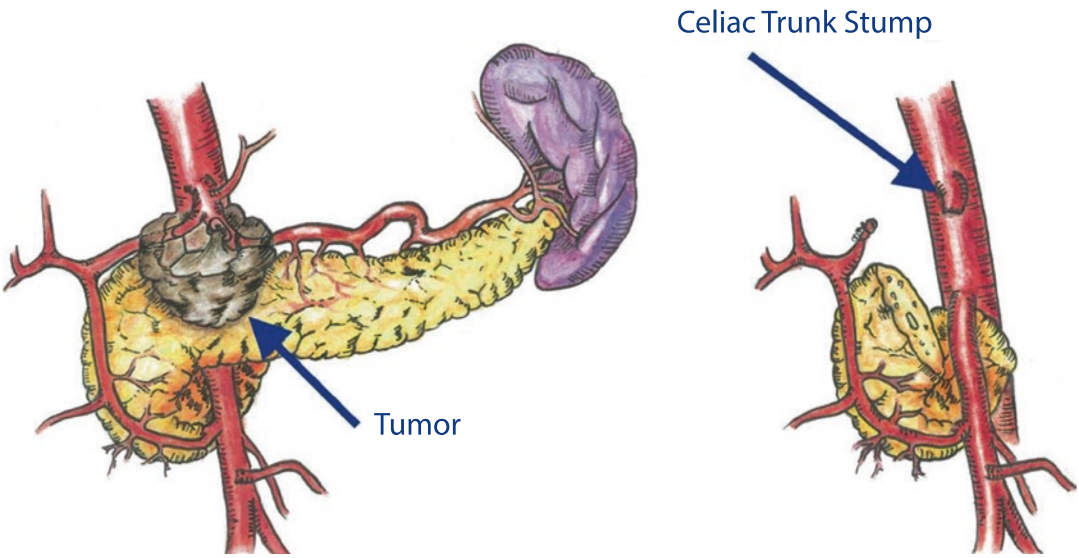

Fig. 9.1 This picture is from Recent Progress in Pancreatic Cancer

the main source of blood supply to the upper abdominal organs. It starts from the anterior wall of the abdominal aorta slightly below the aortic fissure and often travels 1–2 cm forward and downward. It has three branches: the common hepatic artery, the splenic artery, and the left gastric artery. In most cases, the common hepatic artery divides into the proper hepatic artery and the gastroduodenal artery, and the superior pancreaticoduodenal artery from the gastroduodenal artery, and the pancreaticoduodenal artery from the superior mesenteric artery form arch around the pancreatic head. After ligation of the common hepatic artery, on the premise of maintaining the normal blood flow of the superior mesenteric artery, part of the blood flow can enter the proper hepatic artery through the arch of the superior and inferior pancreaticoduodenal artery and the gastroduodenal artery, thus to ensure the blood flow of the liver; at the same time, the other part of the blood flow supplies blood to the greater and lesser curves of the stomach, respectively, through the right gastroepiploic artery from the gastroduodenal artery and the right gastric artery from the proper hepatic artery. In a few cases, however, there are anatomical variations of hepatic arteries, such as hepatic artery branches from the abdominal aorta or the superior mesenteric artery. Therefore, partial arterial blood supply of the liver can be ensured even though the celiac trunk is resected.

The Operative Indications: Because of the complexity, difficulty, and high risk of DP-CAR operation, it is very important to master the surgical indications for the success of the operation. At present, the surgical indications of DP-CAR generally recommended at home and abroad mainly include [7, 8]:

1. Tumors of the body and tail of the pancreas did not invade the head of the pancreas and had no distant metastasis.
2. The tumors did not invade the celiac trunk or common hepatic artery, but the boundary of the tumors was less than 10 mm from the root of the splenic artery.
3. The tumors invaded the celiac trunk, but the superior mesenteric artery, abdominal aorta, and gastroduodenal artery were not invaded, and the boundary of the tumors was more than 5 mm from the root of the celiac trunk.
4. The collateral circulation from superior mesenteric artery was well established.
5. Tumors invaded superior mesenteric vein or portal vein >180°, vein invasion ≤180°, but

vein contour was irregular or there was vein thrombosis, but there were suitable veins in the proximal and distal parts of the involved site to ensure the complete resection and vein reconstruction.

The Achievable Clinical Results: (1) Increasing R0 resection rate: Compared with traditional radical distal pancreatectomy (DP), the advantage of DP-CAR is that it can significantly improve R0 resection rate and postoperative survival rate, which is related to the radical cure of DP-CAR [9]. (2) Improving the quality of life of patients: Relieve intractable abdominal pain or low back pain.

9.2 Case

9.2.1 General Information of Patients

A 67-year-old woman was admitted to the hospital for "6 days of upper abdomen and lumbar back pain." Physical examination: no skin or sclera yellow staining, flat abdomen, no gastrointestinal peristalsis wave, soft abdominal muscles, no tenderness or rebound pain, deep tenderness of upper abdomen, no mass, no percussion pain in liver or kidney area, and four times per minute of intestinal sounds.

9.2.2 The Inspection Data

There were no obvious abnormalities in blood routine, liver, and kidney function. Tumor marker plants: CA19-9150.24 U/mL; CA120 17.36 U/mL; AFP 2.32 ng/mL; and CEA 3.41 ng/mL. Blood and urine amylase were normal.

9.2.3 Imaging Data

Ultrasonography of liver, gallbladder, pancreas, and spleen: tumors of the body and tail of the pancreas were 45 × 23 mm.

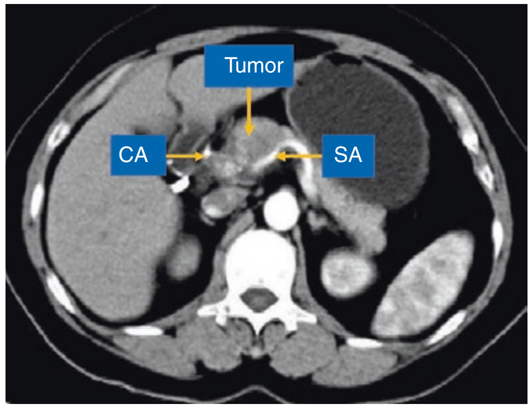

Fig. 9.2 CT image showed a mass in the head of the pancreas

Upper abdominal enhanced CT report (Fig. 9.2): (1) There was a space-occupying lesion in the body and tail of the pancreas, which appeared as a round, slightly low-density mass with mild enhancement, blurred boundary, about 28 × 23 mm in size. The pancreatic duct in the tail of the pancreas was obviously dilated. The abdominal trunk and its branches were involved, the main splenic vein was involved and stenosis, and the abdominal lymph nodes were not obviously enlarged. (2) The size and shape of liver, gallbladder, and spleen were normal, and no obvious abnormality was found.

9.2.4 Diagnosis

1. Carcinoma of the body and tail of the pancreas with invasion of abdominal trunk, common hepatic artery, and splenic vein;
2. Pancreatic duct dilatation.

9.2.5 Treatment Options

After discussion in the department, DP-CAR can be considered for radical resection of tumors. If necessary, consult a vascular surgeon to assist in vascular reconstruction on the operating table.

Informed consent was obtained from all participating patients, and the ethics committee of Nanfang Hospital approved this study.

9.3 Details of Procedure

After disinfection, take the central incision of the upper abdomen around the umbilicus, and layer by layer enter into the abdomen. No metastasis was found in pelvic or liver, and gastrocolic ligament was incised. No abnormality was found in stomach and colon. The size of pancreatic body tumors is about 4 × 4 × 4 cm. Free gastric lesser curvature and cut off the left gastric artery. During the operation, the root of the left gastric artery was invaded by tumors, and the exposure was not clear. Preserve the arch of gastric lesser curvature. The right gastric artery and vein were preserved. Free the posterior gastric wall, cut off part of the posterior gastric artery and short gastric artery, and free the greater curvature of the stomach. The right gastroepiploic vessel should be preserved, and the arch of the greater curvature of the stomach should be preserved as far as possible. The body and tail of the pancreas and pancreatic tumors were exposed. Further investigation revealed that the tumors involved the abdominal trunk, common hepatic artery, splenic vein, and portal vein of splenic vein confluence. After the superior mesenteric vein was fully exposed, the gap between the neck of the pancreas and the portal vein was separated by tunnel, which confirmed that the posterior space of the neck of the pancreas and the anterior space of the portal vein could be connected up and down. The proper hepatic artery was exposed and separated from the celiac trunk along the proper hepatic artery. Perivascular adipose lymphoid tissue was removed (Fig. 9.3). It was further confirmed that the tumor invaded the common hepatic artery (Fig. 9.4) but did not invade the origin of the gastroduodenal artery. The neck of the pancreas was cut off at about 2 cm distal to the tumor; the left main pancreatic duct was sutured (Fig. 9.5); and 6-0 prolene was used to repair portal vein defect. The superior mesenteric artery was exposed and separated upward to the rear of the tumor to confirm that the superior mesenteric artery was not invaded. The common hepatic artery was clamped for 2 min (Fig. 9.6), and the proper hepatic artery in the hepatoduodenal ligament was pulsated well. The ultrasound Doppler

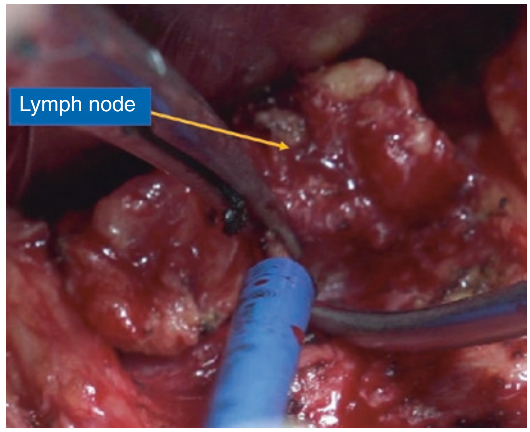

Fig. 9.3 The lymph nodes are removed

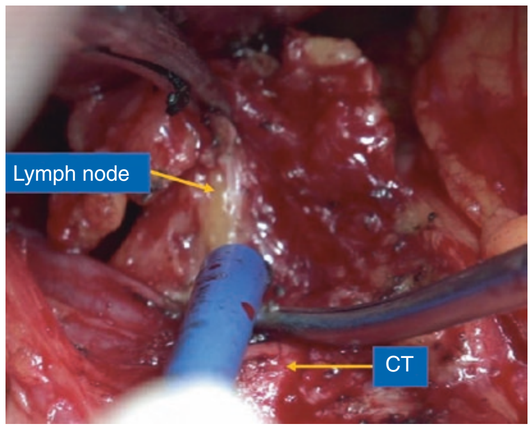

Fig. 9.4 The celiac trunk is exposed

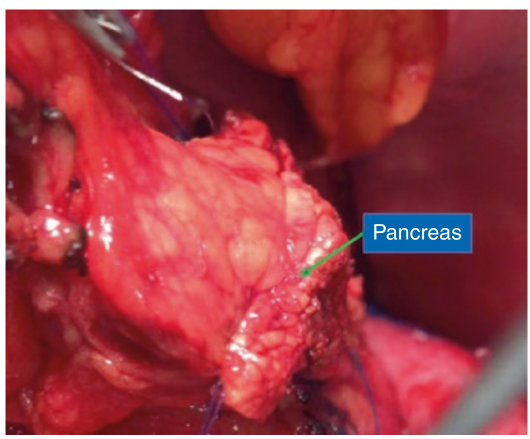

Fig. 9.5 Pancreatic head and neck stump

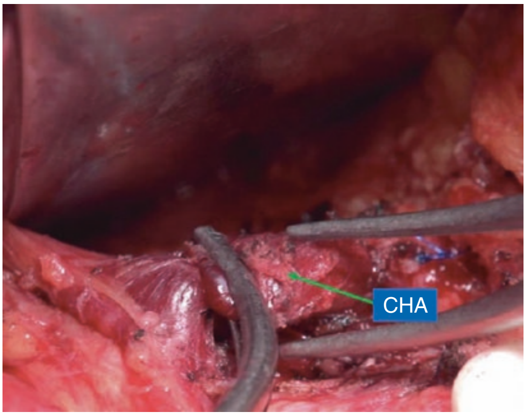

Fig. 9.6 The proper hepatic artery is clipped

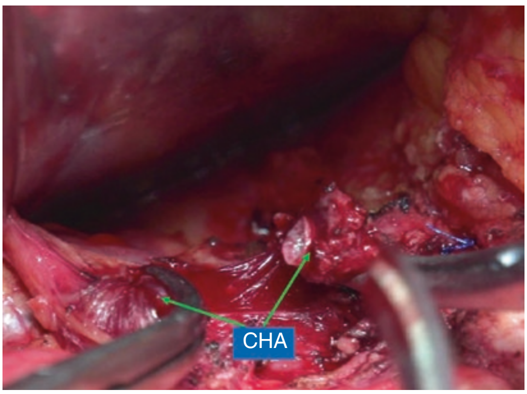

Fig. 9.7 The proper hepatic artery is severed

probe was placed on the surface of the liver. The reverse flow velocity of the blood into the liver through the superior mesenteric artery and the pancreaticoduodenal vascular arch was measured at 25 cm/s. The proper hepatic artery had adequate blood flow, and the common hepatic artery was cut off Fig. 9.7. The incision margin of the pancreas was sutured by mattress suture. The portal vein and superior mesenteric vein were blocked, and the entrance vein of splenic vein was resected Fig. 9.8. The ligaments around the spleen were cut off, and the spleen and the tail of the pancreas were pulled out. The abdominal aorta above the abdominal trunk was exposed in Fig. 9.9. The root of the celiac axis was resected by clamping in Fig. 9.10. The

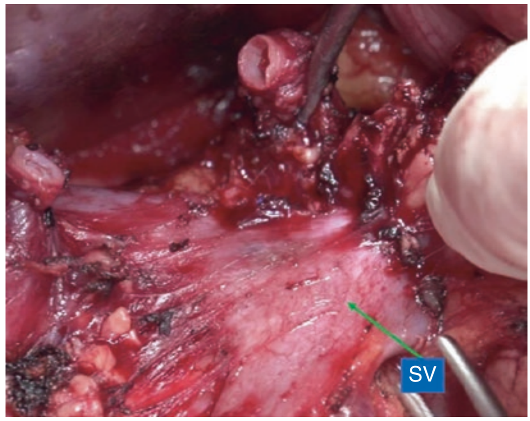

Fig. 9.8 The splenic vein is exposed

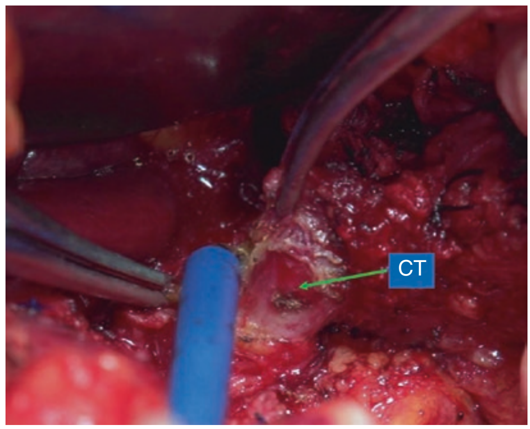

Fig. 9.9 Separate the celiac stem and prepare to disengage

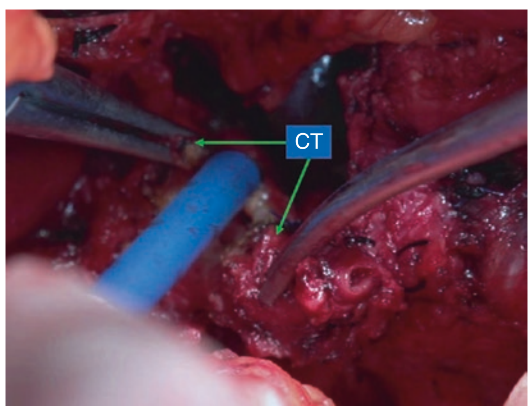

Fig. 9.10 The celiac stem is severed

whole resected specimen was washed out, and hemostasis was thorough. One splenic fossa drainage tube and one pancreatic stump drainage tube were retained. Close the abdomen layer by layer. The operation time was 260 min, and the bleeding was 240 mL.

9.4 Pathology and Prognosis

9.4.1 Postoperative Treatment

1. Routine fasting and water deprivation, and complete parenteral nutrition, until the patient's condition is stable, and early enteral nutrition can be given after recovery of intestinal function;
2. Fluid infusion, shock prevention, adequate nutrition, timely correction of water, and electrolyte imbalance; anemia can be transfused; hypoproteinemia should be supplemented with albumin to enhance the body's immunity.
3. Analgesic treatment: Tramadol, Caffeine, Ternadine, and other commonly used drugs.
4. Antibiotic treatment: Because of the abdominal infection usually caused by intestinal bacteria, mostly *Escherichia coli* and anaerobic bacteria, antibiotics for this effect can be preferred before the pathogen is determined. Then effective antibiotics should be selected according to the results of bacterial culture (ascites culture or blood culture, etc.) and antibiotic sensitivity test.
5. Antiacid and antienzymatic treatment: proton pump inhibition such as omeprazole, somatostatin inhibition of trypsin secretion, etc.
6. Liver protection treatment: cautious use of hepatotoxic drugs, attention to protein intake, and appropriate amount use of liver protection drugs such as polyoleic acid preparations, glycyrrhizic acid preparations, reduced glutathione, etc.

9.4.2 Complication

There were no complications after operation.

9.4.3 Pathology

Postoperative pathology of the patient: pancreatic body and tail tumors 4 × 3 × 2 cm in size, gray in section, and medium in texture; no tumors were found after splenectomy. Pathological diagnosis: ductal adenocarcinoma Grade II, involving the peripancreatic adipose tissue and nerves. No cancer was found in the incised margin of the pancreas. Two peripancreatic lymph nodes were found, and metastasis was found in one of them.

Metastasis modes include: (1) blood metastasis: metastasis in liver is most common and can be transferred to liver, lung, and other organs through blood; (2) lymphatic metastasis: can be transferred to peripancreatic lymph nodes, superior mesenteric lymph nodes, peritoneal trunk and parahepatic lymph nodes, and lymph nodes around splenic arteries and veins; (3) local dissemination and implantation metastasis: local or extensive metastasis occurred in abdominal cavity through direct dissemination and implantation metastasis, etc.

9.4.4 Other Treatments

1. Neoadjuvant therapy: mainly including radiotherapy and chemotherapy. The commonly used neoadjuvant chemotherapy regimens are FOLFIRINO (oxaliplatin, calcium folinate, irinotecan, fluorouracil) or gemcitabine + albumin-bound paclitaxel regimens.
2. Neoadjuvant therapy, on the one hand, can prevent patients with progressive diseases from performing unnecessary surgery and, on the other hand, can improve the resection rate and survival time [10].

9.5 Comment

Advantages of this operation

1. It can significantly improve the resection rate of R0 and the survival rate of patients after operation;
2. It can better solve intractable pain or low back pain to ensure the short-term and long-term quality of life of patients;

3. There is no vascular reconstruction or digestive tract reconstruction during the operation, so it can reduce the incidence of digestive tract anastomotic edema, anastomotic leakage, and refractory diarrhea after operation.

9.5.1 Operative Skill

Although this method is more and more recognized, it is still a difficult operation. If this method is chosen: (1) the indications of operation before operation should be strictly grasped, the arch of large and small curves of stomach should be kept as far as possible during operation, and the right gastric and gastroepiploic vessels should be retained to ensure that the liver can get enough blood supply through collateral circulation of superior mesenteric artery. (2) During the operation, the neck of the pancreas should be cut off, the posterior pancreatic vessels should be separated from the left, the spleen would be pulled out from the tail of the pancreas, and the left and right should join to the front of the celiac trunk and superior mesenteric artery. Then the anterior wall of the superior mesenteric artery should be separated upward, and the abdominal aorta was separated downward and joined up. Finally, the whole specimen should be resected together with the blood vessel, and the superior mesenteric artery and the abdominal aorta, and other important structures to ensure the safety of surgery. (3) Removal of the lateral abdominal aorta nerve and adipose tissue can not only fully expose and protect the abdominal aorta, but also alleviate postoperative pain.

9.5.2 Summary

Overall, the new surgical method is relatively safe and feasible, and its combination with neoadjuvant radiotherapy and chemotherapy, adjuvant radiotherapy and chemotherapy can further prolong the quality of life and survival time of patients with advanced cancer. However, there are still some problems, such as the uniform standards and consensus on surgical indications, resection scope and laparoscopic application is lacked; the choice of neoadjuvant radiotherapy and chemotherapy, and transformation therapy, and the operation timing opportunity need further study; whether the short-term increased mortality and complications can be compensated by the long-term increased survival rate is still a question, and because the learning curve of pancreatic surgery is long, and DP-CAR operation is complex, time-consuming, and involved in important organs and blood vessels, the operation should be carried out by a proficient surgeon group on the patients at stage T4 pancreatic body and tail cancer strictly selected.

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Part III

Adenocarcinoma of the Pancreas: Pancreatectomy

10 Total Pancreatectomy

Xiang-Song Wu and Ying-Bin Liu

10.1 Introduction

Rockey [1] performed the first successful total pancreatectomy (TP) for pancreatic adenocarcinoma in 1943, which resulted in early perioperative mortality because of a bile duct fistula. The procedure was considered as a "radical operation" for the surgical treatment of pancreatic cancer. However, performing TP for pancreatic neoplasms has not been shown to bring any survival benefit over the less aggressive techniques of resection [2]. The short- and long-term morbidity and mortality related to apancreatic state continue to be of concern today [3]. Therefore, TP cannot be considered as the standard procedure for the surgical treatment of pancreatic cancer.

Even if the number of TP performed has decreased over time, there is still a role of this procedure in pancreatic surgery. In the case of chronic pancreatitis without dilation of pancreatic duct in patients resistant to medical treatment, TP with or without auto-islet transplantation has been proposed [4, 5]. The procedure is also proposed for patients with hereditary pancreatitis who are at elevated risk for pancreatic cancer development. Intraductal papillary mucinous neoplasms of the pancreas (IPMNs) also comprise precancerous lesions of pancreatic cancer. TP is recommended in case of diffusely lesions, with an advanced stage of dysplasia present in the entire duct. Multifocal islet cell neoplasms and multifocal neuroendocrine tumors are also considered as indications of this procedure. In patients undergoing pancreatectomy for pancreatic ductal adenocarcinoma (PDAC), TP provides chances of R0 resection in isolated neck margin-positive patients and was associated with a survival benefit. TP is recommended for patients having cancer spread to the left part of the pancreas [6]. In cases when reconstructions of the hepatic and superior mesenteric arteries are undertaken, TP is generally performed [7, 8]. The complete resection of pancreas reduces the rate of morbidity and mortality by eliminating completely the incidence of pancreas fistula and its potentially fatal effect on the arterial anastomosis.

10.2 Case

The patient was a 66-year-old woman admitted to our hospital because of upper abdominal discomfort for 2 weeks. Laboratory examinations showed an elevation of liver function tests: total bilirubin (TB) 22 μmol/L and direct bilirubin (DB) 7 μmol/L. The following tumor markers identified elevated: CA19-9 283 kU/L, CA72-4 70 kU/L, CA21-1 4 μg/L, CA24-2 57 kU/L, and CEA 7 μg/L.

The abdominal contrast computed tomography (CT) showed a mass in the head and neck of the pancreas and a dilation of pancreatic duct. CT also indicated that the junction of SMV and splenic

X.-S. Wu · Y.-B. Liu (✉)
Xinhua Hospital, Shanghai Jiaotong University, Shanghai, China

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vein has been involved by the mass. Pancreatic adenocarcinoma was considered (Fig. 10.1a, b).

From these findings, a diagnosis of pancreatic duct adenocarcinoma located in the head and neck was made and TP with resection of PV/SMV was performed.

Informed consent was obtained from all participating patients, and the ethics committee of Xinhua Hospital, Shanghai Jiaotong University School of Medicine, approved this study.

10.3 Details of Procedure

10.3.1 Kocher's Maneuver to Lift the Head of the Pancreas and the Duodenum

Kocher's maneuver was performed as the start of PD, which is described previously [9]. The right anterior renal fascia was cut open along the external edge of the descendant duodenum. After the head of the pancreas and the duodenum were lifted to the left upper side, expose right renal vein, right genital vein, and inferior vena cava, and then leftwards expose and inspect the spaces behind the pancreatic head and portal vein. After the exposure of the distal end of left renal vein and the abdominal aorta leftwards, expose the root of superior mesenteric artery that is located above the cephalic aorta at the distal end of left renal vein and inspect whether the superior mesenteric artery has been involved. (Fig. 10.2).

10.3.2 Inspect Whether Cephalic Aorta and Its Branches Have Been Involved by Tumor

Cut open the serosa of above hepatoduodenal ligament above duodenum to identify hepatic artery

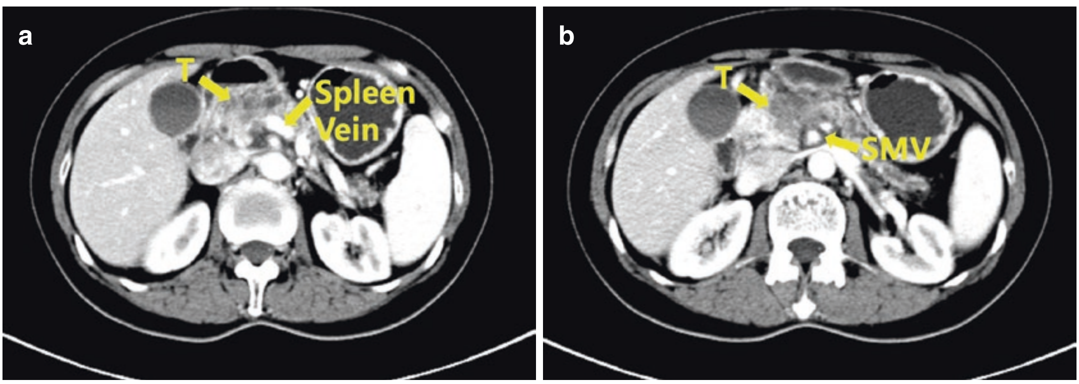

Fig. 10.1 CT image showed a mass in the head and neck of pancreas. (**a**) The spleen vein was invaded. (**b**) The SMV was invaded

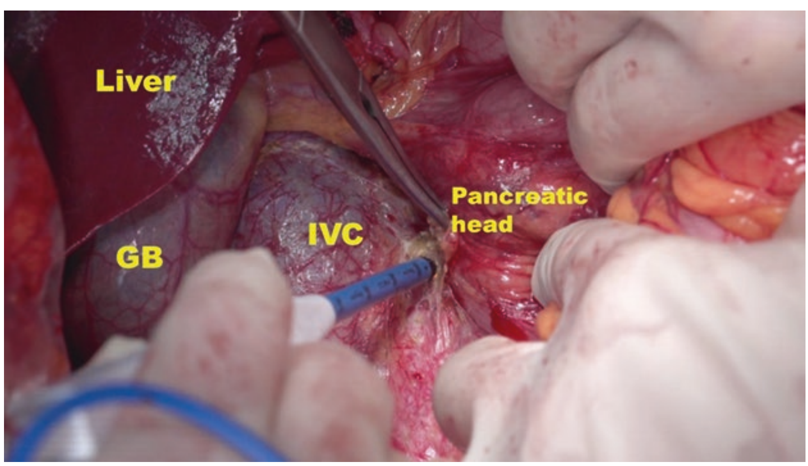

Fig. 10.2 Kocher's maneuver to lift the head of the pancreas and the duodenum

and the root of splenic artery. The right gastric artery was ligated at the proximal end to expose the proper hepatic artery. Then we conformed hepatic artery and the root of splenic artery have not been involved (Fig. 10.3).

10.3.3 Inspect Whether the Superior Mesenteric Vein Has Been Involved by Tumor

From the hepatic flexure of colon to the middle colic vein, expose and ligate the right gastro-epiploic vein, and dissect the greater omentum and the anterior lobe of the transverse meso-colon till the lower edge of the pancreas. After exposing the superior mesenteric vein (SMV) beneath the pancreatic neck, the superior mesenteric vein was found to be involved by tumor (Fig. 10.4).

Based on inspection and CT, a big mass, located at the head and neck of pancreas, invaded the junction of SMV and splenic vein. No obvious metastatic lesions were found. Therefore, we decided to perform a TP with dissection of Portal Vein (PV)/SMV, just as planned.

10.3.4 Skeletonizing the Hepatoduodenal Ligament

After the removal of the gallbladder, transect the common hepatic duct over the cystic duct, skeletonize the hepatoduodenal ligament, and divide and ligate the gastroduodenal artery (Fig. 10.5).

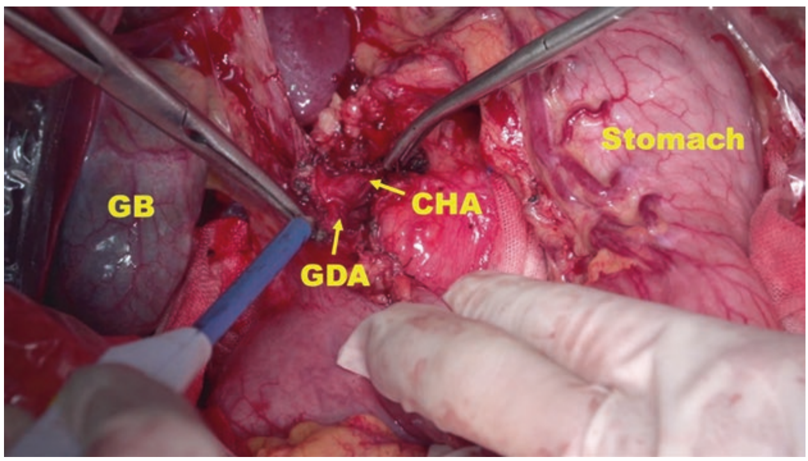

Fig. 10.3 Inspect whether cephalic aorta and its branches have been involved by tumor

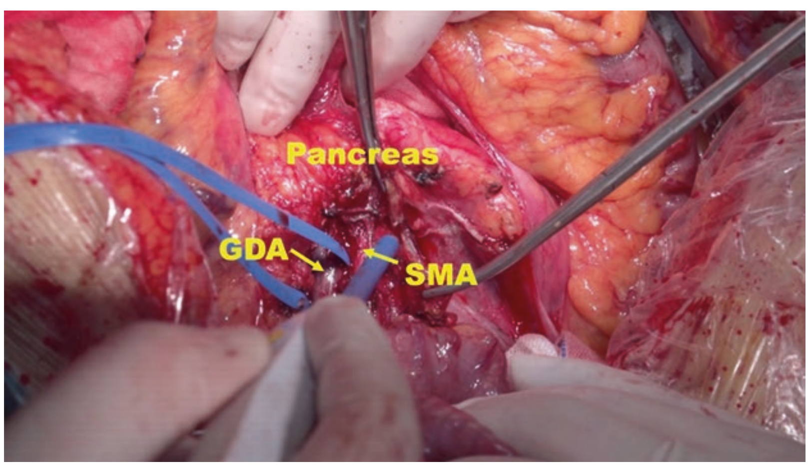

Fig. 10.4 Inspect whether the superior mesenteric vein have been involved by tumor

10.3.5 Dividing the Gastric Antrum

Divide the greater omentum from the middle to the right side along the external side of the gastroepiploic arterial arch till the gastric antrum. Remove the lesser omentum from the distal end of the left gastric vein to the gastric antrum along the external side of the vascular arch of the gastric lesser curvature. Then divide and ligate these two vascular arches above and below gastric antrum. Divide the gastric antrum by using a stapler and cutter.

10.3.6 Transecting Jejunum

Lift the transverse colon upwards to expose the inferior mesenteric vein. Open the retroperitoneum along the right edge of the inferior mesenteric vein and divide the Treitz's ligament. After isolating the ascending portion of duodenum and the jejunum from posterior abdominal wall, the jejunum was transected 15 cm away from the Treitz's ligament.

10.3.7 Mobilization of the Spleen and the Body and Tail Portion of Pancreas

Divide and ligate the root of splenic artery. Divide the splenocolic ligament, splenophrenic ligament, and splenogastric ligament. Dissociate the spleen and the body and tail portion of pancreas from posterior abdominal wall (Fig. 10.6).

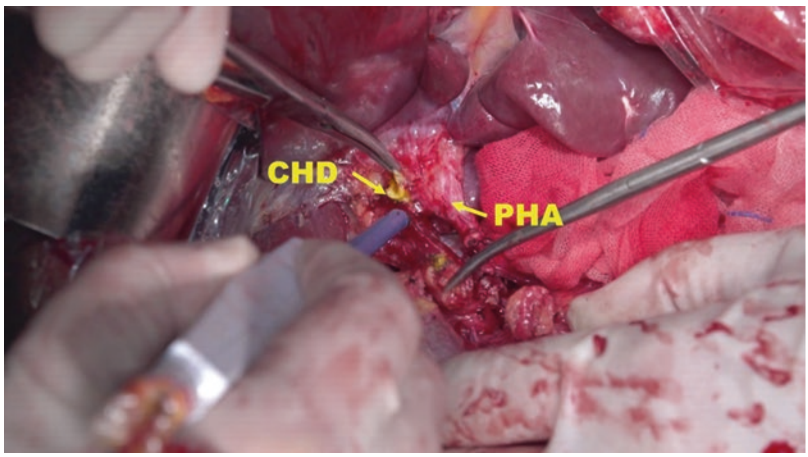

Fig. 10.5 Skeletonizing the hepatoduodenal ligament

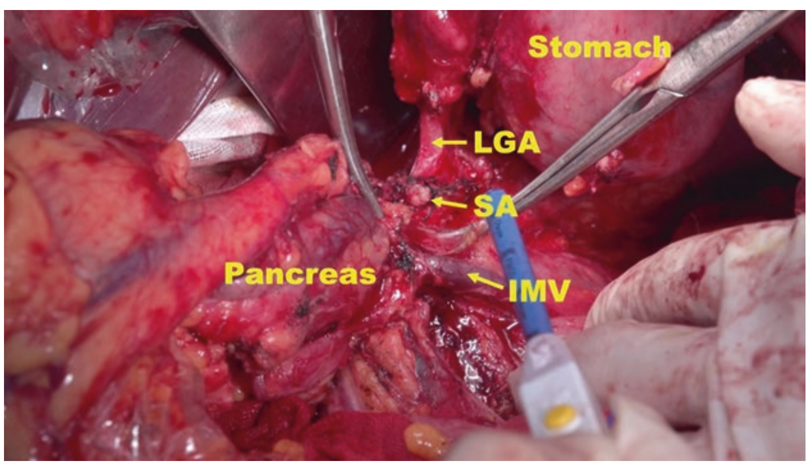

Fig. 10.6 Mobilization of the spleen and the body and tail portion of pancreas

10.3.8 Transecting PV/SMV and Dissecting the Uncinate Process of the Pancreas

Divide and clip the PV above the pancreas and the SMV below the pancreas by bulldog clamps. Pull away the uncinate process to expose the superior mesenteric artery. Then, the lymphatic and nerve tissues around the superior mesenteric artery were dissected till its root. Separate and ligate the small blood vessels in the uncinate process to complete the en bloc resection of the pancreas and duodenum (Fig. 10.7). The PV and SMV were reconstructed with an end-to-end anastomosis (Fig. 10.8).

10.4 Pathology and Prognosis

Pathology diagnosis was moderately differentiated pancreatic duct adenocarcinoma located at the head and neck of pancreas, invading the peripancreatic fatty tissue and the junction of SMV and splenic vein. The cutting margins of common bile duct, stomach, and jejunum were negative; 12 lymph nodes including peripancreatic lymph nodes (4), the superior mesenteric artery lymph nodes (3), No.16 lymph node (2), and No.12 lymph nodes (3) were dissected totally, and none of them was positive.

The patient recovered uneventfully and was discharged 11 days after the operation. Twelve months after surgery, follow-up CT, and tumor marker revealed no recurrence.

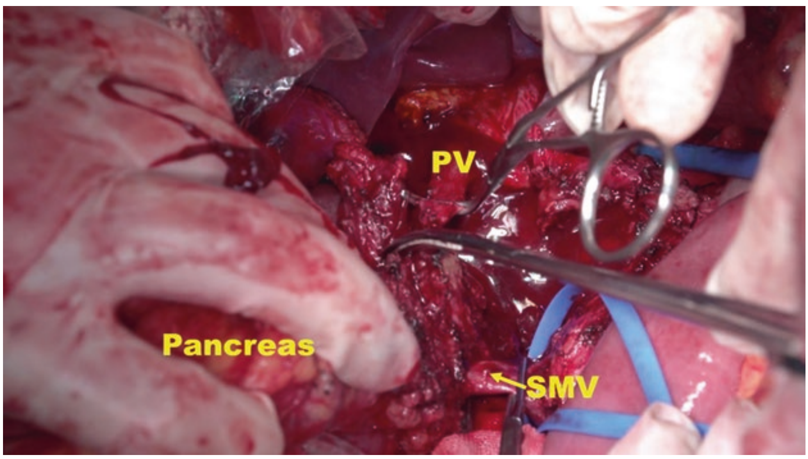

Fig. 10.7 Transecting PV/SMV and dissecting the uncinate process of the pancreas

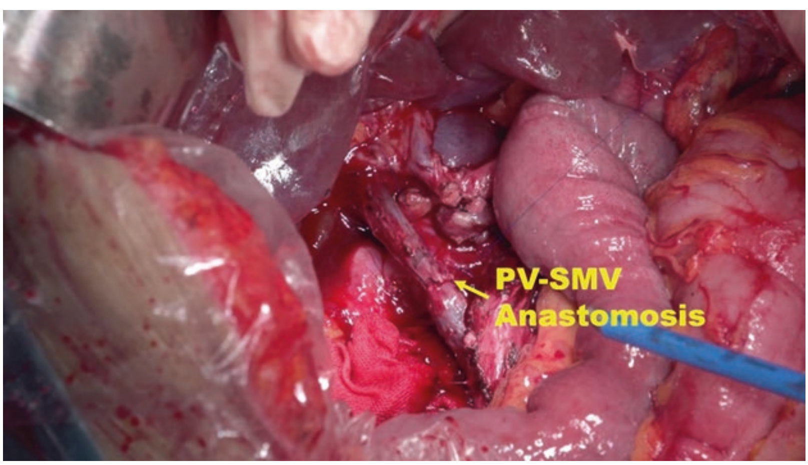

Fig. 10.8 The PV and SMV were reconstructed with an end-to-end anastomosis

10.5 Comment

Despite the fact that surgeons performed fewer TP for the treatment of pancreatic diseases in recent years, there are some limited indications for this procedure. For patients with PDAC, use of TP is supported for the treatment of pancreatic adenocarcinoma in appropriately selected patients because the long-term survival rates of patients who underwent TP for pancreatic cancer were comparable to those for patients who underwent PD [10]. The similar 3- and 5-year survival rates in patients who underwent TP vs. those who underwent PD suggested that the glycemic issues were not major determinants of death in the long term [11]. There are several reports of post TP deaths caused by hypoglycemia [11]. However, the patients referred to the endocrinology unit after TP for education purposes can have a good glycemic control and self-management [12]. Therefore, death due to diabetic complications or metabolic consequences related to TP during long-term follow-up was eliminated.

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11 Pancreatectomy with Other Organ Resection

Xiao-Ming Ma and Wei-Long Cai

11.1 Introduction

Pancreatic cancer usually refers to ductal adenocarcinoma of the pancreas, accounting for more than 95% of pancreatic malignant tumors [1]. Surgical resection is the only effective method for pancreatic cancer patients to obtain a chance of cure and long-term survival. In the past, distant metastasis of pancreatic cancer was considered as a contraindication for surgery, and radiotherapy was recommended instead of surgical resection. With the development of surgical techniques, the safety of surgery was increased in recent years, and the death rate from surgery-related diseases has dropped to less than 5% [2]. Therefore, for patients with isolated distant metastasis of pancreatic head cancer, such as liver metastasis or lung metastasis, whether extended pancreaticoduodenectomy can be performed has aroused the interest of the majority of pancreatic surgeons.

It has been reported in the literature that compared with standard surgery, extended resection increased the operation time, intraoperative blood loss and transfusion volume, length of hospital stay and perioperative complications, etc., but there was no significant difference in mortality between the two groups. Expanded surgical resection can significantly improve the patient's prognosis [3]. Among the cases when cancer was directly infiltrate adjacent organs or had liver metastasis, the primary lesion was excised together with involved organs, which can not only alleviate symptoms, improve quality of life, but also achieve radical cure and long-term survival in some cases.

Expansion of pancreaticoduodenal resection, also named the pancreatic duodenal multiorgan resection, is based on standard pancreaticoduodenectomy with the combination of peripheral organ resection like gastric resection beyond gastric antrum or 1/2 distal of the stomach, part of the mesocolon and colon resection, more than the first period range of jejunum resection, part of the portal vein, superior mesenteric vein and (or) inferior mesenteric vein excision, part of the hepatic artery and celiac artery and (or) the superior mesenteric artery resection, partial excision of inferior vena cava and right adrenal resection, right kidney and vascular resection, partial hepatectomy, and part of the diaphragm excision (Fig. 11.1).

Currently, extended resection is performed only in large pancreatic centers by experienced pancreatic surgeons. Therefore, there is no uniform standard for surgical indications, but it is generally believed that patients requiring expanded resection are mostly those with distant

X.-M. Ma (✉)
The Second Affiliated Hospital of Soochow University, Suzhou, China

W.-L. Cai
Huzhuo Central Hospital, Huzhou, China

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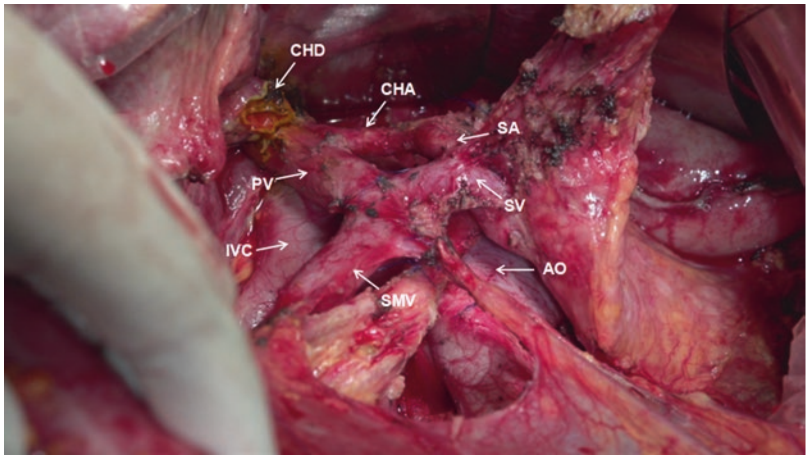


Fig. 11.1 *SMV* superior mesenteric vein, *PV* portal vein, *CHA* common heptic artery, *SA* spleen artery, *SV* spleen vein, *IVC* inferior vena cava, *CHD* common heptic duct, *AO* abdominal aorta

isolated metastasis in the locally advanced stage, and the preoperative evaluation is feasible for R0 resection. The effect of this operation on perioperative safety and improving the prognosis of patients revealed good results in some center [4], but after all, for the insufficient sample size and lack of the support of prospective studies with large multicenter sample size, it can only be comprehensively considered according to the general situation of patients, clinical manifestations, tumor resection evaluation, patient tolerance, etc. [5].

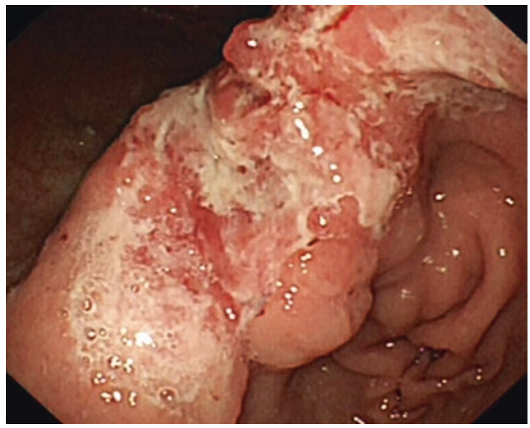


Fig. 11.2 Gastric horn erosion showed through gastroscopy

11.2 Case

The patient was a 74-year-old woman admitted to the hospital due to the upper abdomen discomfort and pain for 1 year. Gastroscopy showed gastric horn erosion, with a 2.5 × 2 cm mucosal defect in the upper forearm of the upper gastric antrum and the gastric horn (Fig. 11.2). Gastroscopy biopsy pathology showed poorly differentiated adenocarcinoma of gastric horn.

The tumor marker CA19-9 was increased to 83.01 U/mL, and other markers such as CEA, AFP, CA153, and CA125 were normal. Laboratory examinations showed an elevation of liver function tests: ALT 228.2 IU/L, AST 202.0 IU/L, ALP 1138.8 IU/L, γ-GT 881.5 IU/L, TB 113.74 mol/L, and DB 63.6 mol/L.

Abdominal computed tomography (CT) showed a mass in the head of pancreas, and a dilation of common bile duct and pancreatic duct (Fig. 11.3a, b). Pancreatic carcinoma was to be considered too.

From these findings, a diagnosis of gastric carcinoma was made, although the nature of the pancreatic mass was uncertain, pancreatoduodenectomy combined subtotal gastrectomy was performed then.

Informed consent was obtained from all participating patients, and the ethics committee of the Second Affiliated Hospital of Soochow University approved this study.

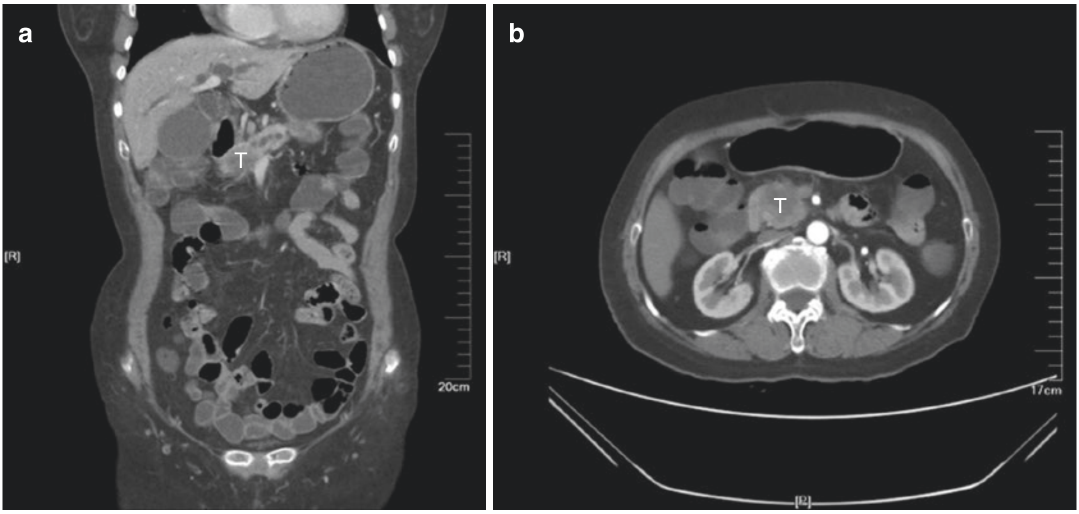


Fig. 11.3 CT image showed a mass in the head of pancreas and a dilation of common bile duct and pancreatic duct. (**a**) A mass in the pancreatic head, the bile duct and pancreatic duct were dilated. (**b**) The mass in the pancreatic head. T = tumor

11.3 Details of Procedure

11.3.1 Exploration of Gastric Cancer Combined with Pancreatico-duodenectomy

After the peritoneum was cut open in the lateral of descending part of duodenum, the second segment of the duodenum and the head of the pancreas were dissociated from the retroperitoneum to the forward (Kocher maneuver). Up to the upper margin of the pancreas along the anterior lobe of the hepatoduodenal ligament and down to the third segment of the duodenum, the hepatic artery was exposed then. Turning the duodenum and pancreatic head to the left to expose the inferior vena cava (IVC) and abdominal aorta (AO) (Fig. 11.4), NO.13 and NO.16 lymphatic groups can be dissected. Dissociating the right and liver area of the transverse colon, stripping transverse anterior mesocolon until the pancreas in order to let the second and third segment of the duodenum easily to be dissociated forward. Superior mesenteric vein and superior mesenteric artery across the third segment of the duodenum in front can be detected. Blunt dissecting the loose tissue from the venous surface to the superior margin and then the venous was separated from pancreatic cervical back wall. At this point, the tumor has been separated from SMV-PV, IVC and AO, and pancreaticoduodenectomy is possible.

11.3.2 Lymph Node Dissection for Gastric Cancer with Dissection of the Severed Stomach

Sever the lesser omental, dissect the NO.1 lymph node groups, and then dissect the NO.3 and NO.5 lymph node groups from the right margin of the esophagus and cardia. The left gastric artery, common hepatic artery, celiac artery, and splenic artery were dissociated, and the NO.7, 8, 9, and 11 lymph node groups were dissected too (Fig. 11.5); after that, remove the left gastrocolon ligament and the splenogastric ligament of the greater omentum and dissect the NO.4 and 6 lymphatic groups. The proximal part of the stomach was separated from the tumor more than 5 cm away.

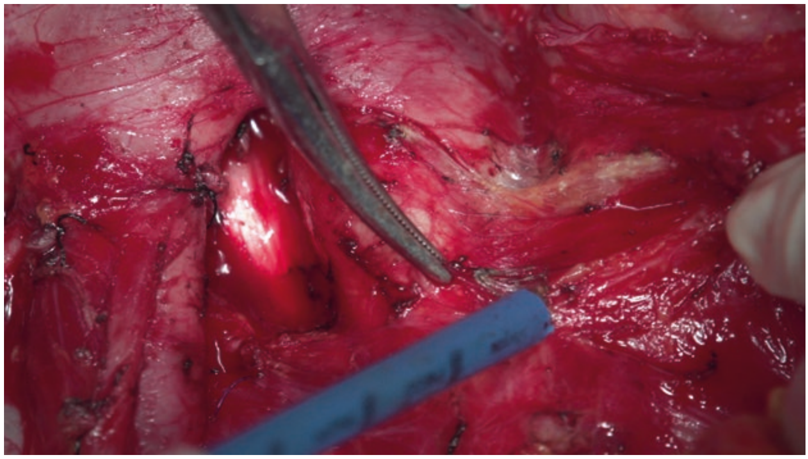


Fig. 11.4 Expose the inferior vena cava (IVC) and abdominal aorta

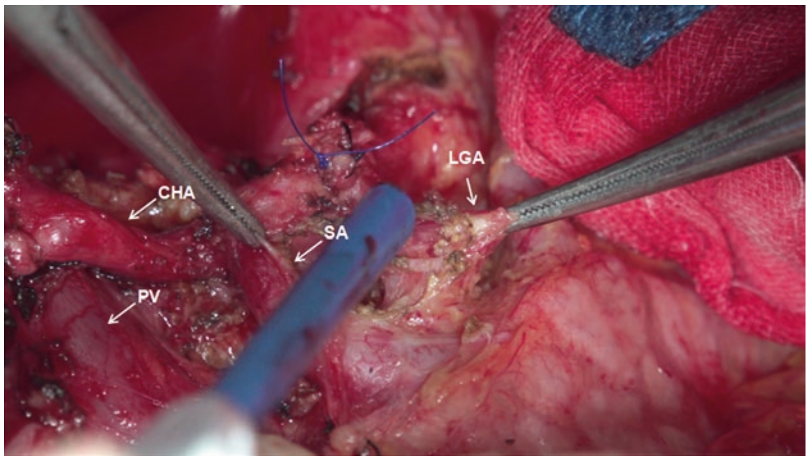


Fig. 11.5 *PV* portal vein, *CHA* common heptic artery, *SA* spleen artery, *LGA* left gastric artery

11.3.3 Cut Off the Hepatic Duct and Perform Choroid Lymphatic Dissection of the Hepatic Duodenal Ligament

Strip the gallbladder from the gallbladder bed, cut the hepatic duodenal ligament longitudinally to the hilum of the liver, and free the hepatic duct and transect it. The hepatic artery and portal vein were pulled apart by traction strips, respectively, and all the remaining NO.12 lymph node groups were removed (Fig. 11.6).

11.3.4 Cut Off the Pancreas

Make a stitch with silk thread on the upper and lower edges of the caudal pancreas at the predetermined tangent, respectively, and ligate it to block the transverse blood vessels. Gradually cut off the pancreas from the left side of superior mesenteric vein, and it was easy to find the pancreatic duct and stop bleeding by curettage and suction dissection (Fig. 11.7). After the pancreas was completely severed, a silicone tube with side holes was inserted into the distal end of the pancreas.

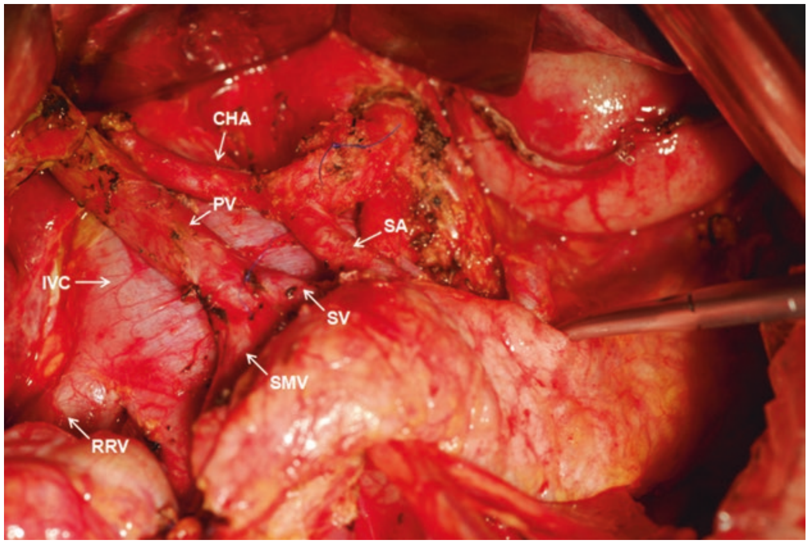


Fig. 11.6 Lymphatic dissection of the hepatic duodenal ligament

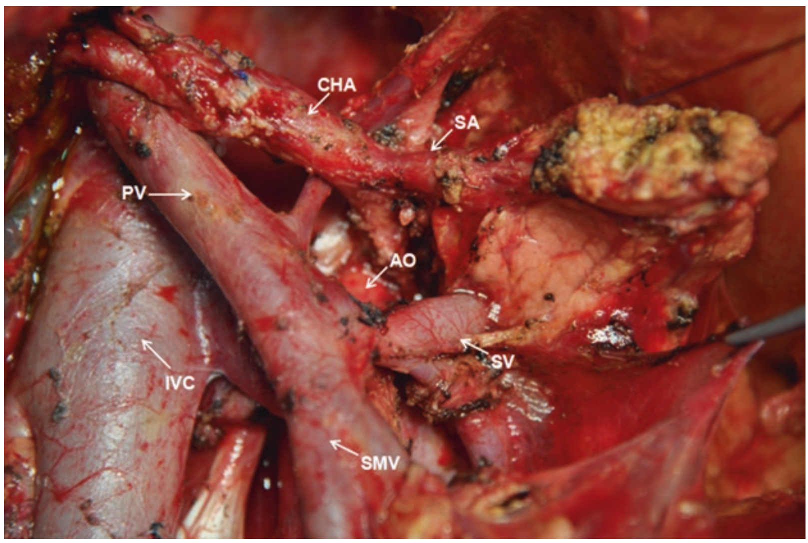


Fig. 11.7 *SMV* superior mesenteric vein, *PV* portal vein, *CHA* common heptic artery. *SA* spleen artery, *AO* abdominal aorta, *SV* spleen vein, *IVC* inferior vena cava

11.3.5 Cut Off the Jejunum

Cut the Treitz ligament, free the beginning of the jejunum, and cut the jejunum about 10–15 cm away from the Treitz ligament. The proximal jejunum was closed by suture, and the distal jejunum was temporarily closed to perform pancreatic jejunostomy later.

11.3.6 Cut Off the Uncinate Process of the Pancreas

The proximal jejunum and duodenum is pulled from the posterior part of superior mesenteric blood vessels to the upper part of the colon. At this time, only the uncinate process of the pancreas is connected to the superior mesenteric vein and artery (Fig. 11.8). Carefully separating the loose connective tissue, several venules join into SMV can be detected and should be ligatured carefully one by one. The superior mesenteric artery was palpated on the left hand, and the connective tissue connected to the uncinate process of the pancreas was clamped on the right of the SMA. The connection tissue between the superior mesenteric artery and the pancreas was gradually clamped, cut, and ligatured from top to bottom, while the inferior pancreaticoduodenal artery should be ligated and cut separately. At this moment, the entire specimen can be removed, the surgical field flushed, and bleeding stopped completely.

11.3.7 Child Reconstruction

Anastomosis was performed in the order of pancreatic intestine, biliary intestine, and gastrointestinal tract. Pancreaticojejunal mucosa end-to-side anastomosis was adopted for pancreaticojejunal anastomosis (Fig. 11.9): the pancreas and the jejunal sarcoplasmic layer were sutured together, a small hole was made in the corresponding jejunal mucosa, jejunal and pancreatic mucosal posterior wall anastomosis was performed, and then the drainage catheter in the pancreatic duct was placed in the jejunum and fixed. The anterior wall of the pancreatic duct and jejunal anastomosis was then sutured and fixed on the pancreatic capsule.

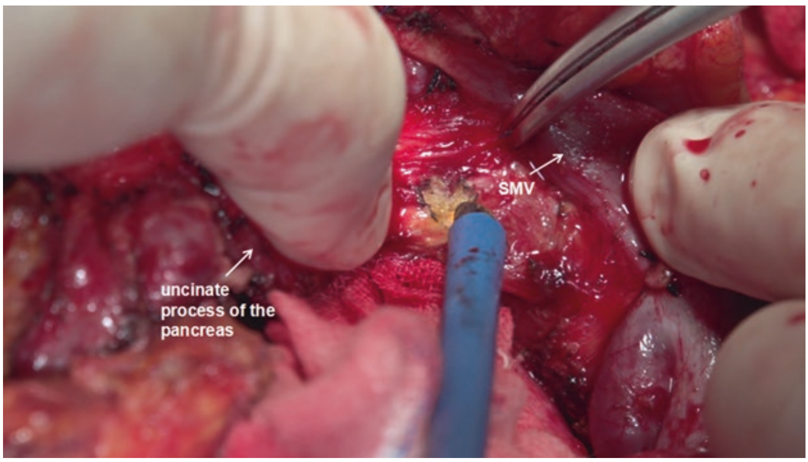


Fig. 11.8 Cut off the uncinate process of the pancreas

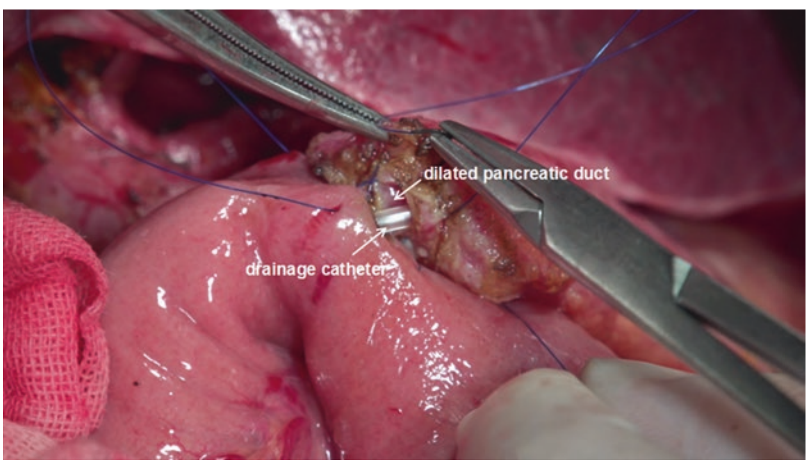


Fig. 11.9 Pancreaticojejunal mucosa end-to-side anastomosis

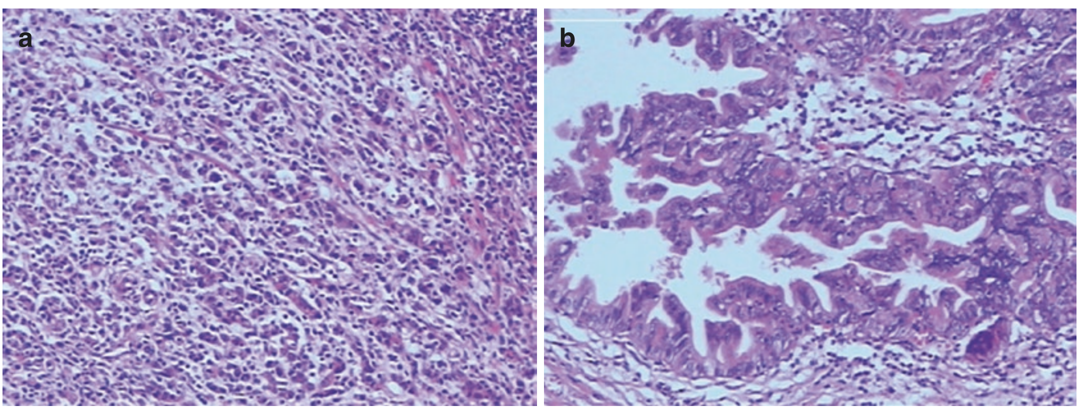
11.4 Pathology and Prognosis

The resected specimen was showed in Fig. 11.10. Postoperative pathology diagnosis: (distal stomach) poorly differentiated adenocarcinoma with mucinous adenocarcinoma. The upper and lower cutting margins submitted for inspection are negative. (head of pancreas) intraductal papillary mucinous tumor with focal carcinoma. Twenty-four lymph nodes including the large curvy lymph nodes (8), the small curvy lymph nodes (7), and the peripancreatic lymph nodes (9) were dissected totally and all of them were negative (Fig. 11.11a, b). The patient had postoperative gastroparesis for a time, but recovered after conservative treatment, and is now surviving well by following up for more than 2 years. The follow-up CT and tumor marker revealed no recurrence.

Fig. 11.10 Overview of the resected specimen

11.5 Comments

The expanded pancreaticoduodenectomy includes standard pancreaticoduodenectomy combined with distal stomach, part of liver, part of colon, and other adjacent organs, which is mainly suitable for the metastasis and invasion of pancreatic head cancer to adjacent organs that preoperative evaluation is feasible for R0 resection. For this case, carcinoma of the head of pancreas and carcinoma of the stomach are primary tumors, which is rare in clinic. After surgery treatment, the patient had postoperative gastroparesis for a time, but recovered after conservative treatment, and the patient is now surviving well by following up for more than 2 years which reveals the obvious benefit of the operation. Therefore, expanded pancreaticoduodenectomy should be encouraged in patients with pancreatic cancer involving peripheral organs, such as the SMV, portal vein, distal stomach, and iso-



distal stomach: poorly differentiated adenocarcinoma with mucinous adenocarcinoma.

head of pancreas: intraductal papillary mucinous tumor, focal carcinoma.

Fig. 11.11 Postoperative pathology diagnosis of the resected specimen. (**a**) Postoperative pathology diagnosis of the distal stomach. (**b**) Postoperative pathology diagnosis of the pancreas head lated metastatic lesions in the liver or diaphragm without obvious contraindications. However, it should emphasized that this procedure should be performed in a large-scale pancreatic center by experienced pancreatic surgery experts to reduce the incidence of postoperative complications.

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Part IV

Adenocarcinoma of the Pancreas: Laparoscopic Surgery

12 Laparoscopic Pancreaticoduodenectomy with Hong's Pancreaticojejunostomy

Xiao-Long Liu and De-Fei Hong

12.1 Introduction

Since laparoscopic pancreaticoduodenectomy (LPD) was first descripted in 1994, people have never stopped their steps in looking forward to promoting minimally invasive surgery for pancreaticoduodenectomies.

Laparoscopic procedure has been increasingly accepted as a choice for selected patients who undergo pancreaticoduodenectomy (PD) during last decades. Its safety and feasibility have been proved in selected minimally invasive pancreatic surgery centers [1]. Compared to the open group, data has already shown that LPD does conceive a shorter hospital stay and less than 30-day morbidity [2–5]. However, LPD is still considered a technically challenging operation currently and therefore performed only in few specialized doctors [6–8].

Reconstruction of digestive tract is the key procedure of pancreatoduodenectomy. Various pancreaticojejunostomy methods have been reported, but there is not yet an agreement on its preference. Among those different methods, duct to mucosa (DTM) pancreatoduodenectomy is the mainstream. Yet, it is still technically difficulty especially for those soft pancreas and small pancreatic duct. Unsuccessful pancreaticojejunostomy will certainly increase the risk of pancreatic fistula.

X.-L. Liu · D.-F. Hong (✉)
Department of General Surgery, Sir Run Run Shaw Hospital, The Medicine School of Zhejiang University, Hangzhou, China

The incidences of postoperative pancreatic fistula were 10–30% in traditional PJ anastomosis [5, 6]. According to professor Hong's opinion, the reason why so high postoperative PF is because surgeons emphasize too much on surgical reconstruction techniques, but despise the mechanism of pancreatic intestinal anastomosis healing. Professor Hong proposes the "fistula formation" theory based on the healing mechanism of pancreatic bowel anastomosis. According to this theory, professor Hong develops Hong's pancreaticojejunostomy method. The key point for Hong's pancreaticojejunostomy method is to create an *artificial fistula* to drainage pancreatic juice and make a simple tissue alignment. Multicenter large-sample clinical trail has proved that Hong's pancreaticojejunostomy technique is a safe and feasible method with advantage of decrease operation time [9–11]. The incidence of pancreatic fistula is 7.2% (0.9% for grade C) with Hong's pancreaticojejunostomy method, while the rate of pancreatic fistula is 10–30% with traditional PJ. The time of PJ decreases from 60 min to 25 min. Due to the remarkable clinical effect of this technique, it has been applied in more than 100 hospitals in open, laparoscopic or robotic pancreatoduodenectomy in China.

According to Professor Hong's opinion, with enlarged pancreatic duct (>8 mm) and thin pancreatic parenchyma, pancreaticojejunum reconstruction can be treated as a gastrointestinal anastomosis, while in patients with small duct and normal pancreatic parenchyma, the

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pancreaticojejunum reconstruction technique should be based on "fistula formation" theory, and Hong's pancreaticojejunostomy method is the best choice for those patients.

12.2 Case

A 64-year-old woman was admitted due to abdominal pain associated with jaundice for 10 days.

The tumor marker CA19-9 was increased to 72.80 IU/L, and other markers such as CEA, CA153, CA125, and AFP were normal. Laboratory examinations showed an elevation of liver function tests: ALT 505 IU/L, AST 248 IU/L, ALP 305 IU/L, γ-GT 529 IU/L, TB 172.6 umol/L, and DB 104.7 umol/L. Abdominal CT scan revealed a mass in the pancreatic head, and a dilation of common bile duct and pancreatic duct. Pancreatic carcinoma was to be considered (Fig. 12.1). Informed consent was obtained from all participating patients, and the ethics committee of Sir Run Run Shaw Hospital, Zhejiang University School of Medicine, approved this study.

12.3 Details of Procedure

12.3.1 Exploration and Operation Hole Position

Firstly, a 10 mm incision is made under the umbilicus of the patient, then an artificial CO_2 pneumoperitoneum of 13~15 mmHg is established. The laparoscope is inserted to make sure no metastases happened. The other four operation holes are made on the right median clavicle, right anterior axillary line, left median clavicle, and left nipple line, respectively (Fig. 12.2).

12.3.2 Cut Off the Stomach

Cut off the stomach colon ligament from the distal stomach to the start part of duodenum and

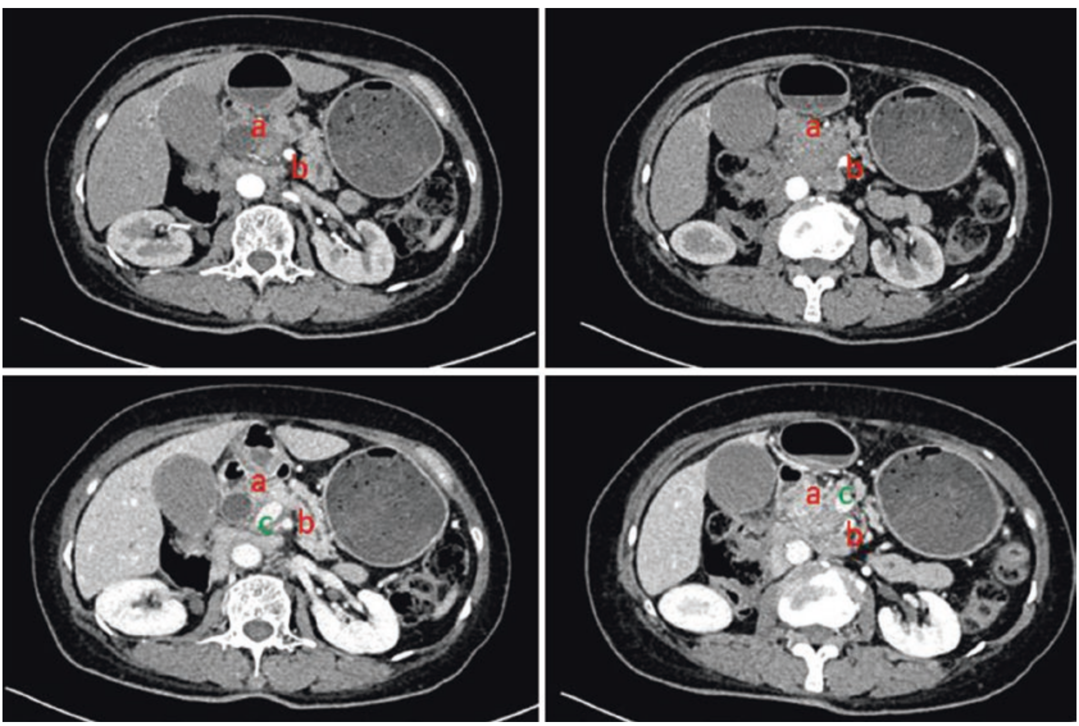

Fig. 12.1 CT showed pancreas head carcinoma. (a) Mass. (b) SMA. (c) SMV

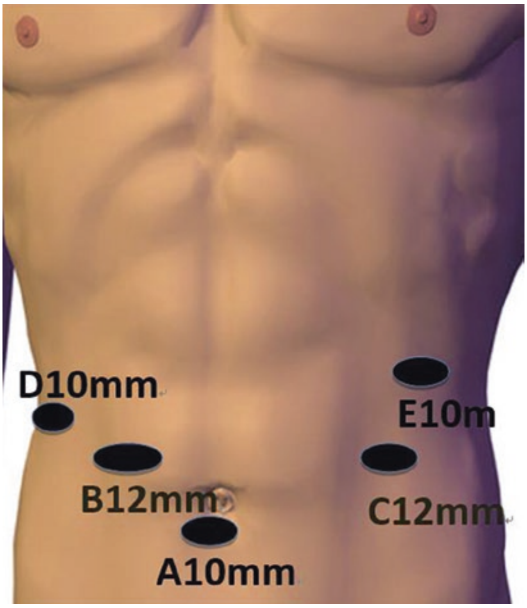

Fig. 12.2 Incision holes for LPD

expose the pancreas by using Harmonic Scalpel or ligasure. Cut off the lesser omentum from duodenum to the left gastric artery. Cut off 40% of the distal stomach by using stapler.

12.3.3 Overhanging the Liver

A pocket-string needle is punctured from the outside of the abdominal wall to the inside, then punctured back to the outside, and fixed to the hepatic vein ligament by a hem-o-lock clamp. Ligate the needle outside the abdominal wall and the liver will be lifted to create enough surgical space.

12.3.4 Lymph Node Dissection

Dissect lymph nodes surrounding the common hepatic artery and the intrinsic hepatic artery with Harmonic Scalpel by following the pulsations of the common hepatic artery. Then dissociate the right gastric artery, ligate the proximal end, and then it is served with Harmonic Scalpel. Dissociate the gastroduodenal artery, then ligate the proximal end with 4-0 vicaud wire and 5 mm hem-o-lock. The distal end is clamped with hem-o-lock and then it is served. The common hepatic artery is lifted by a vascular band (about 8 cm in length) in order to facilitate the dissection of surrounding lymph nodes.

12.3.5 Cut Off the Common Hepatic Duct and Perform Choroid Lymphatic Dissection of the Hepatic Duodenal Ligament

Free the gallbladder artery and clamp the proximal end. The distal end is served by Harmonic Scalpel. Strip the gallbladder from its bed, cut the hepatic duodenal ligament longitudinally to the hilum of the liver, then free the common hepatic duct and transect it. The hepatic artery and the distal common bile duct are pulled apart by traction strips. Dissect the remaining lymph nodes from the hilum of the liver to the pancreas till the portal vein on the pancreatic neck is clearly revealed. The proximal end of the portal vein branch is double clamped, and the distal end is served by Harmonic Scalpel. A rapid biopsy for pathological examination must be taken to make sure a benign edge of the common bile duct. Additionally, those aberrant extrahepatic bile duct or hepatic artery originated from SMA should be carefully protected. For those patients without obstructive jaundice or already underwent PTCD to reduce jaundice, we usually clamp the common bile duct with 10 mm or 12 mm hem-o-lock and then cut off the duct directly. Otherwise the proximal end of the bile duct should be kept open which is conducive to intraoperative biliary decompression and jaundice reduction.

12.3.6 Dissociate the SMV

After the retroperitoneum at the pancreas lower edge is cut open, the ventral side of the superior mesenteric vein (SMV) is separated, and the retropancreatic SMV is bluntly separated by aspirator head or intestinal clamp, thus the retropancreatic tunnel is established. But those patients with chronic pancreatitis should not be separated ahead, for SMV and Henle trunk can be exposed after pancreas is cut off. The branch of Henle trunk should be double clamped carefully.

12.3.7 Kocher Incision

The peritoneum of duodenum side should be cut open by using Harmonic Scalpel and dissociated from right anterior renal fascia to the second and third segments of duodenum till the left side of the abdominal aorta. Then the distal end of SMV is exposed. Cut off the Treitz ligament and then pull the proximal jejunum to the right side behind the mesenteric vessel. The 16a2 and 16b1 lymph node can be dissected and sent to rapid biopsy for pathological examination.

12.3.8 Cut Off the Jejunum

The Treitz ligament has been cut off before, and here we free the beginning of the jejunum for about 10~15 cm away from the Treitz ligament. The proximal jejunum will be closed by suture; the distal end will be temporarily closed and prepared for pancreatic-jejunum reconstruction later.

12.3.9 Cut Off the Pancreas

Normally, we do not ligate the pancreas ahead of the cut procedure, although some authors believe this can do good to block the transverse blood vessels. We suggest to cut off the pancreas from the left side of SMV with Harmonic Scalpel gradually. For it can help effectively stop bleeding, it is easy to find the pancreatic duct.

12.3.10 Cut Off the Uncinated Process of the Pancreas

The proximal jejunum and duodenum has been pulled from the posterior part of SMV and SMA to the upper part of the colon. At this time, only the uncinated process of the pancreas is connected to the SMV and SMA. Carefully separate the loose connective tissue, several veins join into SMV can be detected and should be ligatured carefully one by one. The SMA is palpated on the left hand, and the connective tissue connected to the uncinated process of the pancreas is clamped on the right of the SMA. The connect tissue between the SMA and the pancreas should be ligated and cut separately. At this moment, the entire specimen can be removed, the surgical field flushed and bleeding stopped. Put the specimen into the specimen bag and close the specimen bag with 10 mm hem-o-lock; remove the specimen bag to the right hepatic gap.

12.3.11 Child Reconstruction: Pancreaticojejunal Anastomosis

Anastomosis is performed in the order of pancreatic intestine, biliary intestine, and gastrointestine tract. Duct to mucosa (DTM) anastomosis is adopted for pancreaticojejunal anastomosis.

This is the most important procedure of LPD. Traditionally, the pancreas and the jejunal seromuscular were sutured together directly, a small hole was made in the corresponding jejunal mucosa, jejunal and pancreatic mucosal posterior wall anastomosis was performed, and then the drainage catheter in the pancreatic duct was placed in the jejunum and fixed. The anterior wall was then sutured and fixed. Yet, sometimes due to the small pancreatic duct or the duct is not long enough, it is difficult to complete pancreaticojejunal anastomosis. We suggest a new method.

12.3.12 Hong's Pancreaticojejunostomy

Prepare a 15 cm pancreatic juice drainage tube that matches the diameter of the main pancreatic duct. Cut 2–4 side holes at the insertion end. Then insert the tube into the main duct for about 3–5 cm (Fig. 12.3). Penetrate a 4-0 PDS from the ventral side of the pancreas through the whole drainage tube to the dorsal side. Make sure the margin should be no less than 5 mm, then fix the tube. That is so-called "Hong's single stitch" (Fig. 12.4a,b). An additional suture might be adopted to close the gap between the drainage tube and main duct if needed (Fig. 12.5). Pull the drainage tube and once it cannot be pulled out, it means the drainage tube has been firmly fixed (Fig. 12.6). Traditionally, the drainage tube mainly plays a supporting role in case of pancreatic duct obstruction. Yet, our drainage tube plays a drainage role which can drain almost all the pancreatic juice from pancreatic main duct to jejunum.

Penetrate a 3-0 prolene from the pancreas to the jejunum seromuscular layer and then back to the pancreas, making an "8" suture on the upper layer of the tube (Fig. 12.7). This is the first suture. Be careful we should penetrate the whole pancreas. Similarly, penetrate a second suture from the whole pancreas to the jejunum, then use a titanium clip to fix the suture in advance. Ligate the first suture to keep the pancreas and jejunum in apposition. *20 W electric coagulation burns the corresponding jejunum seromuscular layer* (Fig. 12.8), and cut a small hole in the corresponding jejunum

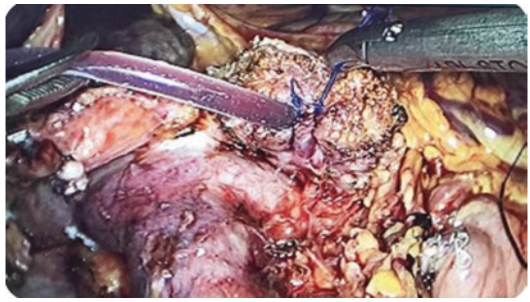

Fig. 12.5 An additional suture should be adopted to close the gap between the drainage tube and main duct once the drainage tube is not suitable for the main duct, making sure all the juice can drain to the jejunum

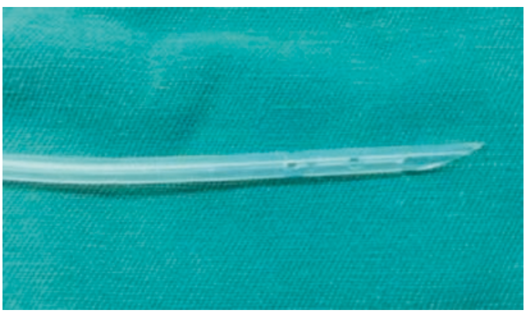

Fig 12.3 Pancreatic juice drainage tube

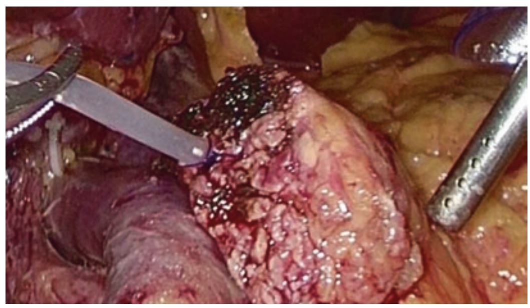

Fig. 12.6 The drainage tube cannot be pulled out, meaning it has been firmly fixed

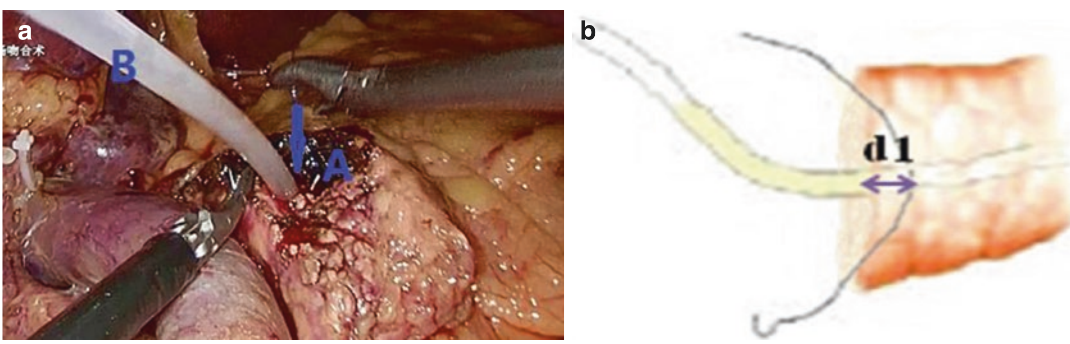

Fig. 12.4 (**a**) A 4-0 PDS was penetrated from the ventral side of the pancreatic duct through the whole drainage tube to the pancreatic duct dorsal side. A: pancreatic duct; B: pancreatic juice drainage tube). (**b**) A 4-0 PDS was penetrated from the ventral side of the pancreatic duct through the whole drainage tube to the pancreatic duct dorsal side (d1 ≥ 5 mm)

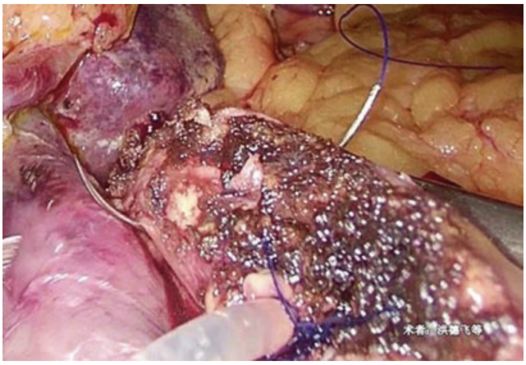

Fig. 12.7 A 3-0 prolene was penetrated through from the whole pancreas to the jejunum seromuscular layer to connect pancreas and jejunum

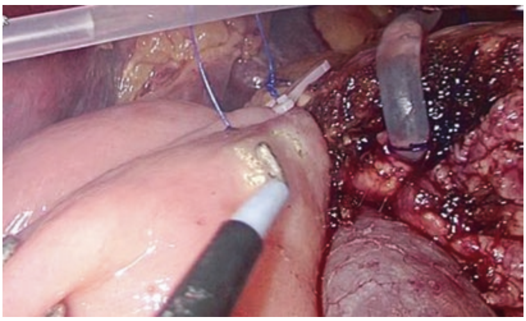

Fig. 12.8 20 W electric coagulation burning the corresponding jejunum seromuscular layer

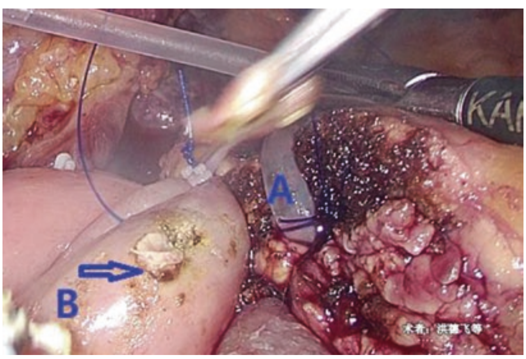

Fig. 12.9 Cut a small hole in the corresponding jejunum to match the pancreatic duct

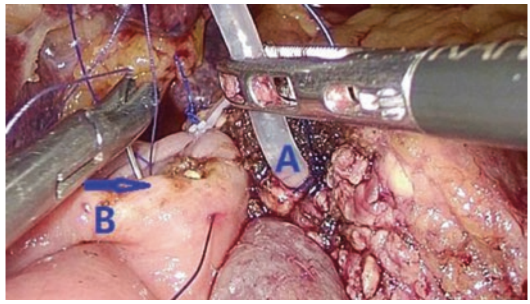

Fig. 12.10 A purse suture has been made around the small hole in advance

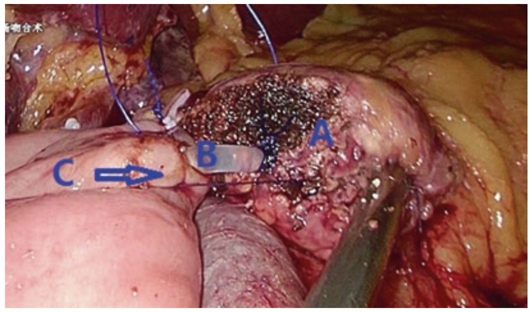

Fig. 12.11 Place the free side of the drainage tube into the jejunal, then ligate the purse suture

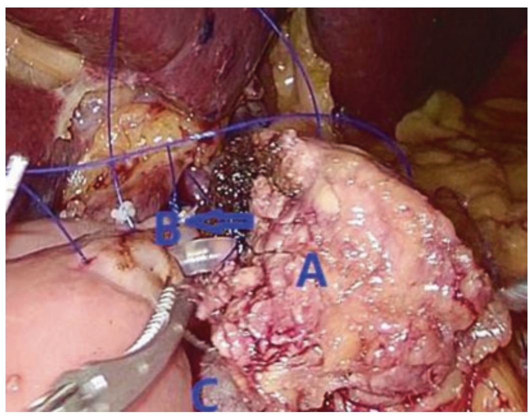

Fig. 12.12 An "artificial fistula" has been formed between pancreas and jejunum

(Fig. 12.9). Make a purse suture around the small hole in advance (Fig. 12.10), and then place the free side of the drainage tube into the jejunal, ligate the purse suture to form *"artificial fistula"* (Fig. 12.11). The pancreatic juice can be output to the jejunum through the fistula. Make a third suture on the lower layer of the tube similar like the second (Fig. 12.12), then ligate the second suture. Make a fourth suture similar to the first, and then ligate the third and the fourth suture. Thus complete the *Hong's pancreaticojejunal anastomosis* (Fig. 12.13a,b).

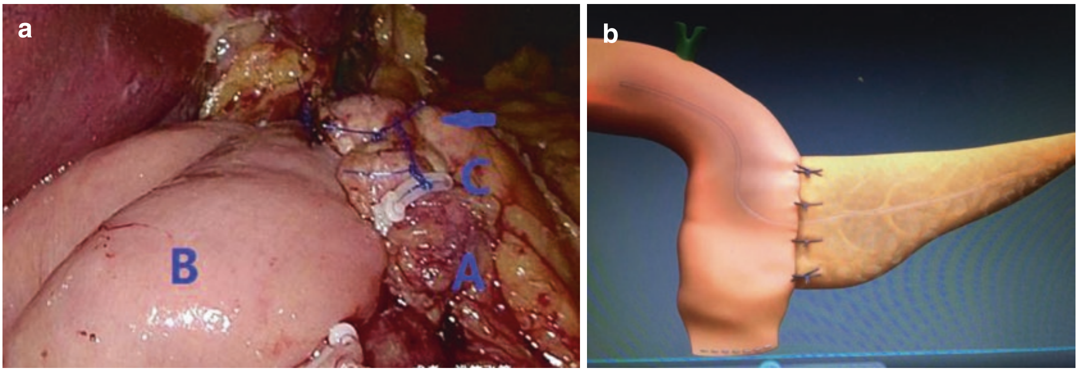

Fig. 12.13 (**a**, **b**) Hong's pancreaticojejunostomy finished

12.3.13 Choledochojejunostomy

The jejunum prepared for choledochojejunostomy should be 10–15 cm far away from pancreaticojejunal anastomosis in case of tension. We suggest 4-0 PDS for this suture, and we strongly suggest a continuous suture for patients whose bile duct is more than 10 mm in diameter. Otherwise, we suggest continuous suture for the posterior wall and discontinuous suture for the anterior wall. A dry gauze must be used to confirm no bile leakage happens. An additional suture might be needed once bile leakage happens.

12.3.14 Gastrointestinal Anastomosis and Nutrition Tube Placement

After a nutrition tube has been placed into the stomach, the distal jejunum should be pulled before colon to perform gastrointestinal anastomosis. The stomach and jejunum seromuscular layer should be sutured together with 4-0 vicaud wire in advance, and a small hole should be cut both on the stomach side and the jejunum side by electric hook. Use a closing stamp to suture the stomach and the jejunum. Be aware no bleeding on the inner wall of the gastrointestinal anastomotic stoma should be left. Pull the nutrition tube into the output loop of gastrointestinal anastomosis for about 20 cm, then suture the incision to complete the gastrointestinal anastomosis.

12.3.15 Free Falciform Ligament of Liver and Ligamenta Teres Hepatis

Free falciform ligament and ligamenta teres hepatis with ultrasonic scalpel. The free end of the ligament is placed behind pancreaticojejunostomy to separate pancreaticojejunostomy from portal vein and GDA stump. For we believe this will protect GDA stump and portal vein from corrosion of pancreatic juice.

12.3.16 Remove the Specimen and Place the Abdominal Drainage Tube

Extended longitudinally the 10 mm incision under the umbilicus to 5 cm, take out the specimen bag with the specimen. Close the 5 cm incision and an artificial CO_2 pneumoperitoneum is re-established. Two abdominal drainage tubes are placed, one anterior to the choledochojejunostomy and the other one at posterior of the pancreaticojejunostomy.

12.3.17 Pathology and Prognosis

Postoperative pathology diagnosis: moderately to poorly differentiated adenocarcinoma of pancreas, nerve, and whole layer of common bile duct wall invaded. One in 16 lymph node is positive, the others are all negative. The patient suffered from postoperative gastroparesis for a time but recovered after conserved treatment. This patient has been followed up for 3 years already, and the latest abdominal CT scan revealed no recurrence.

12.3.18 Comments

LPD has shown promising result compared with open PD in several centers [2–5]. Among them, pancreaticojejunostomy is the key part of a successful LPD. It is complex and correlated with PF, which is the most dangerous complication postoperatively. Although several kinds of pancreatic reconstruction methods have been developed, DTM is the most preferred one. However, traditional DTM methods are so complex and high technique demanding under laparoscopic that they are hard to be reproduced at other centers. Classical DTM methods have some drawbacks under laparoscopy, especially for those patients with soft pancreas or small duct. *Hong's pancreaticojejunostomy* is a modified duct-to-mucosa anastomosis technique compared with traditional DTM.

Hong's pancreaticojejunostomy requires only one stitch on pancreatic duct, one stitch on jejunum, and four stitches in pancreas-jejunum layer. It costs less time and suffers from less bleeding. Fewer stitches are associated with less damage or tear of pancreas parenchyma, related with fewer incidences of postoperative PF. Besides, it is suitable for all the pancreatic duct size especially suitable for soft pancreas with small pancreatic duct. Thus decrease in the incidence of PF. *Hong's pancreaticojejunostomy* has several advantages.

1. Hong's pancreaticojejunostomy is a modified duct-to-mucosa method, and the pancreatic stump is completely imbedded in the serosa of intestine without space. The risk of erosion of pancreatic stump and its related bleeding is decreased. In this study, no postoperative PF-related bleeding was occurred.
2. Anastomosis healing can be divided into growth healing and adhesion healing. Growth healing can be seen in gastrointestinal anastomosis, intestinal anastomosis, etc. The tissues in these anastomosis are similar and with good blood supply, so if these anastomosis is sutured well without tension, it heal quickly with lower risk of leakage.

   The adhesion healing occurs in different tissue parenchymal. Due to inconsistent tissue embryo source and poor blood supply to the tissue, adhesive healing heals slowly, such as fistula, sinus. The healing mechanism of traditional DTM includes growth healing and adhesion healing. The healing of pancreatic duct and jejunum mucosa is growth healing, but the blood supply of the pancreatic duct is significantly worse than the stomach and intestine. If the pancreatic duct is small, quality of anastomosis is usually satisfied. The healing of the pancreatic parenchyma and the jejunum muscle layer is adhesion healing; the healing process is very slow, so pancreaticointestinal anastomosis is prone to pancreaticointestinal fistula.

   Hong's pancreaticojejunostomy change the healing theory of pancreaticojejunostomy completely. The PDT is very important Hong's pancreaticojejunostomy. It connects pancreatic duct and intestinal as artificial fistula. Pancreatic juice was drained completely from pancreas to intestine through this fistula. Sufficient time was provided to wait for the slow adhesion healing of the pancreatic stump and the jejunum. However, stent used in traditional DTM is to identify anterior and posterior aspect of DTM, not for drainage pancreatic juice. Otherwise, electric coagulation burning the corresponding jejunum seromuscular layer can accelerate the adhesion healing of the pancreatic parenchyma and the jejunum muscle layer. So, *Hong's pancreaticojejunostomy is not only technically, but also from the healing mechanism to prevent pancreatic fistula*. Theoretically, if the PDT drains the pancreatic juice completely, no clinically relevant

PF will happen. Only biochemical leak could happen due to small amount of pancreatic juice from pancreatic stump.

3. Hong's pancreaticojejunostomy had only one stitch in pancreatic duct and four stitches in pancreas-jejunum layer. Compared with traditional PJ methods, our technique had less stitches. Hong's pancreaticojejunostomy reduces the time to perform LPJ. The median time of LPJ is 25 min in this serial. However, LPJ time was about 60 min when we use traditional PJ approach (results not show here).

   Less stitch was associated with less damage or tear of pancreas parenchyma, which related with fewer incidences of postoperative PF. The incidence of grade B PF in this serial was 6.3% in our serial and 0.9% grade C PF occurred, better than reported multiple centers OPD and LPD study (10~30%).
4. Pancreatic surgeons come to the consensus that pancreas (texture and size of pancreatic duct), pancreaticojejunostomy and the quality of reconstruction are the most important factors associated with postoperative PF. Hong's pancreaticojejunostomy is a simplified technique, easy to grasp. This simplified PJ method is a safe approach and allow surgeons to finish PJ at a high quality. Hong's pancreaticojejunostomy is especially suitable for those surgeons at learning curve of LPD.
5. Hong's pancreaticojejunostomy is suitable for all the pancreatic duct size especially suitable for soft pancreas with pancreatic duct undilated which is believed to have high risks of postoperative PF. Hong's pancreaticojejunostomy allow surgeons finish LPJ at a high quality easier than tradition PJ in these patients.
6. Our method change the mind that suture of pancreatic duct and intestinal mucosa is not necessary for DTM.

   Our preliminary results are favorable and encouraging. 6.3% patients had grade B PF and 0.9% grade C PF occurred; no PF related postoperative bleeding or mortality. The median PJ time is 25 min, which is shorter than that we are using traditional LPJ method. According to the reasons described above and the encouraging preliminary results. We believed that Hong's pancreaticojejunostomy is a safe technique. Besides this, it is simple, less time-consuming, reproductive, and easy to grasp. Hong's pancreaticojejunostomy is a novel PJ method especially suitable for those who are not so experienced with laparoscopic intracorporeally suturing technique. It can shorten the learning curve for surgeons who start LPD.

12.4 Part 2: Laparoscopic Pancreaticoduodenectomy with Major Venous Resection

12.4.1 Case 2

A 74-year-old woman was admitted due to abdominal pain associated with jaundice for 2 weeks.

The tumor marker CA19-9 was increased to 1575.23 IU/L, CEA was 5.65 IU/L, and other markers such as CA153, CA125, and AFP were normal. Laboratory examinations showed an elevation of liver function tests: ALT 165 IU/L, AST 69 IU/L, ALP 352 IU/L, γ-GT 547 IU/L, TB 210 umol/L, and DB 120.5 umol/L. Abdominal CT scan revealed a mass in the head of pancreas, and a dilation of common bile duct and pancreatic duct. Pancreatic head carcinoma was to be considered and invaded the PV-SMV (Fig. 12.14). Informed consent was obtained from all participating patients, and the ethics committee of Sir Run Run Shaw Hospital, Zhejiang University School of Medicine, approved this study.

After transection of stomach, jejunum, bile duct, and pancreas as described before, the final step of the resection part is to transect the uncinate process. If combined major vein resection is indicated, we stop separating unci-

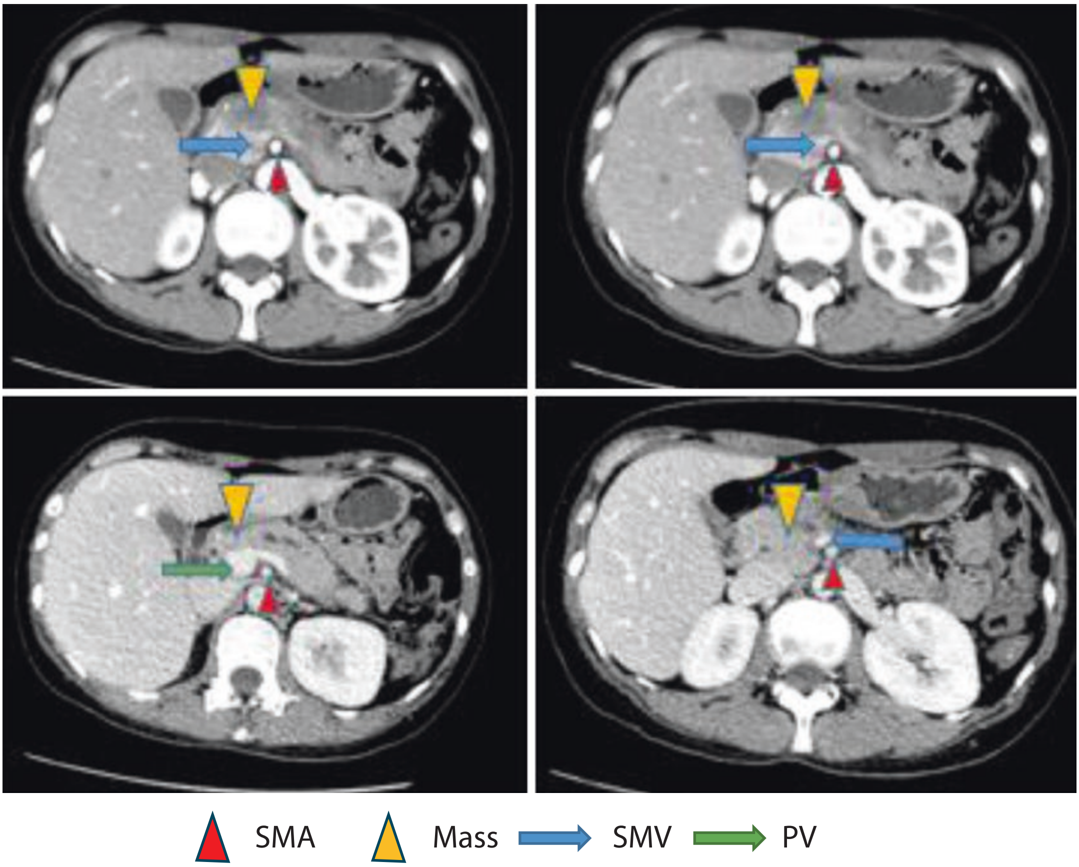

Fig. 12.14 CT scan showed pancreas head carcinoma invaded SMV and PV

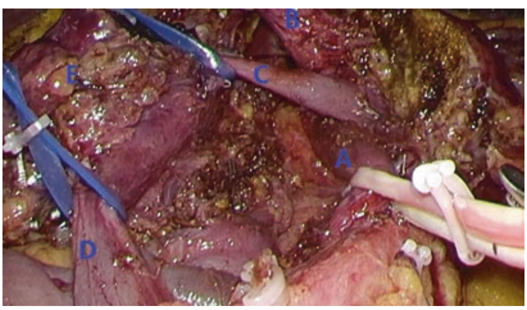

Fig. 12.15 Cut off the uncinated process of the pancreas from the left side of SMV and celiac trunk (A: SMA; B: celiac trunk; C: SPV; D: SMV; E: Specimen)

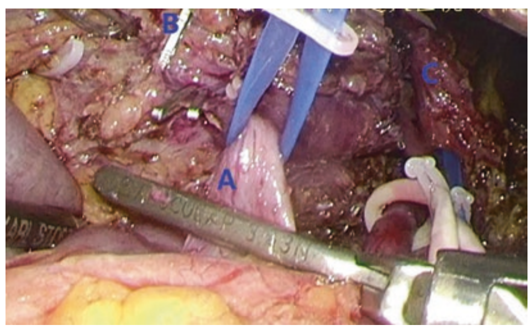

Fig. 12.16 Laparoscopic Bulldog Block SMV

nate process from SMV. The SMV, SPV, and PV are dissociated and roped. The SMA is then dissociated and roped (Fig. 12.15). Pull SMV to right to make a good exposure of the right side of SMA. Transect the uncinate process from the right side from SMA to celiac trunk. Depending on the size of the tension after resection, it is decided whether to transect the spleen vein or not. If the resection of the vein is more than 3 cm, we recommend that the spleen vein should be transected to reduce the tension of the venous anastomosis. Laparoscopic Bulldogs are used to occlude the SMV (Fig. 12.16) and PV (Fig. 12.17). The major veins are transected by scissor, and the specimen sends for frozen resection (Fig. 12.18).

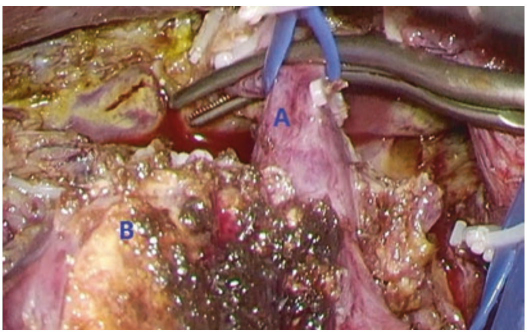

Fig. 12.17 Laparoscopic Bulldog Block PV

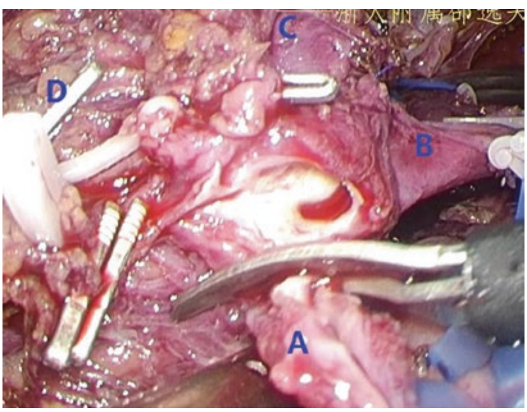

Fig. 12.18 Dissociated the specimen together with invasive SMV and PV

5-0 prolene is applied for vein reconstruction. A simple continuous suture method is used for reconstruction (Fig. 12.19). Adequate growth factor should preserve to avoid stenosis of the anastomosis (Fig. 12.20).

The reconstruction part is same as described before.

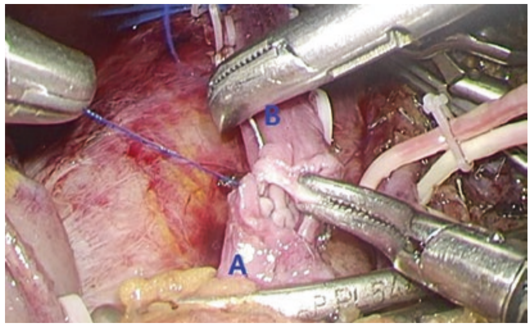

Fig. 12.19 End to end PV-SMV reconstruction of vascular with continuous suture. A: SMV; B: PV

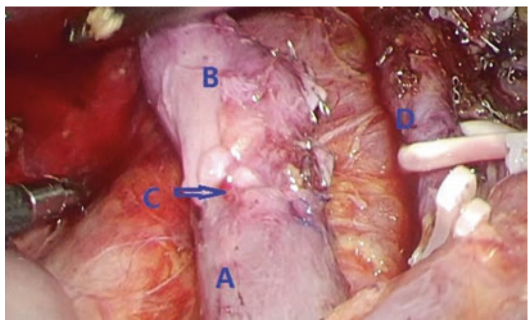

Fig. 12.20 End to end PV-SMV reconstruction succeeded A: SMV; B: PV; C: PV-SMV reconstruction

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13 Laparoscopic Distal Pancreatectomy with Splenectomy

Yu-Hua Zhang

13.1 Introduction

Left-sided pancreatic cancer has poor prognosis because of the low resectibility. However, surgical resection remains the only chance for a potential long survival for these patients. Distal pancreatectomy with splenectomy is the standard resection procedure. While in 2003, Professor Strasberg introduced a modified distal pancreatectomy with splenectomy, radical antegrade modular pancreatosplenectomy (RAMPS) [1]. It emphasizes on improving tangential margins as well as obtains enough N1 lymph node clearance for these patients. With recent years' development, RAMPS has gained more and more consent in pancreatic surgeons. Theoretically, it has survival advantages over standard resection. However, because of the limited clinical cases, this should be proven future with more evidences [2].

Laparoscopic left pancreatectomy with or without splenectomy has been accepted by more and more pancreatic surgeons because it has been proved to be a safe and feasible procedure for benign and borderline malignant tumors [3]. More and more surgeons try to use laparoscopic technique to perform resection of left pancreatic adenocarcinoma. And some experienced surgeons also reported laparoscopic RAMPS [4].

The pancreatic surgeries style changed recent years especially with improving skill of vein reconstruction, the key point whether pancreatic cancer is resectable or not mostly depends on the relationship between tumor and the arteries such as superior mesentery artery and/or celiac trunk. So, artery first approach was introduced in pancreatic surgeries [5]. In pancreaticoduodenectomy, numerous artery first approaches have been reported, while artery first was not so common in distal pancreatectomy. Because the arteries are on the back of the pancreas, it is difficult to expose them without transection of pancreas [6]. Traditional, surgeons arrive at the artery area after transect pancreas when performing left pancreatectomy. However, this is a point of no return, which means surgeons have to do pancreatectomy with positive margin if you find the artery is involved by tumor after transection of pancreas.

Due to the different view of laparoscopic surgery and magnify of local anatomy, laparoscopic surgery has advantages in exposing and dissecting retropancreatic areas compared with open surgery before transect of pancreas. So laparoscopic technique has advantages in artery first RAMPS procedure.

13.2 Case

This is a 67-year-old male patient. He was admitted because of found a pancreatic mass for 5 days. No jaundice, no abdominal pain, and no

Y.-H. Zhang (✉)
Zhejiang Provincial People's Hospital, People's Hospital of Hangzhou Medical College, Hangzhou, China

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abdominal mass were found in physical examination. Laboratory test: liver function and CBC was in normal range. The tumor marker CA19-9 was increased to 37.1 kU/L, CEA: 6.1 U/L and others were normal. The abdominal ultrasonography (US), abdominal computed tomography (CT), and MRI showed a mass in the body of the pancreas (Fig. 13.1a, b). The tumor is about 3 cm in diameter. Endoscopic ultrasonography finds similar results. Preoperative diagnosis was pancreatic cancer. After MDT, surgery, first strategy was decided. And laparoscopic RAMPS procedure was planned.

Informed consent was obtained from all participating patients, and the ethics committee of Zhejiang Provincial People's Hospital, People's Hospital of Hangzhou Medical college, approved this study.

13.3 Detail of Procedure

13.3.1 Preparation for Operation

Patient was in a supine position with legs apart and secured firmly on the bed.

Two surgeons stand on both side of the patient, and another surgeon stands between patient's legs to control the optic trocar.

One 12-mm, two 10-mm, and two 5-mm trocars were introduced. Beside these trocars, another small incision (2–3 mm) was made at left side of subxiphoid area for stomach hanging maneuver. The position of trocars was shown in Fig. 13.2a, b. Laparoscopic energy devices such as LigaSure and ultrasonic knife were used to perform operation.

13.3.2 Laparoscopic Explorations

To detect organs that can be seen inside the abdominal cavity, including liver, peritoneum, greater omentum, etc. Make sure there is no visible metastasis.

13.3.3 Division of Gastrocolic Ligament and Stomach Hanging Maneuver

Gastrocolic ligament was divided near the stomach, and the blood supply of the stomach should be preserved as possible as we can (Fig. 13.3a, b). The stomach was hanged on the front abdominal wall using an elastic belt such as urethral tube. This tube was pull out of the abdominal wall through a small incision in left side of subxiphoid

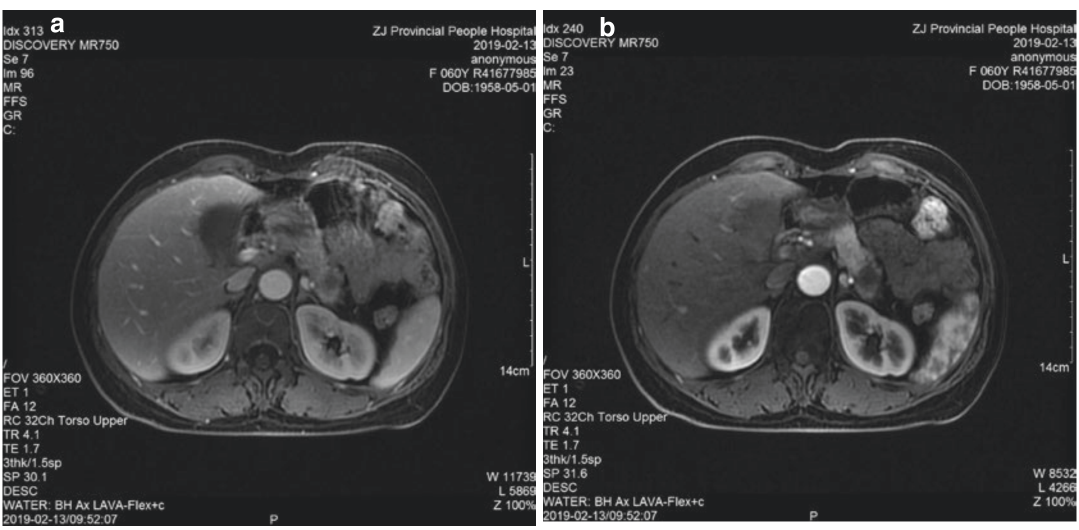

Fig. 13.1 (**a**, **b**) MRI showed a mass in the body of the pancreas

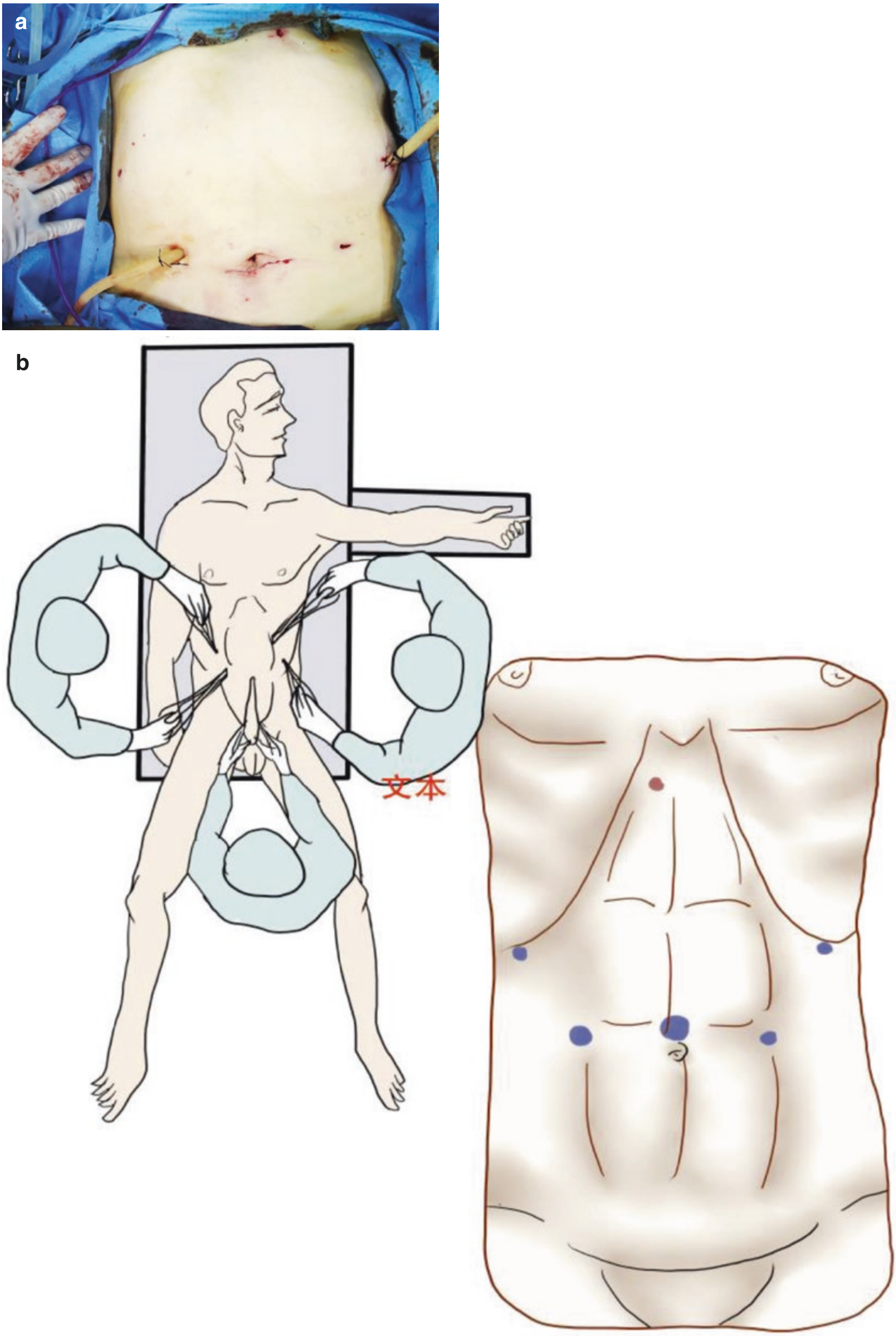

Fig. 13.2 (**a**, **b**) The position of trocars

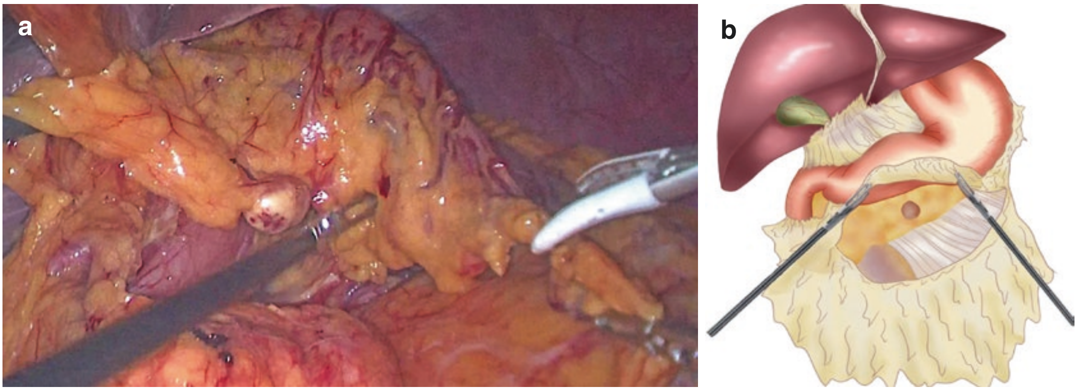

Fig. 13.3 (**a**, **b**) The blood supply of the stomach should be preserved

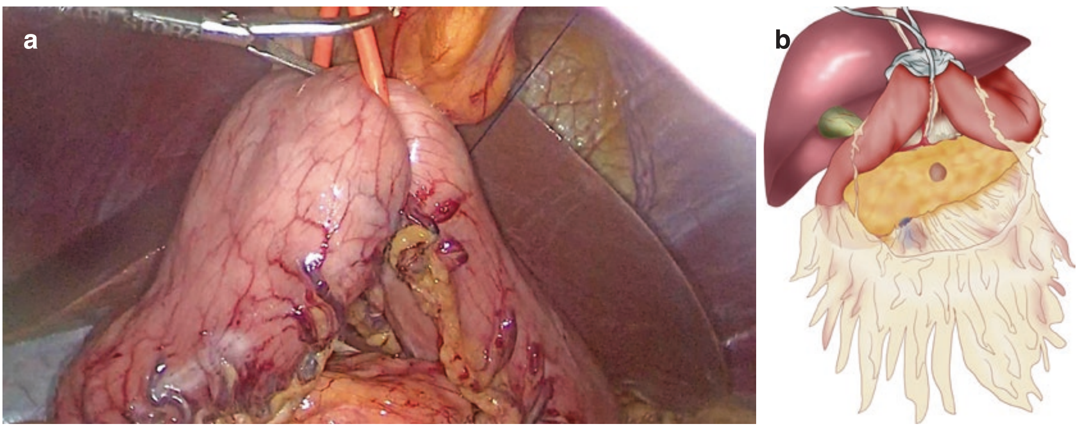

Fig. 13.4 (**a**, **b**) Exposure of the pancreas

area (Fig. 13.4a, b). Make sure there is a good exposure of the pancreas.

13.3.4 Dissect the Neck of Pancreas

Dissection of pancreatic neck usually starts at superior border. No. 8a lymph node was resected and sends for frozen resection if possible. After this, the common hepatic artery and gastroduodenal artery are detected, and the common hepatic artery is looped. Find the right space between common hepatic artery and pancreas and try to make it as big as possible; this makes next step (create retropancreatic tunnel) much easier. Usually, the splenic vein or portal vein can be detected in this space. Then we turn to the inferior board of pancreas. Find the right space between the pancreas and superior mesenteric veins and make the retropancreatic tunnel. The pancreatic neck was then looped (Fig. 13.5a, b).

13.3.5 Dissect the Retropancreatic Area

The transverse colon was retracted upward, and ligament of Treiz was exposed. The first part of intestine was pulled to the right side gently to make a good exposure of the Treiz ligament. After mobilizing the left side of the duodenum, the duodenojejunal flexure was rotated to right, aorta, inferior vena cava, and left renal vein was found. SMA could be found on cephalad side of left renal vein, followed by celiac trunk.

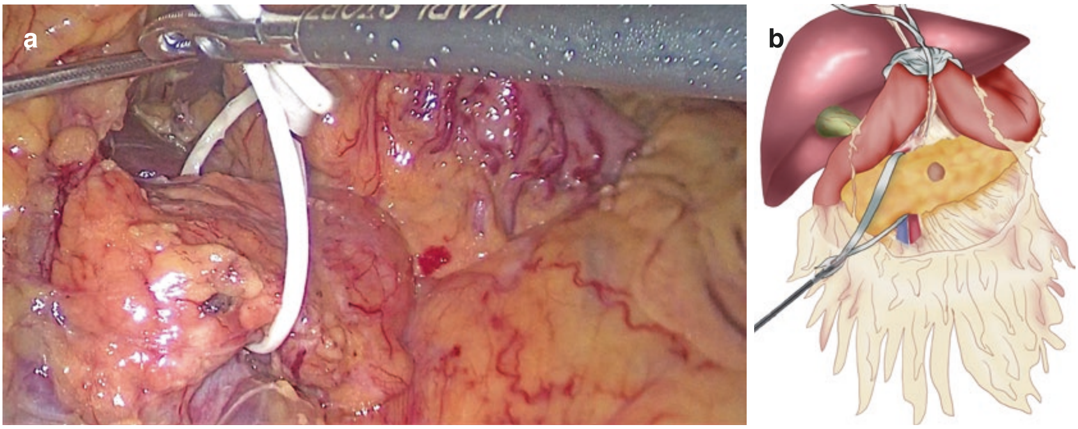

Fig. 13.5 (**a**, **b**) The pancreatic neck was looped

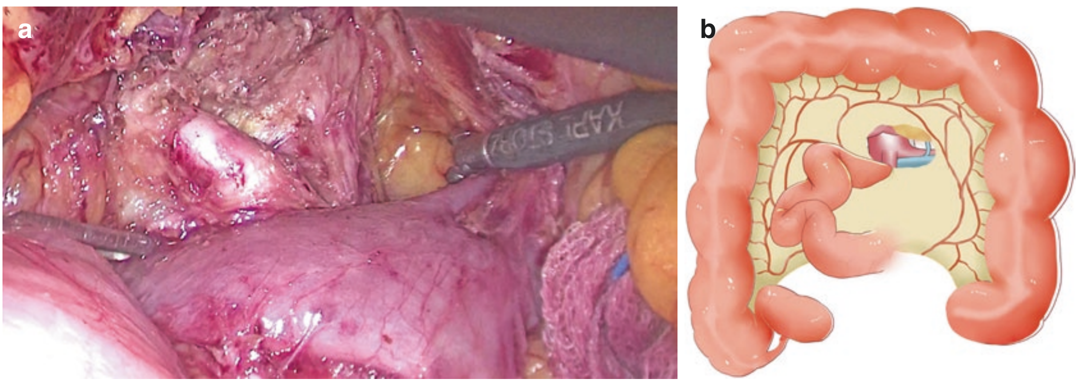

Fig. 13.6 (**a**, **b**) All the soft tissues on the left side of SMA and CT were completely removed

All the soft tissues on the left side of SMA and CT were completely freed from the arteries (Fig. 13.6a, b). Frozen section of these tissues were send if possible, and here we can make sure whether this is a resectable case or not.

13.3.6 Transect Pancreas, Splenic Vein, and Splenic Artery

The transverse colon was pulled downward. An endoscopic stapler was usually used to divide pancreatic neck followed by dividing the splenic vein and splenic artery (Fig. 13.7a, b). The soft tissues on the right side of superior mesentery vein were transected from the ventral side to the back side. The previously established space at the right side of the arteries was countered (Fig. 13.8).

13.3.7 Remove the Ramps Specimen

The connective tissues anterior and to the left of the superior mesenteric artery, between the celiac artery and superior mesenteric artery, are completely swept with this step. The resection line was then following the left side of aorta in the sagittal plane onto the diaphragm making the right board of RAMPS. The connective tissues on the left border of the proper hepatic artery and portal vein and the lymph nodes around the common hepatic artery are swept. After the right border was decided, the dissection plane turns to left. The left renal vein was the inferior border of the RAMPS. The posterior dissection plane depends on the tumor stage, if the plane that is left adrenal is preserved; the posterior plane of RAMPS was anterior surface of renal vein, adrenal surface,

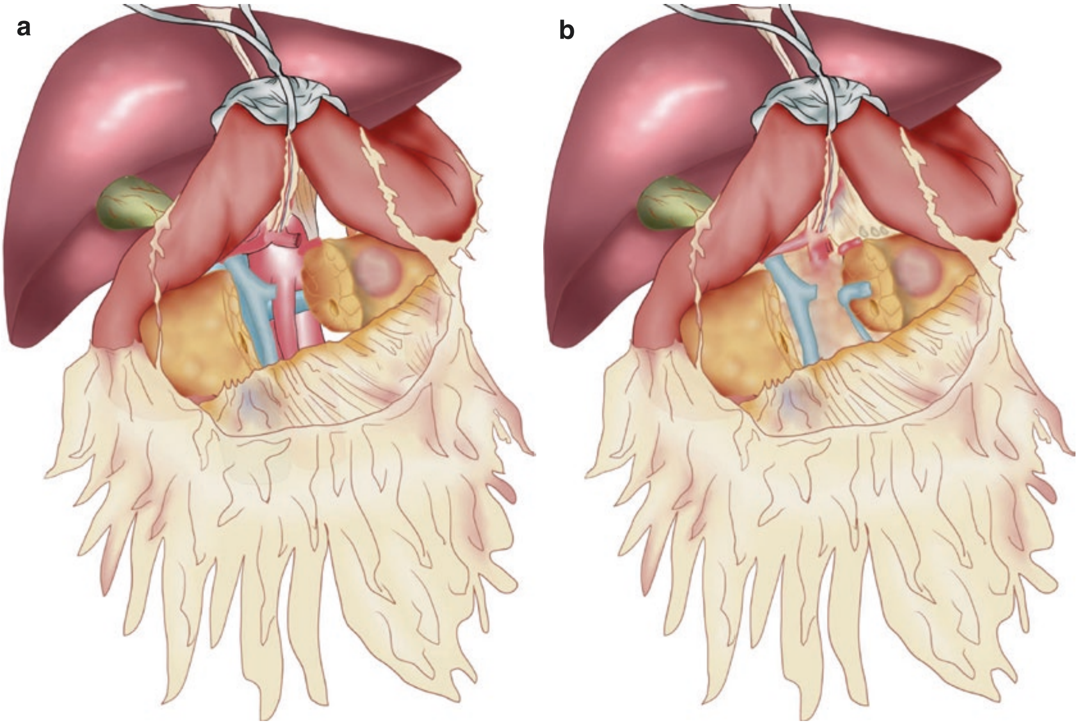

Fig. 13.7 (**a**, **b**) The splenic artery was cut off

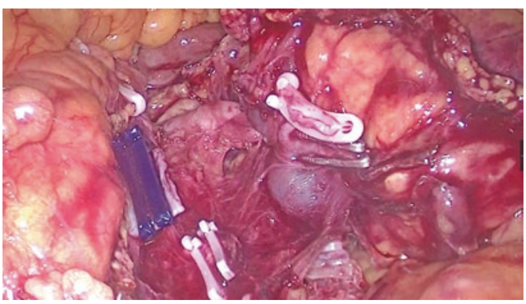

Fig. 13.8 The previously established space at the right side of the arteries was countered

and kidney. If the planned posterior plane of dissection is posterior to the adrenal, the dissection is carried down to the left side of the aorta. The left-sided pancreas with Gerota's fascia was removed en bloc (Fig. 13.9a, b).

13.3.8 Extraction of Specimen and Drainage

The specimen was put in a bag and took out of abdomen through a 3–4 cm incision in per umbilical area (Fig. 13.2a), and specimen margins were sent for frozen resection (Fig. 13.10). Two drainage tubes were placed, one near stump of pancreatic and another placed at left upper abdomen.

13.4 Postoperative Results

The patient recovered uneventfully without pancreatic fistula or other morbidity. After CT scan, two tubes were removed at fourth and fifth days after operation. He was discharged 8 days after operation.

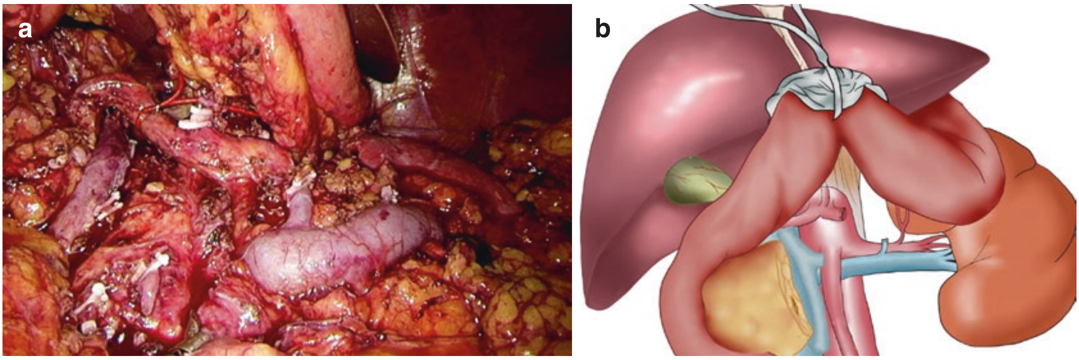

Fig. 13.9 (**a**, **b**) The left-sided pancreas with Gerota's fascia was removed

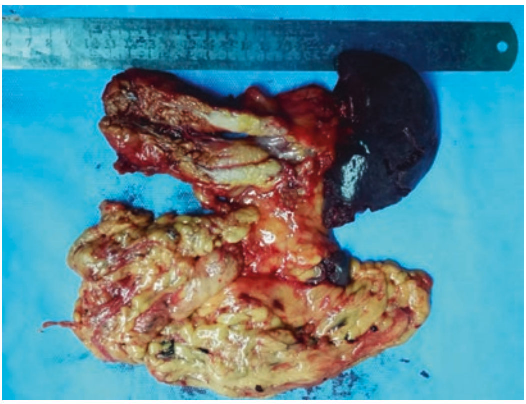

Fig. 13.10 The specimen

13.5 Pathological Results

Intraoperative frozen section result confirmed pancreatic duct adenocarcinoma, the cutting margin is negative. Final pathologic diagnosis is moderately differentiated pancreatic duct adenocarcinoma (grade II) without venous infiltration. Eleven lymph nodes including peripancreatic lymph nodes [3], the superior mesenteric artery lymph nodes [4], and No.12 lymph nodes [4] were dissected, and none of them was positive.

Follow-up results:

Eleven months after surgery, follow-up CT and tumor marker revealed no recurrence.

13.6 Comments

For patients with left pancreatic cancer, RAMPS allows them to have a potential better survival with acceptable risks. Laparoscopic RAMPS is technically feasible. This laparoscopic inframesocolic SMA-first RAMPS takes the advantages of laparoscopic technique and using the characteristics of local anatomy. It allows surgeon to arrive at SMA and celiac trunk directly before transection of pancreas, which enables an early judgment of an involvement of the arteries during operation.

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14 Laparoscopic Distal Pancreatectomy with Splenic Preservation

Wei Cheng

14.1 Introduction

Since laparoscopic distal pancreatectomy with splenectomy (LPDS) was first reported by Cuschieri [1] in 1996, laparoscopic surgery has been widely applied in the field of pancreatic surgery with the gradual improvement on laparoscopic surgery proficiency and the rapid development of laparoscopic surgical instruments. Nowadays, laparoscopic distal pancreatectomy has gradually become the preferred surgical method for the treatment of distal pancreatic lesions [2].

Due to the close anatomical relationship between distal pancreas and spleen, LPDS has always been the classical operation method for distal pancreas lesions. With the development of the precise surgery and the further recognition of the functions of spleen, splenic preservation during LPDS has become a new pursuit in modern pancreatic surgeons. For benign or low-grade malignant lesions of the distal pancreas, laparoscopic distal pancreatectomy with splenic preservation (LSPDP) is undoubtedly the best choice in the condition of patients without preexisting spleen diseases [3]. There are two main ways to preserve spleen: Kimura method and Warshaw method. The former one is spleen-preserving distal pancreatectomy with conservation of the splenic vessels (Fig. 14.1a), which is the most widely used method of spleen preserving at present. The latter one was the resection of splenic vessels with conservation of spleen collateral circulation, for example, short gastric vessels and left gastroepiploic vessels. (Fig. 14.1b) [4–6].

For benign, borderline and low-grade malignant lesions of the distal pancreas, Kimura method is the first choice for LSPDP due to its superiority for completely preserving all blood flow of the spleen. But sometimes the spleen blood vessels are difficult to separate because of local adhesions and inflammation, Warshaw method or combined splenectomy was considered. A case of LSPDP in Kimura method is represented below.

14.2 Case

A 56-year-old woman presented to hospital with repeated left upper abdominal pain for 1 month. Computed tomography (CT) in the community hospital showed a cystic and solid mass at the junction of the body and tail of the pancreas, which is high and probably considered as serous cystadenoma in imaging diagnosis, but the possibility of solid pseudopapillary tumor could not be excluded. Physical examination: no jaundice, deep tenderness of left upper abdomen, no rebound tenderness, and no

W. Cheng (✉)
Hunan Provincial People's Hospital, Changsha, China

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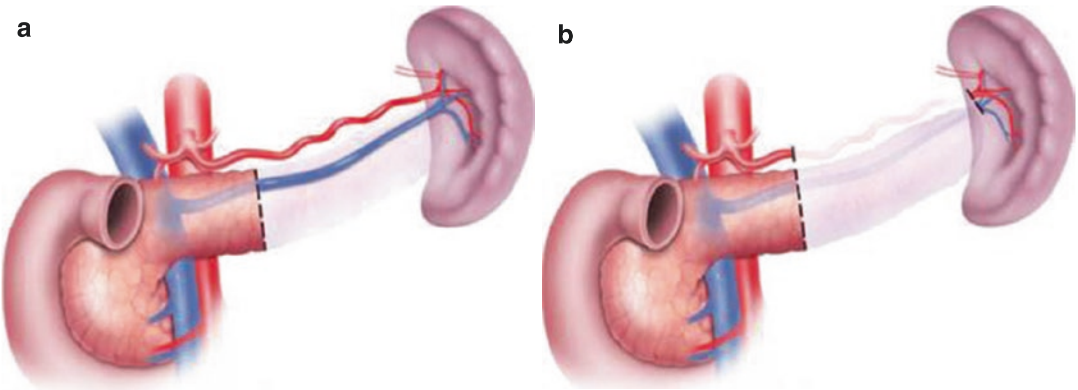

Fig. 14.1 (**a**) Spleen-preserving distal pancreatectomy with conservation of the splenic vessels—Kimura method (Reproduced with permission from [6]). (**b**) Splenic arterial and splenic vein resection with splenic preservation—Warshaw method (Reproduced with permission from [6])

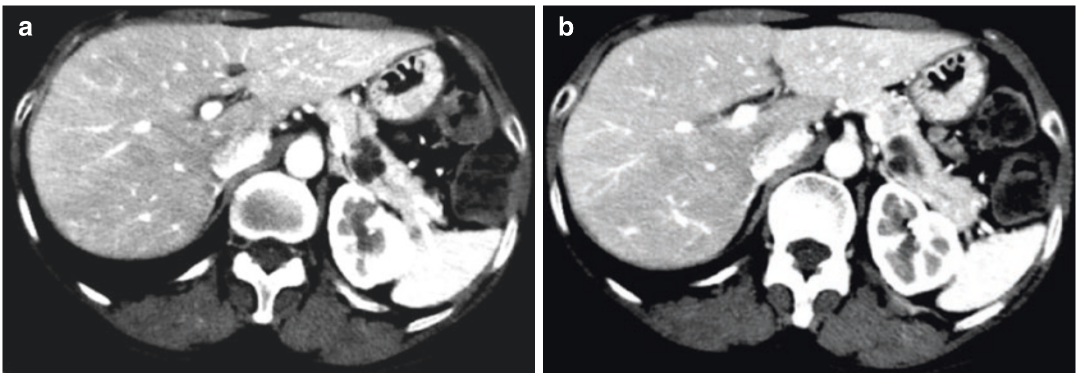

Fig. 14.2 (**a**, **b**) CT image showed a cystic mass in the distal pancreatic lesions

palpable mass in the whole abdomen. Laboratory examination: blood routine, liver and kidney function, amylase, CA199, CA125, and CEA were normal.

Abdominal CT showed a low-density mass at the junction of the body and tail of the pancreas, no dilatation of main pancreatic duct, which was considered as cystadenoma in imaging diagnosis (Fig. 14.2a, b). Abdominal magnetic resonance imaging (MRI) showed a cystic mass with smooth edge and septal changes at the junction of the body and tail of the pancreas, which was considered as serous cystadenoma in imaging diagnosis (Fig. 14.3).

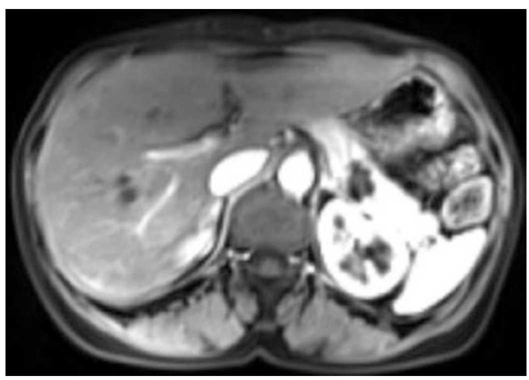

Fig. 14.3 MRI image showed a cystic mass in the distal pancreatic lesions

According to the patient's history, physical examination, and auxiliary examination, the diagnosis was considered as serous cystadenoma of the distal pancreas. Because of the recurrent pain in the left upper abdomen, the patient exists operative indication. For the reason that the patient did not pre-exist spleen diseases, LSPDP could be performed in Kimura method.

Informed consent was obtained from all participating patients, and the ethics committee of Hunan Provincial People's Hospital approved this study.

14.3 Details of Procedure

14.3.1 Patient Position and Trocar Placement

The patient was positioned at supine straddle position. The surgeon stands to the right of the patient; the primary assistant stands to the left, while the camera operator stands between the patient's legs. First, a 12-mm trocar was placed 1 cm below the umbilicus for the laparoscopy, two more 5-mm trocars then were placed at 2 cm below the right subclavian midline, and 5 cm below the left subclavian midline, respectively. Another 12 mm Trocar was placed at the conjunction between the left clavicular midline and the umbilicus line (Fig. 14.4a, b).

14.3.2 Exposure of the Distal Pancreas

The lesser sac is widely opened by dissecting the gastrocolic ligament near the great curvature of the stomach using Ultrasound dissector or Ligasure from the splenic hilum on the left to the neck of the pancreas on the right. Then the part of the splenocoloic ligament was opened. With the traction of the greater omentum and transverse colon by the primary assistant, the lesion in the body and tail of the pancreas together with the relationship between splenic hilum and splenic vessels were exposed. The stomach was suspended by the suture on the anterior abdominal wall to provide sufficient operating space and gain access to the body and tail of the pancreas (Fig. 14.5a).

14.3.3 The Dissection of the Pancreas

The inferior border of the pancreas is dissected from the neck of the pancreas, and the superior mesenteric vein and the beginning part of splenic vein were confronted (Fig. 14.5b). There is a layer of loosen tissue between the vein and the pancreatic parenchyma, which is easy to separate. Then splenic vein and pancreatic parenchyma were separated from the beginning of the splenic vein to the splenic hilum. After the superior border of the pancreas had been detached, dissection of the splenic artery from the pancreas, located at the upper portion of splenic vein, was undertaken using same method (Fig. 14.5c). The posterior pancreatic tunnel was completely dissected along the superior mesenteric vein and the beginning of the splenic vein, and the neck of the pancreas was suspended with silk thread (Fig. 14.5d).

14.3.4 Distal Pancreatectomy

The pancreas was transected at the neck of the pancreas with Endo-GIA stapler. The splenic artery and splenic vein needed to be protected during the transection process. No active hemorrhage or pancreatic leakage was confirmed after the separation of the pancreas. The broken end of the pancreatic duct was ligatured and closed with suture when necessary (Fig. 14.5e). Frozen-section margin examination was performed. The pancreas was lifted cephalad and anterior, then the splenic vein and splenic artery are progressively dissected and freed from the tail of the pancreas from right to left by using the ultrasonic scissors. Small venous branches serving the pancreas should be divided and ligated. With dissecting to the splenic hilum, the tail and body of the pancreas was completely resected (Fig. 14.5f, g).

14.4 Pathology and Prognosis

Figure 14.6a is the photo of the resected specimen. Postoperative pathological results showed about $3 \times 3\ cm^2$ polycystic mass in the distal pancreas. The pathological diagnosis was serous cystic tumor (Fig. 14.6b, c), and the resection margin was negative. The recovery of the patient was smooth; no complications such as pancreatic leakage, bleeding, or infection were happened. The amylase of abdominal drainage fluid

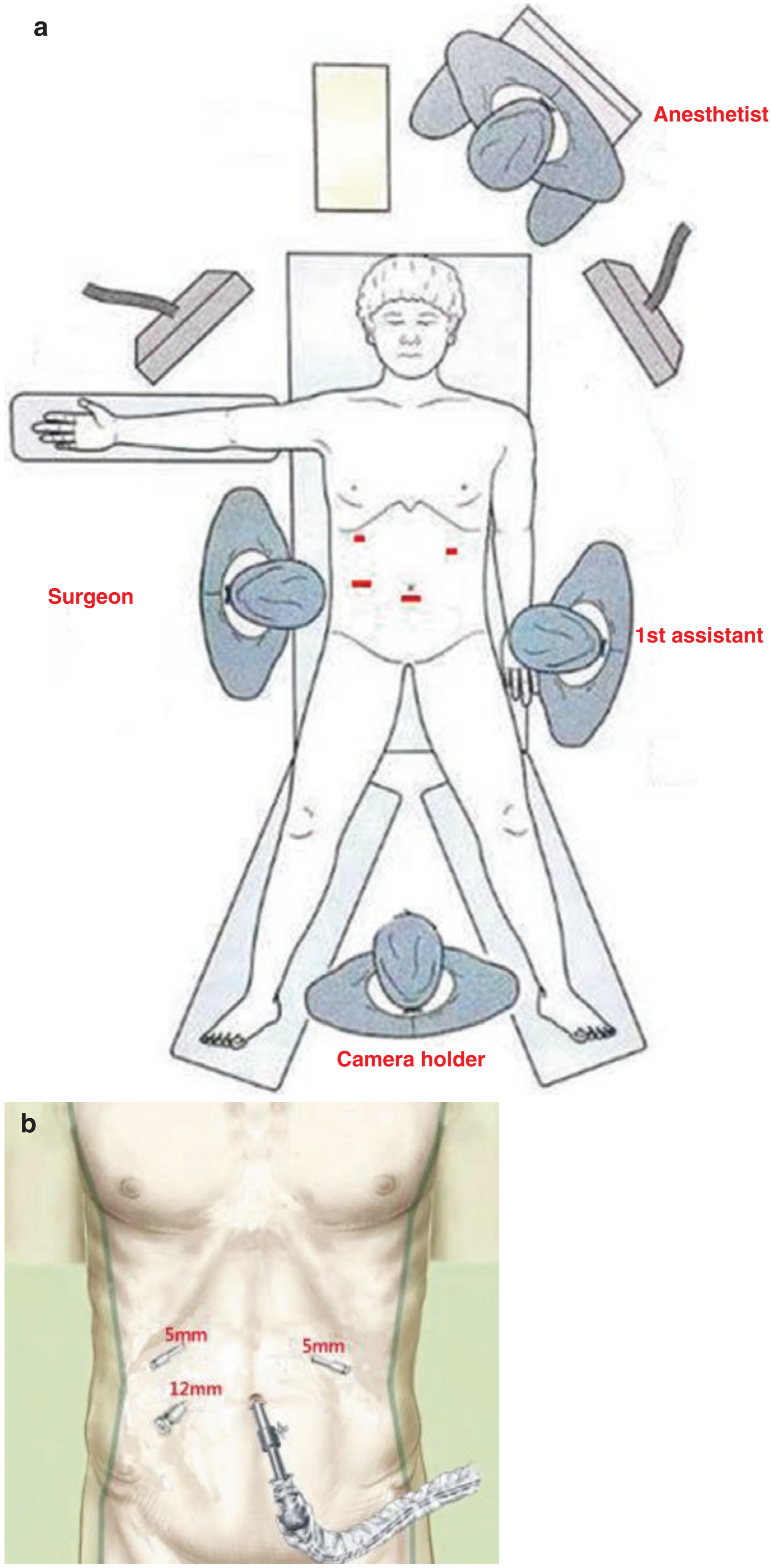

Fig. 14.4 (**a**) Patient position and operation layout. (**b**) Trocar placement

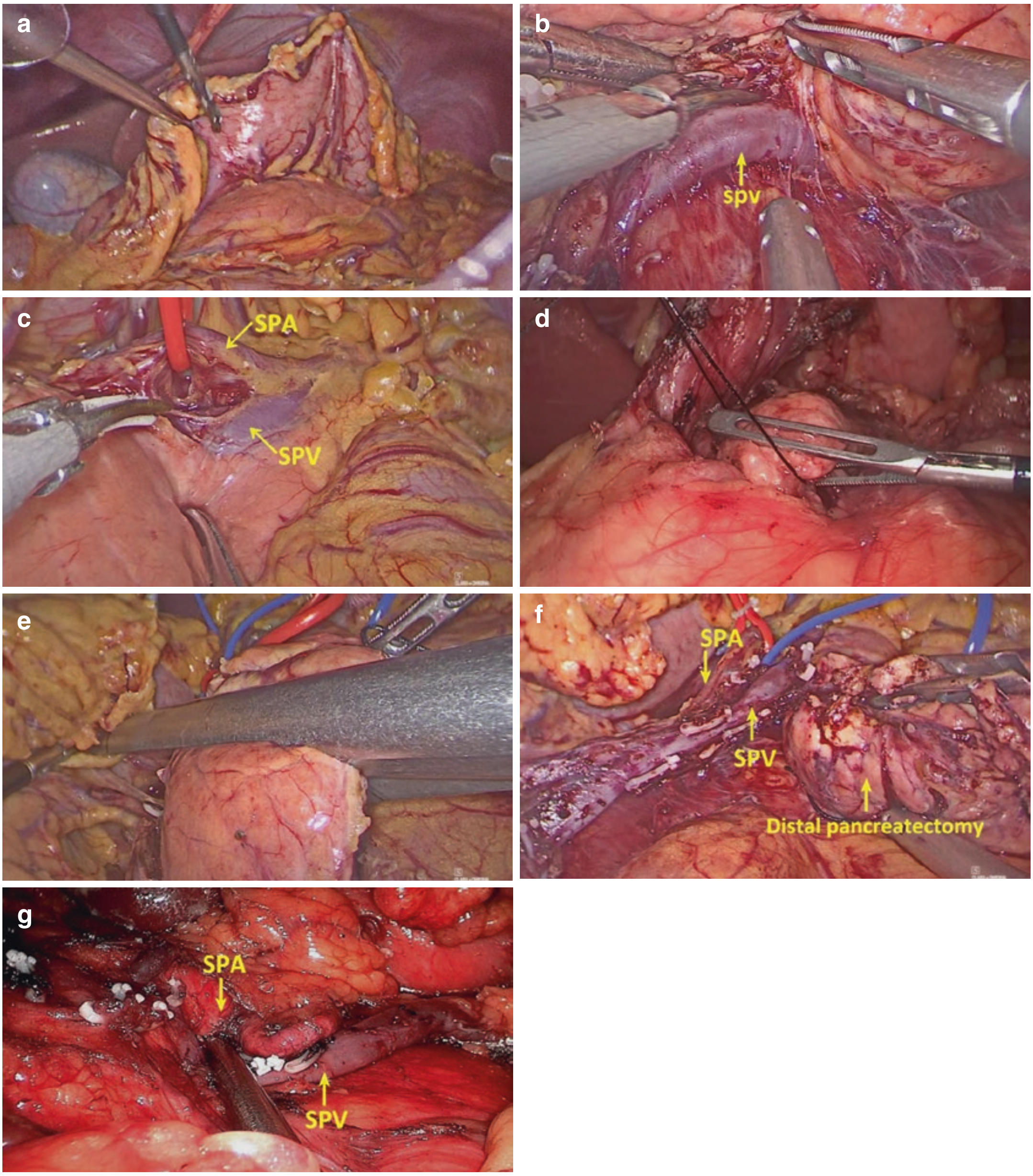

Fig. 14.5 (**a**) Exposure of the distal pancreas. (**b**) Free splenic vein. (**c**) Free splenic artery. (**d**) The pancreas is suspended with silk thread. (**e**) The pancreas is severed at the neck of the pancreas. (**f**, **g**) Splenic artery and splenic vein were completely dissociated and resected from the distal pancreas

was 857 U/L, 432 U/L, and 130 U/L on the first, second, and third days after operation, respectively. The abdominal drainage tube was pulled out after CT reexamination on the fifth day after operation. The patient was discharged on the sixth day after operation. The patients were followed up for 7 months, and no compliants were responded.

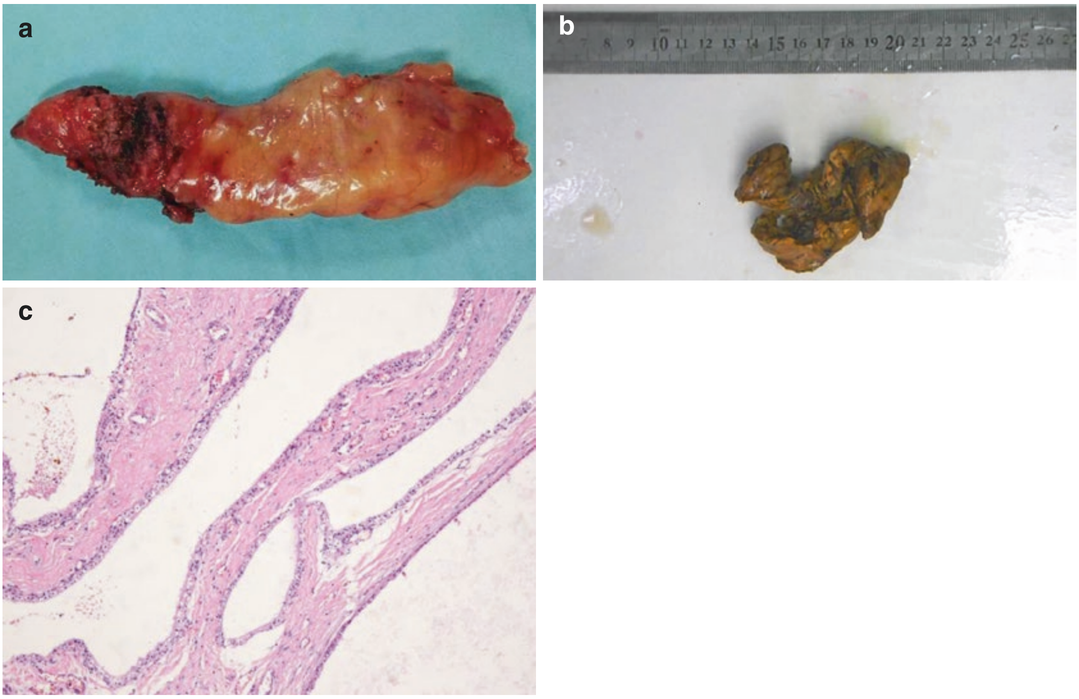

Fig. 14.6 (**a**) The resected specimen. (**b**) Surgical specimens. (**c**) Pathological section

14.5 Comment

Preservation of the splenic blood supply is the core of LSPDP. Kimura method well preserves it and can avoid splenic infarction. It is the first choice when there is no substantive adhesion between the lesion and splenic artery, or vein and local inflammatory are mild. But the operation is relatively difficult. However, the splenic artery and vein were severed in Warshaw method, and only the spleen collateral circulation was retained to provide splenic blood supply. The advantages of this operation were relatively simple. It is the first choice when it was difficult to separate distal pancreatic lesions safely from the splenic vessels. In some cases when it is difficult to repair the splenic artery or vein injury during the operation, this method is also adopted. But splenic infarction and abscess or regional portal hypertension may occur because of insufficient collateral circulation [7, 8].

The Kimura method is more in line with anatomy and physiology, so it is more often the first choice in use. The safe and effective separation of splenic artery and vein is the key to the operation. It is safer to free splenic artery and vein from the neck of the pancreas to the splenic hilum because the anatomic structure is easy to identify, and less branches of the splenic artery and vein will enter into the pancreas. If the tumor is located in the tail of the pancreas, it is necessary to transect the pancreas more close to the left in order to retain more pancreas, making it more difficult to free splenic blood vessel. Under these circumstances, we can free splenic blood vessel with both antegrade and retrograde method. The splenic vein often traverses in the middle of the dorsal side of the pancreas, and the wall of the splenic vein is thin and easy to tear, so it is more difficult to separate the splenic vein than the splenic artery, which means the separation of vein needs more patience and skill. The serosa of the lower margin of the pancreas should be fully opened in the first step, then the pancreas and the splenic vein should be stripped from the retroperitoneum together; after the pancreas are turned over to the head side, the splenic vein located in the loose tissue (Toldt fusion fascia) is distinguished from the dorsal side of the pancreas. In final step, fine ligation of splenic vein branches is completed.

Laparoscopic distal pancreatectomy with splenic preservation, which has obvious advantages in the surgical treatment of distal pancreas lesions, has become the first choice for many centers. The method is worth popularizing, and open surgery will be gradually replaced.

Even though it is technically difficult to perform laparoscopic surgery, the characteristic of more clear and amplified visual field provided by laparoscopy can never be beat. Therefore, when coming across some refine manipulation of vessel, laparoscopic surgery would be a better choice. Numerous new laparoscopic devices are making operation easier and safer. For instance, Endo-GIA Stapler simplified the suture of the pancreas, and the energy device makes it safer and more reliable to distract the small branches that originated from the spleen vessels and injected in the pancreas. Adequate operating space and proper use of laparoscopic equipment are the key to successful surgery. At the same time, we cannot ignore the teamwork and laparoscopic suture. The difficult part of the Kimura method lies in the exposure and protection of the spleen blood vessel. Blood vessel breakage and bleeding during the operation is inevitable. In this case, the well-trained doctors and the excellent suture skills will be a firm basis for successful surgery.

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15 Role of Staging Laparoscopy for Pancreatic Cancers

Dan-Lei Chen and Cheng-Hao Shao

15.1 Introduction

Staging laparoscopy, as a less-invasive approach for the detection of peritoneal metastases compared with traditional open exploration, became a commonly accepted practice for treating patients with presumed resectable pancreatic cancer in the1990s [1]. A decade later, with the introduction of high-resolution CT scans, a selective approach became common practice [2]. Laparoscopy was considered in what were deemed “high-risk” patients without ever determining reliable selection criteria, resulting in laparotomy without therapeutic benefit in 6–26% of all patients who undergo operative evaluation [3, 4]. Today, with the introduction of high-resolution laparoscopes, the indication for staging laparoscopy in pancreatic cancer is evolving and remains under debate. The aim of this article is to evaluate the efficacy of staging laparoscopy in pancreatic cancer, with the goal of identifying an optimal operative staging strategy for this patient group.

15.2 Case

The patient was a 66-year-old man admitted to our hospital because of upper abdominal distension and pain more than 2 weeks. Laboratory examinations showed that tumor marker CA19-9 was increased 1102.96 U/mL, others were normal.

The abdominal ultrasonography (US) and abdominal computed tomography (CT) showed a mass of slightly low-density lesions with a length of about 3.1 cm. The enhancement scan showed slightly delayed enhancement. The lesion surrounded SMA and its branches, and the boundary between the lesion and the horizontal part of the duodenum was not clear. Uncinate process of pancreas adenocarcinoma was considered (Fig. 15.1a, b).

The EUS + FNA shows a pancreatic uncinate hypoechoic mass, size about 42 × 35 mm, with unclear boundary, crab-like changes, partially wrapped SMA, puncture pathology suggests adenocarcinoma, source of pancreatic duct (Fig. 15.2).

The digital reconstruction of 3D images was performed, shows tumor invasion of SMA, SMV, and its branches (Fig. 15.3a, b).

From these findings, a diagnosis of pancreatic duct adenocarcinoma located in the uncinate process was made and staging laparoscopy was performed.

Informed consent was obtained from all participating patients, and the ethics committee of Changzheng Hospital, Naval Military Medical University, approved this study.

D.-L. Chen · C.-H. Shao (✉)
Pancreaticobiliary Surgery Department, Changzheng Hospital, Naval Military Medical University, Shanghai, China

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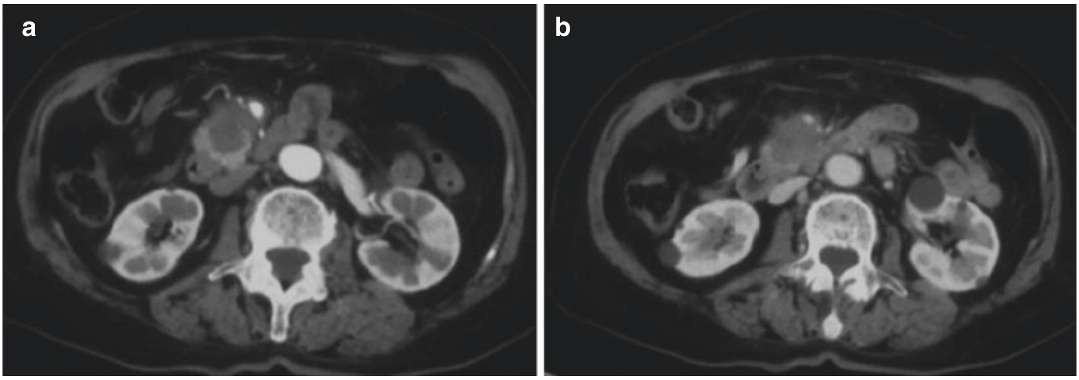

Fig. 15.1 (**a**, **b**) CT image showed a mass in the uncinate process of the pancreas

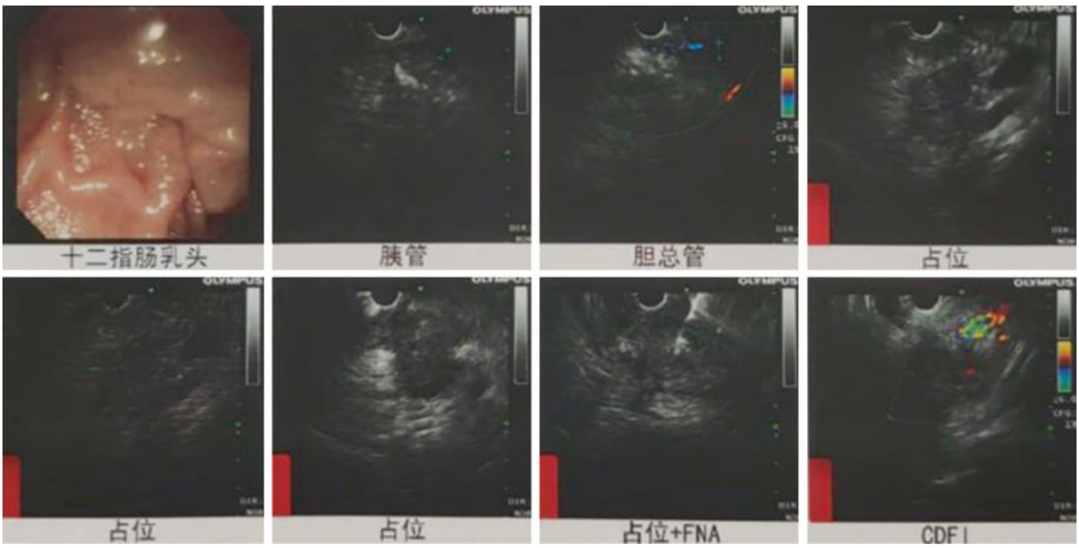

Fig. 15.2 EUS + FNA shows a pancreatic uncinate hypoechoic mass. Puncture pathology suggests adenocarcinoma, source of pancreatic duct

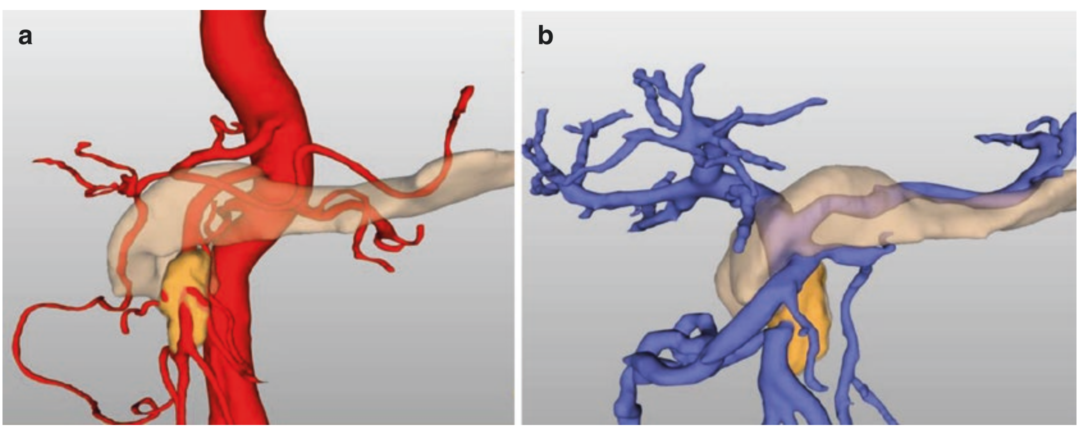

Fig. 15.3 (**a**, **b**) 3D reconstruction images revealed the correlation of the mass and the portal vein, SMA, and SMV

15.3 Important Details of Procedure

15.3.1 The Trocar Placement and Abdominal Exploration

The proposed procedure of extended staging laparoscopy would include placement of a laparoscopic port near the umbilicus. If standard laparoscopy, which should be performed with a high-resolution, 10-mm, 30-degree laparoscope, does not reveal peritoneal metastases in the greater sac, three additional laparoscopic ports should be placed in a configuration as shown in Fig. 15.4. Under this configuration, the liver can be elevated, allowing examination of its posterior surface, and the transverse colon can be retracted allowing examination of the proximal jejunal mesentery. In the absence of visible metastases, the lesser sac can be entered by dividing the gastrocolic ligament using an ultrasonic dissector. If there is still no evidence of metastases, the duodenum can be mobilized if needed to examine the paraduodenal retroperitoneum. The port placement shown in Fig. 15.4a is, in our opinion, best suitable to accomplish these tasks. Most of the laparoscopic incisions can easily be incorporated into the incision and drains placed for any open resection (Fig. 15.4b, c).

15.4 No Metastases Were Found Under Laparoscopy, So We Performed Pancreaticoduodenectomy

15.4.1 Laparotomy Exploration

The uncinate part of the head of the pancreas is a solid mass of about 3.5 × 2.5 × 2 cm, which grows downward, and is hard, indicating that it is not smooth, and is closely related to the surrounding organs. The tumor surrounds the CA, SMA, SMV, and its branches.

15.4.2 Dissection of the SMA and SMV

Follow the arterial first pathway, carefully dissect the SMA and SMV trunks and branches at mesenteric root, be careful not to destroy the main branches of SMA. Move the tumor along with part of the SMV and perform the PV/SMV anastomosis (Figs. 15.5a, b and 15.6).

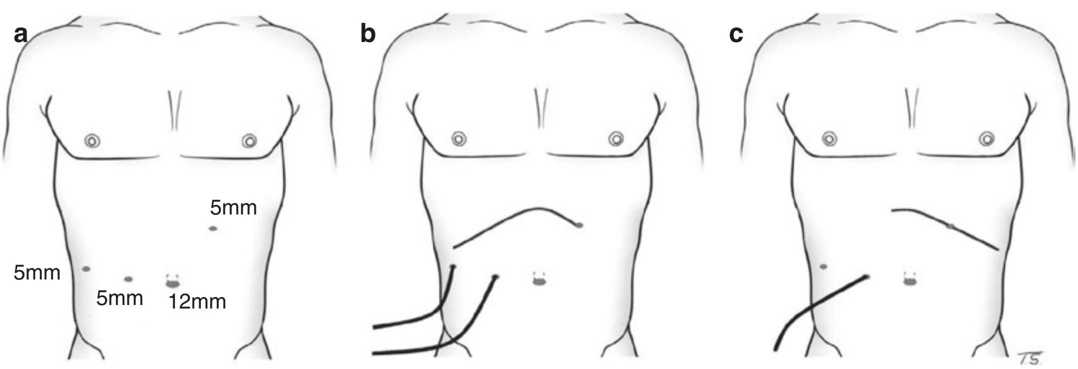

Fig. 15.4 Laparoscopic port placement for (**a**) extended staging laparoscopy, incorporation of some of the port sites into a subcostal or midline (not shown) incision and possible drain placement after (**b**) pancreatoduodenectomy or (**c**) distal pancreatectomy

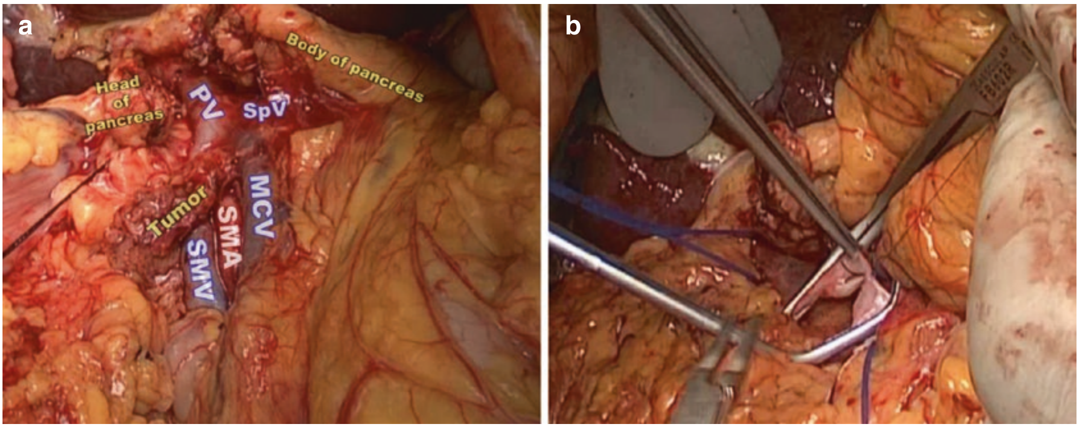

Fig. 15.5 (**a**, **b**) Dissection of SMA and SMV trunks and branches and PV/SMV anastomosis

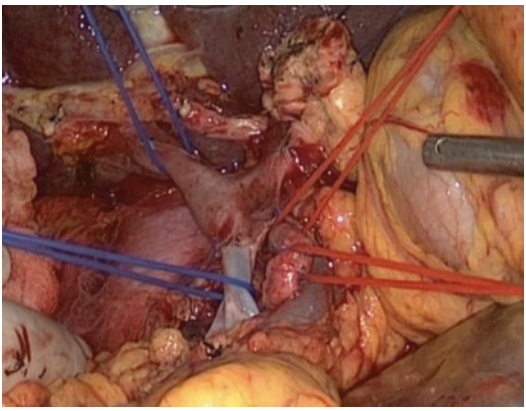

Fig. 15.6 PV/SMV anastomosis is done

15.4.3 Duct-to-Mucosa Pancreaticojejunostomy (Ω-Hat)

Next we do pancreaticojejunostomy, cholangiojejunostomy and gastrointestinal anastomosis. Pancreaticojejunal mucosa end-to-side anastomosis was adopted for pancreaticojejunal anastomosis (Fig. 15.7a, b): the pancreas and the jejunal sarcoplasmic layer were sutured together, a small hole was made in the corresponding jejunal mucosa, jejunal and pancreatic mucosal posterior wall anastomosis was performed, and then the drainage catheter in the pancreatic duct was placed in the jejunum and fixed. The anterior wall of the pancreatic duct and jejunal anastomosis was then sutured and fixed on the pancreatic capsule. The jejunum is covered like a hat on the pancreatic anastomosis, so we name it as "the Ω-Hat Pancreaticojejunostomy."

15.4.4 Cholangiojejunostomy

Then cholangiojejunostomy was performed 10 cm distal from the pancreaticojejunostomy; we use running suture with a 5-0 Y433 (Fig. 15.8), and biliary jejunal end-to-side anastomosis is selected; the jejunum mesenteric for the lateral margin is opened by an incision, the length is equivalent to the bile duct opening.

15.5 Pathology and Prognosis

The resected specimen was showed in Fig. 15.9. Pathology diagnosis was moderately differentiated pancreatic duct adenocarcinoma (grade II),

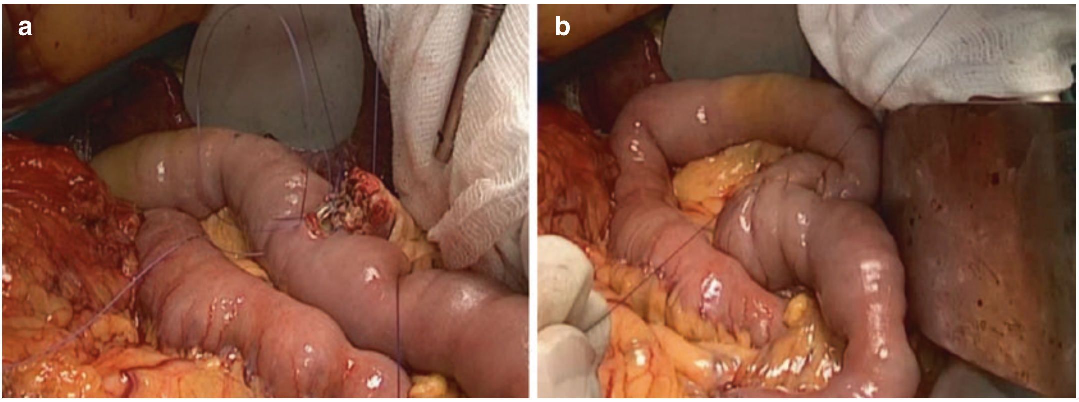

Fig. 15.7 (**a**, **b**) Duct-to-mucosa Pancreaticojejunostomy (Ω-Hat)

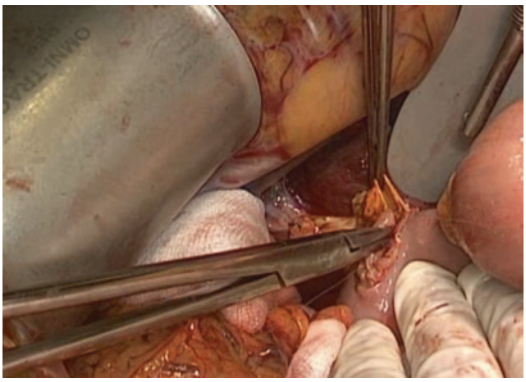

Fig. 15.8 Cholangiojejunostomy

Fig. 15.9 Resected specimen

invading the plexus. The tumor also involves the duodenal wall. The cutting margin of common bile duct, pancreatic margin, stomach, and duodenal were negative; 28 lymph nodes including peripancreatic lymph nodes (12), the superior mesenteric artery lymph nodes (7), No.16 lymph node (4), No.12 lymph nodes (5) were dissected totally, none of them was positive.

The patient recovered uneventfully and was discharged 11 days after the operation. Nineteen months after surgery, follow-up CT and tumor marker revealed no recurrence.

15.6 Comment

Although laparoscopic exploration has many advantages, there are still some problems, such as the swelling of Trocar site or incision in abdominal wall, tumor metastasis [5], invasive, and medical costs are more expensive than endoscopic ultrasonography, CT, and so on. Although laparoscopic and LUS examinations are invasive and costly, they can provide visual intraoperative imaging and endoscopic biopsy, which are not available for other imaging examinations. So selective laparoscopic and LUS examination is very important [6].

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Part V

Adenocarcinoma of the Pancreas: Robotic-Assisted Laparoscopic Surgery

16 Robotic-Assisted Laparoscopic Pancreatoduodenectomy (RPD)

Bai-Yong Shen, Zhi-Hao Shi, and Yu-Sheng Shi

16.1 Introduction

As early as the beginning of the twentieth century, for tumors located at pancreatic head, pancreaticoduodenectomy (PD) was gradually developed. Due to the difficulty of PD, the surgical procedure was more complicated and the morbidity and mortality rate were also higher than other techniques. In the early stage, usually PD is performed by open surgery. With the invention and development of laparoscopic minimally invasive techniques in the 1990s, the first laparoscopic pancreaticoduodenectomy (LPD) was first reported in 1994. At that time, only a few centers in the world were able to complete the minimally invasive PD. The main reason for this is that the complexity of the surgical procedure, especially the technical difficulties encountered during reconstruction, largely limits the development of minimally invasive pancreaticoduodenectomy.

Over time, minimally invasive techniques are developing rapidly, and more and more centers around the world are beginning to report complete LPD. At that time, LPD was considered the most challenging procedure. There are three main aspects to analyze its technical difficulties: (1) The surgical site is located in the posterior peritoneum. (2) The local area of the operation has complex vascular relationships. (3) Three complex reconstructions are required to complete. Therefore, complete LPD can only be performed in a few high-volume pancreatic disease centers, and only by a few surgeons who are proficient in laparoscopic techniques. In low-volume centers, LPD is not only time-consuming but also has a higher incidence of postoperative complications than open PD, so it is difficult to improve. Further analysis of the limitations of simple laparoscopic techniques is mainly due to its two-dimensional view, limited range of movements, loss of tactile feedback from the operator. Because of poor ergonomic experience, surgeons specialized in hepatobiliary and pancreatic are reluctant to perform LPD.

With the introduction of robot-assisted surgical system, minimally invasive surgery comes to a new era. In 1998, Himpens [1] first reported the robot-assisted cholecystectomy. Since then, the application of the robotic system has been significantly improved, not only for hepatobiliary and pancreatic surgery but also for urological surgery, gynecology, thoracic surgery, and cardiac surgery. The application of daVinci™ robot-assisted surgical platform overcomes the shortcomings of many laparoscopic techniques. Its main advantages are as follows: (1) Improved two-eye three-dimensional imaging system. (2) Nearly 720-degree free movement of robotic arms. (3) Further improved surgeons' comfort and precision. The advantages of these robot-assisted surgical systems have for the first time made

B.-Y. Shen (✉) · Z.-H. Shi · Y.-S. Shi
Shanghai Ruijin Hospital affiliated to Shanghai Jiaotong University, Shanghai, China

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the technical difficulty of complex resection and reconstruction to be similar to open pancreaticoduodenectomy (OPD) [2]. Nowadays, more and more centers around the world started to perform robot-assisted pancreaticoduodenectomy (RPD).

RPD is performed by a surgical team with good laparoscopic techniques and sufficient experience in open pancreatic surgery. The da Vinci S or Si robot-assisted surgical systems (Intuitive Surgical, Sunny Valley, CA, USA) were used in China right now. The latest Xi edition has not yet been introduced in China.

Patients received routine preoperative examinations after hospitalization including blood tests, liver and renal functions, coagulation function, tumor markers, electrocardiogram, chest radiograph, and lung function tests to exclude surgical contraindications. At the same time, relevant imaging examinations (abdominal ultrasound, enhanced CT, enhanced magnetic resonance, and endoscopic ultrasonography) are needed for the diagnosis of the disease to determine the location, size, and diagnosis of the tumor and to develop a surgical plan.

This chapter will review the domestic and foreign literature reports and combine with our experience in clinical practice in recent years. According to real cases, we are going to introduce the surgical techniques and postoperative managements of RPD.

16.2 Case

16.2.1 Patient Characteristics

A 56-year-old female patient went to hospital because of recurrent melena with dizziness for 1 month. The symptom became more severe before she went to the hospital. She denied nausea, vomit, abdominal pain or other symptoms. She was given an enhanced CT scan and showed a tumor located at the duodenum near the ampulla (Fig. 16.1). After hospitalization, we gave her a total exam to evaluate the disease. The patient was anemia but with no other abnormity. After an MRI and EUS, the patient was diagnosed as a gist of duodenum. After an MDT discussion, we decided to perform a robot-assisted pancreaticoduodenectomy.

Informed consent was obtained from all participating patients, and the ethics committee of Ruijin Hospital, Shanghai Jiaotong University School of Medicine, approved this study.

16.2.2 Surgical Techniques

16.2.2.1 The Composition of the Da Vinci Surgical System

The da Vinci robot-assisted surgical system is consisted of three parts: the surgeon's operating system, the bedside robotic arm system, and the conversion system. The surgeon's operating system is directly operated by the surgeon, and it will provide a three-dimensional (3D) high-resolution imaging system. The surgeon manipulates the left and right controllers to simulate the movement of the right and left hands during the operation. The foot pedal controls the grip, lens focus, and activation of harmonic and electrocoagulation. The surgeon's operating system is typically placed in a non-sterile area away from the patient and the patient cart. It is manipulated by the surgeon under non-sterile conditions. The bedside robotic system consists mainly of robotic arms and a camera that will strictly follow the operating commands issued by the console. The size of each arm is 8 mm in diameter and it offers a high degree of flexibility. Grasper, needle driver, monopolar coagulation, harmonic, and other robotic instrument can be switched during operation. The conversion system includes a light source, an image conversion element and an image transmission line. It converts the three-dimensional image taken by the camera to the console. The system can filter tremor of the surgeon. The 1# robotic arm acts as the right hand of the surgeon and is typically operated by using harmonic for cutting, dissection, and dissociation. The 2# and 3# robotic arms act like the surgeon's left hand which is usually fixed with a bipolar forceps or grasper to expose the surgical field [3].

16.2.2.2 Patient and Trocar Position

After successful general anesthesia, the patient will be placed in a supine position with head up about 30°. The position of the patient is adjusted by the distance from the umbilicus to the top of

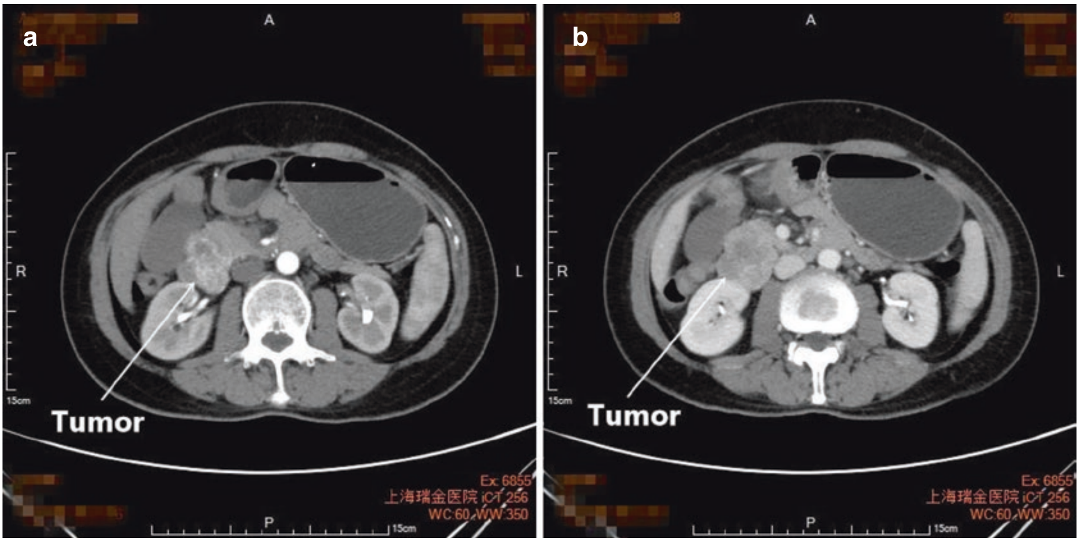

Fig. 16.1 The CT scan of this patient, it showed the tumor was located at the duodenum near the ampulla

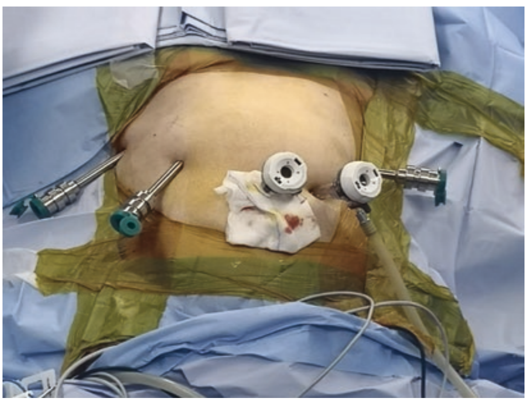

Fig. 16.2 The position of trocars

the operating table so that the camera can reach the optimal angle. The left side of the patient will be raised about 30°.

Nasogastric tube is routinely placed. Before the start of the operation, a central venous catheters and continuous arterial blood pressure monitoring catheters will be routinely placed by anesthetist. The patient's arm is protected with a cushion. A blanket is used to ensure that the patient maintains normal body temperature. Puncture under the umbilicus or left rib arch is usually performed to establish CO_2 pneumoperitoneum.

After the pneumoperitoneum was established in the left quarter rib area, a 12-mm Trocar was placed at the umbilicus as camera trocar, and the lens was probed to determine whether there were any contraindications for surgery (liver metastasis, tumor spread, etc.). After excluding surgical contraindications, the remaining trocars were placed under direct vision. The position of trocars is shown in Fig. 16.2. The 8 mm holes (R1 and R2) of the robotic arm are placed at about 8 cm away from the camera port at the midline of the clavicle. R3 is placed in the midline of the right upper abdomen. Usually a trocar for assistant is needed, the size could be 5 mm or 12 mm, placed about 5 cm below the midpoint between camera and robotic arm #1. During the surgery, the assistant needs to use suction operation, use titanium clips, and EndoGIA. In patients with difficulty in exposure, another 5 mm trocar can be added between camera and robotic arm #2.

16.2.2.3 Ten-Step Operative Technique

1. *Kocher maneuver and exposure of the pancreatic head*

In RPD, as duodenum could not be easily grasped by the assistant, it was hard to incise the peritoneum from the lateral wall of the duodenum directly. First, we should dissect the hepatic flexure of colon and the right hemi-colon from left side to right side (Fig. 16.3). We incised the peritoneum, so the colon would drop down under the

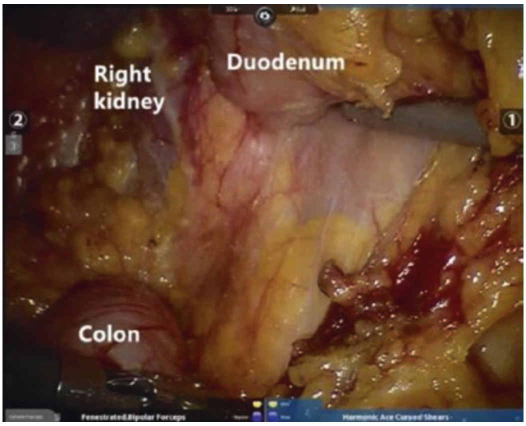

Fig. 16.3 Dissection of the mesocolon

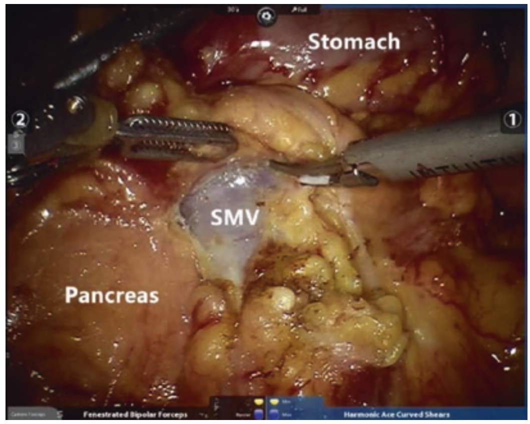

Fig. 16.5 Dissection of the lower border of the pancreas

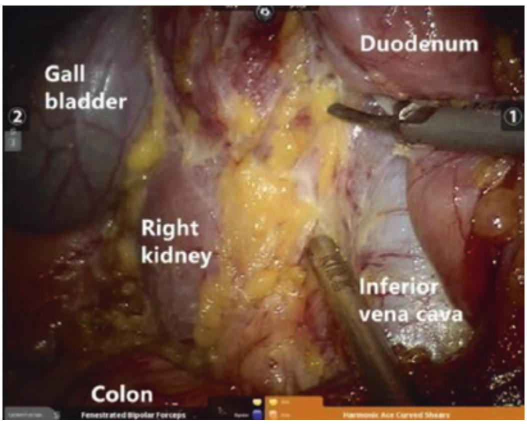

Fig. 16.4 Kocher maneuver

influence of gravity. Then we turned over and dissected the mesocolon so that the Treitz ligament would be very easy to expose. We used harmonic to dissect and scratch the posterior wall of the pancreas and the duodenum from the inferior vena cava and the front border of the right kidney, so an avascular cleavage plane could easily be obtained (Fig. 16.4). After the Treitz ligament had been fully cut off, we should pull out the jejunum through the opening that was made in the mesocolon directly for about 30 cm, then we could use a stapler to cut the jejunum, so we did not need to go back again to find the jejunum behind the mesentery.

2. *Exposure and dissection of the pancreas*

First, we dissected the gastrocolic ligament and used arm 3 to raise the stomach and expose the pancreas. We used harmonic to divide the lower border of the pancreas, and there was relatively little tissue or lymph nodes to be separated away from the SMV along with the SMA (Fig. 16.5). Here we needed to identify the Henle trunk and its branches. Sometimes we could also see inferior pancreaticoduodenal artery and vein (IPDA/IPDV) here (Fig. 16.6). Attention should be paid because there were many kinds of vascular variation. If possible, colonic branch of the Henle trunk should be protected. Here we also needed to find the middle colic artery (MCA) and protect it. Comparing with OPD, it was hard to develop a cleavage plane over the SMV, so we turned to the upper border of the pancreas first. We should pay attention to find common hepatic artery (CHA), gastroduodenal artery (GDA), and right gastric artery (RGA). The peritoneum over these arteries was carefully incised, and these major arteries should be clearly visualized in order to identify them. By careful dissection, the surrounding tissue or lymph nodes could be separated easily until the origin of the RGA and GDA was visualized (Fig. 16.7). Then we should harvest the No.7, No.8a/8p, and No.9 lymph node if the tumor was malignant. After that we could use the harmonic to cut the RGA and GDA temporarily (Fig. 16.8). After these important blood vessels were found and ligated, it would be safe to cut the pancreas now by harmonic. Usually we could identify the main pancreatic duct (MPD), and the assistant would be able to cut it by scissors very clearly.

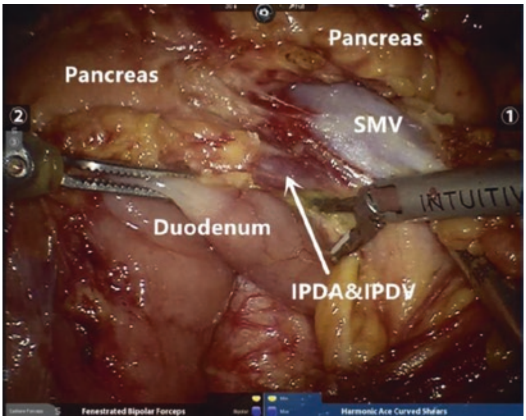

Fig. 16.6 Exposure of the IPDA & IPDV

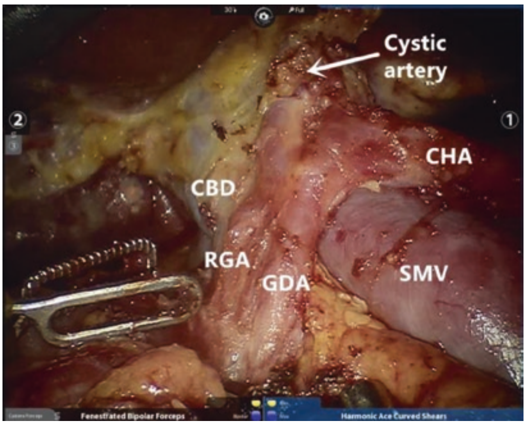

Fig. 16.7 E Dissection of the upper border of pancreas and exposure of blood vessels

3. *Dissection of the hilum and resection of the gall bladder*

We started from the stump of RGA and GDA, from left side to right side. Harmonic was recommended because it could stop slight bleeding and close the lymphatic to avoid lymphorrhagia. To ensure adequate lymphadenectomy of the hepatoduodenal ligament (No.12a, 12b, and 12p), the common hepatic duct (CHD) should be divided just below the confluence, well above the cystic duct junction. The assistant should change the instrument between suction and atraumatic clamps because sometimes traction of the blood vessel was needed. Then we cut the CHD and resected the gall bladder. The cystic artery should be carefully identified.

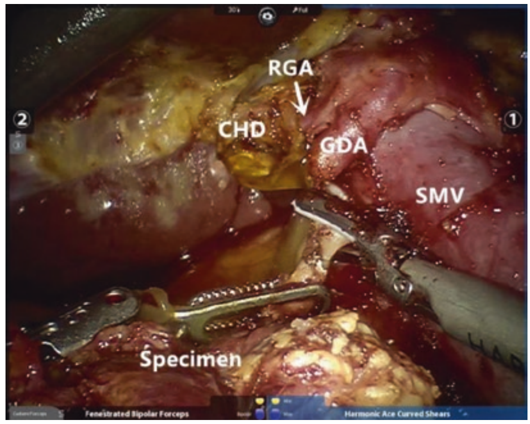

Fig. 16.8 After cutting the blood vessels by harmonic

We could also stop the blood flow temporarily by harmonic.

4. *Resection of the stomach*

We used the harmonic to dissect the greater and the lesser curve of the stomach and cut the arterial arch. We should use the hemlock to avoid bleeding. Then stapler was used to cut the stomach. The specimen was positioned at the right abdomen. Now we could see the pancreatic head and SMV very clearly.

5. *Resection of the uncinate process*

We used harmonic to dissect and separate upwardly. Sometimes, the inferior pancreaticoduodenal artery and vein were thick, so we should cut and ligate them carefully. There were few vessel branches here, so usually less bleeding would occur. However, there were numerous vascular branches entering the head of the pancreas from the right side of the SMV and SMA, and we needed to identify and ligate them. The right wall of the SMA should be exposed if the tumor was malignant in order to achieve R0 resection and adequate clearance (Fig. 16.9). Titanium clip could be used to stop bleeding, but we thought suture maybe more reliable. After the specimen was fully resected, we put it into a sample bag which was designed for minimal invasive surgery.

In this section, the cooperation between the surgeon and the assistant was very important.

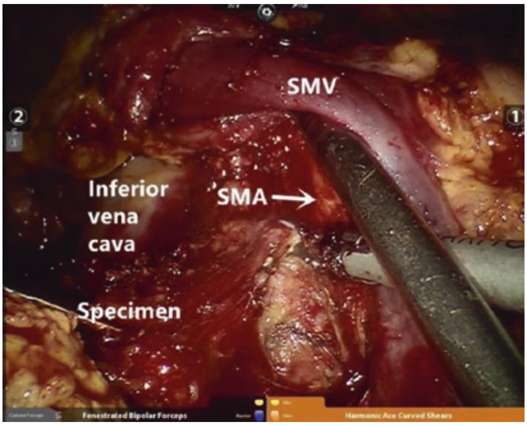

Fig. 16.9 Dissection and resection of the uncinate process

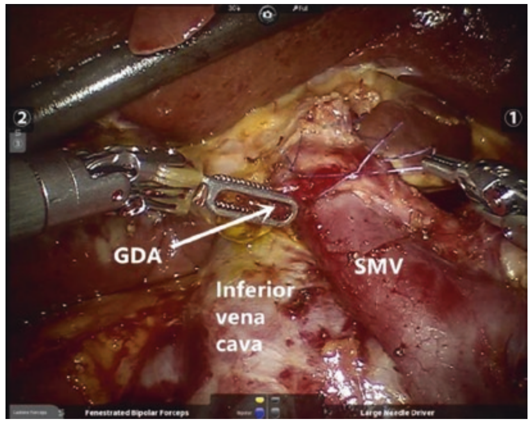

Fig. 16.10 Ligation of GDA

Massive bleeding would happen here, the assistant should suck the blood and help to control the bleeding. Besides, the assistant should push the SMV properly to expose the space between the SMV and the uncinate process. If the bleeding spot was on the main trunk of SMV, suture was recommended instead of titanium clip or hemlock.

6. *Ligation and suture of the bleeding points*

Usually we needed about 30 s to change the instrument of robotic arm. In order to save time, we used harmonic to cut the blood vessel or used the clip to stop bleeding temporarily in dissection. Then after the specimen was resected totally, we ligated and sutured bleeding spot and vessel stump together. We could save 10–15 min by this modification. 6-0/5-0 Prolene were used to ligate the small vascular branches. For RGA and GDA, we used a "cow-boy loop" to ligate so that the adventitia would not be damaged, then the risk of postoperative bleeding would decrease (Fig. 16.10). Cystic artery should not be forgotten, and the transverse pancreatic artery was routinely ligated.

7. *Reconstruction of the pancreatic remnant: Pancreaticojejunostomy (PJ)*

For PD, we preferred PJ to pancreaticogastrostomy (PG), no matter the size of MPD. We used end-to-side duct to mucosa reconstruction (Fig. 16.11). For outer layer we used a 3-0 Prolene. First, the posterior capsule of the pancreas was sutured continuously to the serosa of the jejunum. No tension should be left here in order to maintain enough space. We inserted a silicone catheter inside the MPD according to the its size. With the stent inserted, the margins of the duct were found and freed for a short distance to promise an accurate anastomosis directly to the jejunal mucosa. For the inner layer, we used 6-0 Prolene suture. 5-0 Prolene suture would be chosen if MPD was expanded. Usually 5–6 interrupted stitches were performed. For large MPD, sometimes we also used running suture. After reconstruction of the anterior part of the outer layer, we could easily tighten the suture. However because of lacking force feedback, the surgeon could make the judgment only by his own eyes.

8. *Reconstruction of cholangiojejunostomy (CJ)*

We usually perform a single-layer reconstruction by 5-0 Prolene or PDS (Fig. 16.12). Continues suture was recommended. We first reconstructed the posterior layer starting from the right side of the CHD, then we used another suture to perform the reconstruction of the anterior layer. The two sutures would meet together at both the left and right sides of the CHD. Then we pulled tightly at both sides and made knots. If there was bile leak, additional interrupted sutures could be used to fix it. Then we needed to check tension of the reconstruction. If the tension was too strong, then we needed to perform several sutures nearby to reduce the tension.

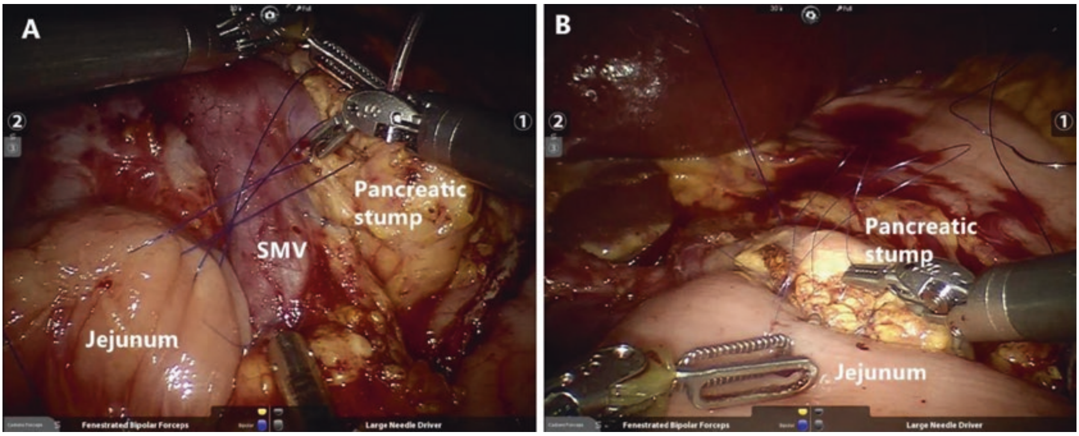

Fig. 16.11 Reconstruction of PJ. It showed an end-to-side duct to mucosa reconstruction of pancreatojejunostomy

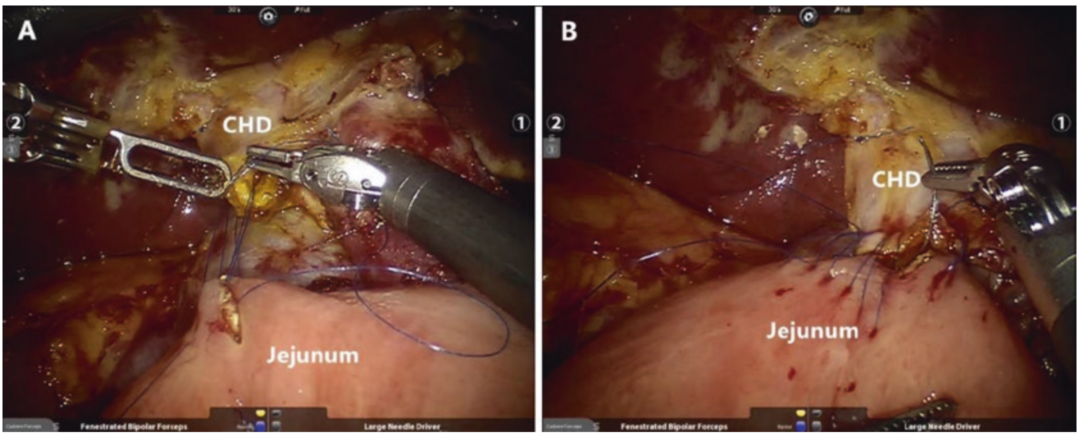

Fig. 16.12 Reconstruction of CJ. It showed a continues suture reconstruction of cholangiojejunostomy

9. *Reconstruction of the gastrojejunostomy (GJ)*

We used a 3-0 Vicryl to make one stitch at about 20–30 cm beneath the CJ. We called it "Marker Line." Then we used robotic arm3 to lift up the transverse colon and pulled out the jejunum from the hole near the Treitz ligament until we found the "Marker Line." Thus we could perform the reconstruction in front of the transverse colon. We had two options for GJ: (1) We performed the GJ inside the abdomen by 3-0 V-lock suture. (2) We anchored the stomach and the jejunum together by two interrupted stitches so that the jejunum would not reverse. Then we made a 4-cm incision just under the xiphoid. We took out the sample bag and performed the GJ outside the abdomen by 3-0 V-lock or a stapler.

10. *Drainage placement and closure*

Two double-lumen drainage tubes were routinely placed: one close to PJ and one close to CJ. At last we closed the incision and the operation was over.

16.2.3 Postoperative Management

Sandostatin (Novartis) was given after surgery routinely. About 600 ug/d was pumped in at day 1 to day 3, afterwards 100 ug every 8 h was injected subcutaneously till discharge. Biological assessments including drain fluid amylase were measured routinely at day 1, 3, 5, 7, and 10. The drainage tube started to be pulled out since day 5 and was usually removed around day 7–10 if no POPF occurred. Total parenteral nutrition (TPN) was given from day 1 to 6, liquid diet started around day 6, and semi-fluid diet started around day 10. A postoperative CT scan was routinely given at day 7–9 to exclude fluid accumulation. If drainage was inadequate, we would place a new drainage tube under the guide of CT scan.

16.3 Pathology and Prognosis

The final pathology was gastrointestinal stromal tumors (GIST) located at duodenum. The patient recovered safely and quickly. There was biochemical leak after surgery but very slight and was cured with medication and controlled diet. There was no bile leak, delayed gastric emptying, abdominal infection and other postoperative complications. It had been 3 months from the surgery till now. The endocrine and exocrine insufficiency did not happen. We would provide long-term follow-up.

Informed consent was obtained from all participating patients, and the ethics committee of Shanghai Ruijin Hospital affiliated to Shanghai Jiaotong University approved this study.

16.4 Discussion

Till today, there had been a lot of reports verifying the safety and feasibility of minimally invasive robot-assisted pancreaticoduodenectomy all over the world. It was an ideal and minimal invasive surgical procedure for patients who meet the surgical indications, especially those with benign, borderline, or early-staged malignant tumors.

Robot-assisted surgery would provide less trauma to patients by comparison to traditional open surgery and could satisfy the cosmetic needs. RPD had been reported for over 20 years, and the exploration of the surgical procedure had diminished over the years as the procedure gradually formed its mature pattern and standard. However, the complexity of intraoperative resection and reconstruction procedures remained as a challenge for many laparoscopic surgeons. The literature reports of simple minimally invasive PD had not shown the advantages of less invasive compared with traditional open surgery. Its operative outcomes were still similar to open surgery [4, 5].

For the standard laparoscopic technique, many hepatobiliary-pancreatic surgeons were reluctant to engage in LPD due to its 2-D imaging, restricted range of instrument activity, and lack of tactile feedback, along with restricted natural hand-eye coordination and poor ergonomic experience. Also the laparoscopic instruments would transmit the surgeon's hand tremor into the surgical site and thus affect the precision of the action which would increase the technical difficulty for the operation in general. In addition, conventional laparoscopic surgery required a relatively long learning process for the surgeon and was difficult to master and routinely perform.

The creation and continuous application of the DaVinci robotic surgical platform had overcome the limitations of traditional laparoscopic surgery, as well as matured in its own techniques over time. The main advantages were as follows: the robotic arm has seven movable joints, which means that it could achieve the same accurate movement as the hand, and be adjusted to any angle during operation; secondly, its three-dimensional visual imaging enabled the surgeon to get approximately the same experience as that of abdominal surgery; thirdly, the proportional movement amplitude adjustment function of the robot arm was able to combine the surgeon's hand movement and the corresponding action of the robot arm at the ratio of 2:1, 3:1, or 5:1, and at the same time filtering the tremor of the physician's hand, making the finer actions easier to implement. All of which help to perform major procedures involving the main blood vessels of the intended surgical fields, dissecting the pancreatic neck and portal vein, and dealing with the uncinate process of the pancreas. Fine anastomosis was also more feasible in RPD than in traditional OPD and LPD.

The pancreaticojejunostomy (PJ) was especially critical for the entire procedure, as this step was closely related to the occurrence of postoperative complications. The robotic assisted system shortened the time required for the specimen removal process so that the surgeon could save their strength for complex anastomosis, moreover, with the advantages of the robotic system, an accurate duct-to-mucosa anastomosis could be achieved even if the pancreatic duct was only 2 mm in diameter, thereby reducing the incidence of postoperative pancreatic fistula. Robot-assisted surgery generally had less estimated blood loss. This was due to its three-dimensional vision and microscopic magnification effect. Small blood vessels could be easily identified and treated, while open surgery often caused anatomical traction in similar situations which leaded to more bleeding from small veins and even caused venous avulsion.

What robot-assisted surgery shared in common with traditional laparoscopic surgery were safety, feasibility, and less trauma. The robot-assisted surgical system had many advantages that traditional laparoscopic technology failed to offer. The robot-assisted surgical system had the advantages over traditional minimally invasive surgery and open surgery, and at the same time overcomed its disadvantages to be safely applied to elderly patients without significant survival difference and complication rate, while shortening the length of hospital stay for elderly patients [6, 7].

Early robot-assisted pancreatic surgery was still relatively rare compared to cardiovascular surgery and urologic surgery. In recent years, robot-assisted pancreatic surgery, including complex RPD, had been increasingly carried out clinically. The safety and effect of robot-assisted surgical system had been recognized, and reports on the application of pancreatic surgery had gradually increased. In 2003 Melvin [8] reported the first robotic aided distal pancreatectomy to treat neuroendocrine tumors of the pancreas, followed by the continuous progress in robot-assisted surgical techniques. In the past 2 years, the safety and applicability of robot-assisted pancreatic surgery had been recognized more by the majority of surgeons, and its efficiency in tumor resection had been confirmed in practice. At the beginning, patients undergone RPD had been strictly selected. The procedure was restrictedly used on patients with benign or borderline malignancies. Thanks to the continuous accumulation of surgical experience in clinical practice and improvement of technique, robot-assisted surgery gradually promoted its adaptation range. It had been used in the different surgical treatments for patients with pancreatic malignant tumors. Experts such as Buchs [9] compared 44 cases of robot-assisted pancreaticoduodenectomy and 39 cases of traditional open surgery performed at the University of Illinois Medical School. The results suggested that with well-trained techniques the robotic surgery appeared to have advantages in operation time, estimated blood loss and postoperative morbidity rate compared with open pancreatic surgery. As for the major postoperative complications, RPD was similar to OPD. The main complications were pancreatic fistula, postoperative hemorrhage, and biliary fistula. These complications had a lower rate in the robotic group. Individual patients might experience postoperative delay in gastric emptying, most of which could be alleviated by conservative treatments. For other rare complications such as pulmonary complications and urinary tract infections, there was no statistic difference in either group. The hospitalization time of the RPD group was shorter comparing with the OPD group, and the reoperation due to complications was less than that of the OPD group, but no statistical significance was found. In the aspect of lymphatic dissection, the number of lymph node specimens obtained by robotic surgery was significantly higher than those of open surgery. The surgical procedure in the posterior peritoneal region and the uncinate process might significantly benefit from the advantages brought by the robot-assisted surgical system.

In the review of the literature, no report of incision implantation associated with robot-assisted surgery was found in the domestic or foreign cases. The lower incidence of incision infection in robot-assisted surgery was of great significance on shortening the length of hospital stay.

As for the extension of the operation time mentioned by some scholars, a considerable part of the factors is the time required for the installation and placement of the robot system and the time required for pancreaticojejunostomy and biliary anastomosis. However, this time could be greatly shortened as the surgeon's experience continues to accumulate. And the time required for minimally invasive surgery to close the abdomen was much shorter than open surgery.

As was suggested by various reports, the prognosis of pancreaticoduodenectomy was related to the differentiation of the pancreatic tumor and the amount of estimated blood loss closely [10]. There had been reports showing that the 5-year survival rate was significantly higher for patients with an estimated blood loss of less than 400 ml. The use of robotic-assisted surgical systems could simultaneously reduce intraoperative blood loss and blood transfusion. The benefit of less blood loss provided by minimally invasive surgery could also be conducive to further improve the survival rate.

Laparoscopic and robot-assisted minimally invasive surgery could cause less immunosuppression than open surgery, which was especially important for patients with malignant tumors [4]. Laparoscopic surgery had been shown to cause less decline in immune response. As the robotic assisted surgery was a derivative of minimally invasive surgery, its impact on the immune system remained an interesting topic.

Different centers had their own experience with the steps of the surgery. As for the five-hole method or the seven-hole method, the difference was mainly that the five-hole method weakened the teamwork, and the single auxiliary hole made it more difficult to expose the intended field in the case of rapid bleeding to achieve hemostasis. The specific choice should be made combing comprehensively the factors of surgeon's experience, the patient's anatomy, and the primary disease.

RPD was a fusion of open surgery techniques into minimally invasive surgery. Similar key technologies included the following: (1) dissection of the neck of pancreas with electrocautery; (2) anatomic separation along the inferior portal vein wall, and branching the tissue correspondingly; (3) dissection of the peritoneal tissue on the level of the SMA, to maximize the removal of the tumor and pay attention to prevent bleeding after pancreatic resection; (4) pancreatic jejunal anastomosis was a double suture of the pancreatic duct to the mucosa; (5) the decision of choosing either continuous or intermittent suture of the biliary tract was made according to the diameter of the tract. The cooperation of the surgical team was crucial. The surgeon should have sufficient experience in pancreatic surgery and laparoscopic surgery. Intraoperative cooperation, adequate exposure of the field, careful and precise operation were the keys to safe and complete cure of the tumor. The enlarged binocular image empowered by the robot system provided three-dimensional vision, clear images, and wide field of view. The flexible operation of the robotic arm facilitated anatomy, anastomosis, and controlled the active bleeding. The robotic arm's strong operability enabled the surgery to be carried out with utmost precision.

Although the robotic system had made further expansion of minimally invasive surgery, the current system still had its limitations. First, formal training was required to familiarize with the operation of the device; secondly, for most centers, the operation time was still significantly longer than that of traditional surgery; third, it took a long time to cope with the lack of tactile feedback; fourth, there was often a lack of rapid response to intraoperative emergencies, such as intraoperative bleeding. Fifth, patients who were too thin or obese were not suitable for robot-assisted surgery. In addition, whether the operation could be carried out smoothly depended highly on the selection of the hole position and posing of the host. The author suggested that surgeons could start with biliary surgery or distal pancreatic surgery, in order to obtain surgical experience, and increase later on the complexity of surgery with the improvement of ability. In addition, the cost of robotic system applications was significantly higher than traditional surgery, which was an important factor that limited the application of robotic systems on a larger scale.

Through the practice of many experts at home and abroad, it had been proved that robot-assisted surgery for pancreatic disease was safe and feasible. However, it did not serve as a complete substitute for laparoscopic surgery, nor was it able to replace the practice of conventional open surgery.

Robot-assisted surgery would undoubtedly witness rapid development in the future. The era of robotic surgery was dawning.

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17 Robotic-Assisted Laparoscopic Distal Pancreatectomy with Splenectomy

Yu-Sheng Shi and Bai-Yong Shen

17.1 Introduction

Distal pancreatectomy is a kind of operation to remove the pancreatic tissue in the left side of superior mesenteric vessels. Distal pancreatectomy incorporating with splenectomy is a conventional procedure for malignant tumors located at the body and tail of pancreas.

In 1882, a German surgeon, Friedrich Trendelenburg, performed first resection for the pancreatic tumor in the pancreatic tail [1]. The patient was soon recovered but died after a few weeks for unknown death cause. Since then, few cases of distal pancreatectomy were reported until 1920. Although the surgical technique was not mature at that time, with the effect of the operation still unsatisfactory, it has been recognized that the success of this operation is easier to achieve in theory compared with pancreaticoduodenectomy, for easier dissection of the pancreatic body and tail, less estimated blood loss (EBL), and no reconstruction of digestive tract.

Cuschieri A and Gagner M took the lead in completing the first laparoscopic pancreatectomy (LDP) in 1996, marking the beginning of pancreatic resection in the field of minimally invasive surgery [2, 3]. A meta-analysis including 18 studies with 1814 patients (43% laparoscopic, 57% open) compared the outcome of LDP and ODP in 2012, and showed lower EBL and shorter postoperative hospital stay in LDP group, with no difference in operation time, margin positivity, and mortality [4]. A systematic review came to a similar conclusion in 2015 [5]. It suggested that pancreatic surgery could be performed safe and feasible in the minimally invasive method.

The invention of the robot-assisted surgical platform further promoted the development of minimally invasive techniques. In 2003, W.S. Melvin reported the world's first robotic-assisted pancreatectomy (RADP). The patient recovered quickly and was discharged on the second day after operation [6]. It suggested the feasibility of performing pancreatic surgery in robotic approach. A retrospective analysis in 2013 with a total of 124 patients (30 RADPs and 94 LDPs) showed that RADP was associated with lower risk of conversion to open surgery, compared with LDP [7]. Therefore, distal pancreatectomy in robotic approach has shown promising outlook for pancreatic surgery.

This chapter mainly discusses distal pancreatectomy with splenectomy. Splenectomy is performed in following circumstances during distal pancreatectomy. Malignant disease like pancreatic ductal adenocarcinoma, neuroendocrine tumor that is >2 cm in size is the surgi-

Y.-S. Shi (✉) · B.-Y. Shen
Shanghai Ruijin Hospital, Shanghai Jiaotong University, Shanghai, China

Y.-b. Liu (ed.), *Surgical Atlas of Pancreatic Cancer*, https://doi.org/10.1007/978-981-32-9864-4_17

cal indication of distal pancreatectomy with splenectomy (DPS). Spleen preservation is considered in pancreatic cystic neoplasms like mucinous tumors, cystadenomas, or intraductal papillary cystic neoplasms for low risk of lymph node metastasis. However, if tumors are so large which compress or very close to splenic vein, splenectomy should be performed to avoid vascular rapture in the operation. If splenic vein is injured and fails to be repaired, which is not planned preoperatively, then splenectomy is also required. Therefore, the decision of splenectomy is based on the comprehensive consideration of intraoperative circumstances, such as the size, location, pathological characteristics, and vascular invasion of tumor. Multidisciplinary consultation with high-quality pancreatic protocol CT is also important to predict the necessity of splenectomy.

17.2 Case

The patient was a 59-year-old woman with findings in the imaging examination and was admitted to our hospital a week ago. Laboratory examination of complete blood count, blood chemistry tests, blood coagulation, and tumor markers was tested before the surgery. It showed a slight decrease in hemoglobin level, i.e., 103 g/L. The tumor marker CA 19-9 was increased to 43.40 U/ml, others were normal.

The magnetic resonance cholangiopancreatography (MRCP) showed a tumor located at the body of pancreas, resulting in the displacement of pancreatic duct. The pancreatic protocol CT showed a similar result, as were all shown in Fig. 17.1 a-c. Pancreatic cystic neoplasm was considered.

From these findings, a diagnosis of pancreatic cystic neoplasm located in the body was made, and distal pancreatectomy with splenectomy was performed because of the less distance between the tumor and splenic vessels.

Informed consent was obtained from all participating patients, and the ethics committee of Ruijin Hospital, Shanghai Jiaotong University School of Medicine, approved this study.

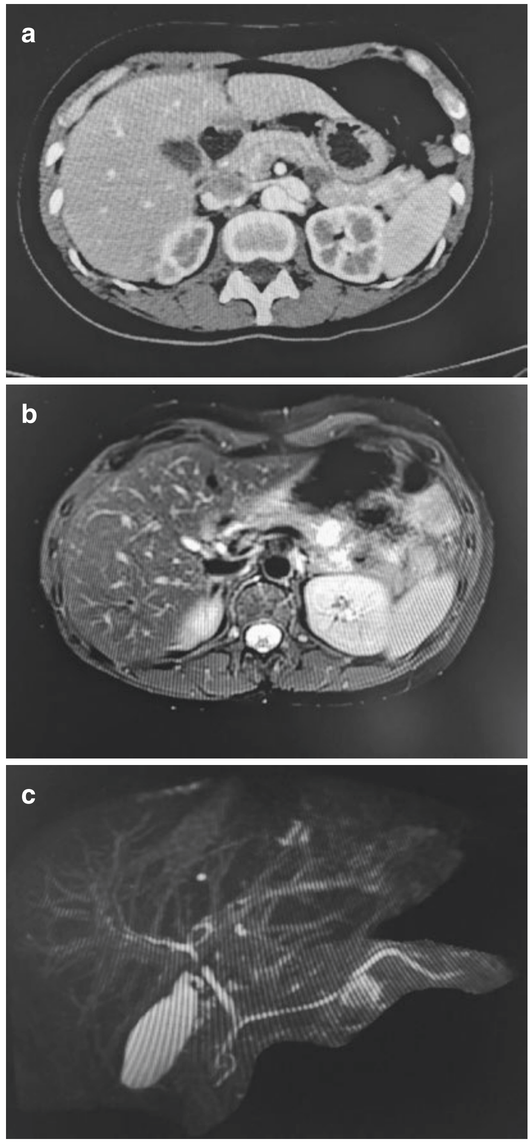

Fig. 17.1 (**a**–**c**) CT and MR image showed a tumor located at the body of the pancreas

17.3 Details of Procedure

17.3.1 Patient Position and Establishment of Pneumoperitoneum

The patient is placed at a supine position with a split leg at operating table. Left arm was extended out to 90° to spare enough space for

Fig. 17.2 The position of ports in the robotic distal pancreatectomy

infusion, and the right arm was tucked next to the body. Urethral and central venous catheterization were completed before operation by routine.

Veress needle was used to get access to the peritoneum. The middle point of the lower edge of the left rib was chosen as the site of puncture. Once pneumoperitoneum was established, the abdomen is insufflated to 15 mmHg of pressure. A periumbilical 12-mm port was placed for camera. Another three 8-mm robotic ports and a12-mm assistant port were placed under the monitor of camera (Fig. 17.2).

17.3.2 Exposure of the Anterior Surface of Pancreas

Before the operation began, check the liver, stomach, bowel and omentum to make sure no metastasis was found in the visual field. Ultrasonic scalpel was used to dissect the greater gastrocolic ligament. Greater curvature of the stomach was dissected in order to expose the pancreas, as shown in Fig. 17.3. The small vascular branches were ligated by harmonic or clip. This step provided the exposure of the pancreas, thus helping us distinguish the relationship between tumor and other organs.

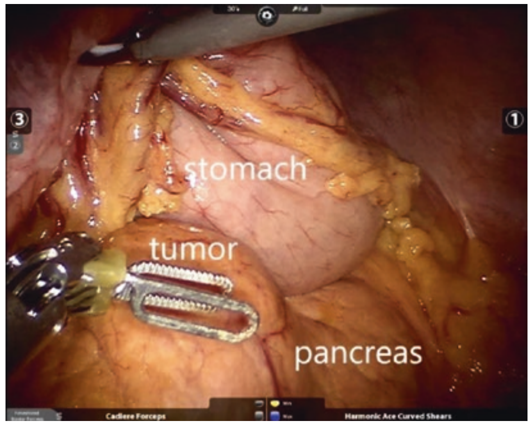

Fig. 17.3 The division of the greater gastrocolic ligament

17.3.3 Isolation of the Splenic Vessels

The superior and inferior borders of pancreas on the right side of the mass were then dissected.

Be careful not to injure the PV/SMV system when separating inferior border by the neck of pancreas. After the inferior border of the pancreas was revealed, the pancreas was lifted up and further divided from bottom to top to create a posterior tunnel, which was ready for the latter transection of the pancreas. Splenic vein was then found and isolated from the posterior border of pancreas, as shown in the Fig. 17.4. Small branches of splenic vein were ligated or cauterized in isolation. If the tumor was found adhering firmly to the splenic vein, just section the vessel at the origin according to the oncologic resecting rules.

Splenic artery was identified in the superior border of pancreas. Careful blunt dissection was used to isolate the splenic artery. If splenic artery was injured and failed to be repaired, ligate and section it at the origin. Details of procedure was shown in Fig. 17.5.

17.3.4 Division of the Pancreas

As the superior and inferior borders of pancreas were dissected and the splenic artery and vein

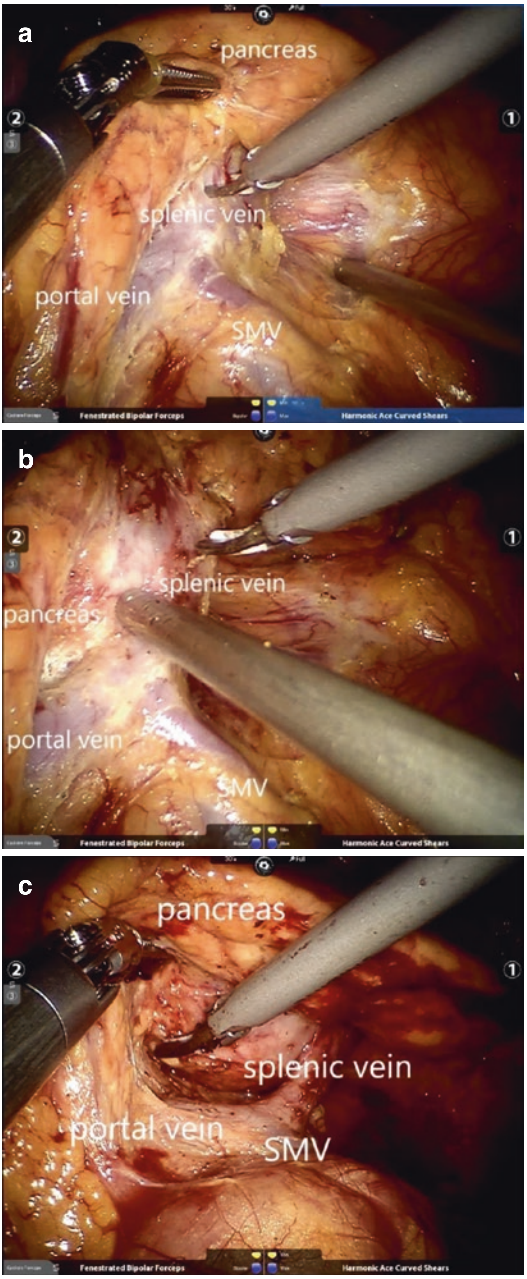

Fig. 17.4 (**a**–**c**) Isolation of splenic vein

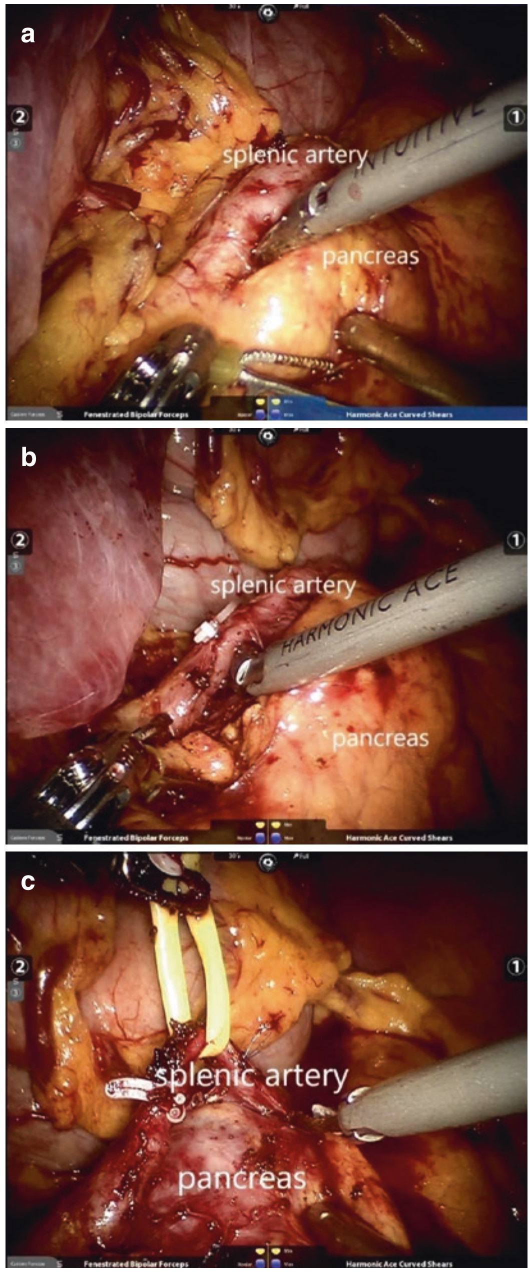

Fig. 17.5 (**a**–**c**) Isolation of splenic artery

were identified, division of the pancreas was performed by EndoGIA stapler. The location of division is based on the tumor, evaluated by its relationship with PV/SMV system. Adequate preservation of pancreatic parenchyma should be considered when division. Function of residual pancreas should be guaranteed to avoid post-operative complications of diabetes mellitus or exocrine pancreatic insufficiency. Details of procedure was shown in Fig. 17.6.

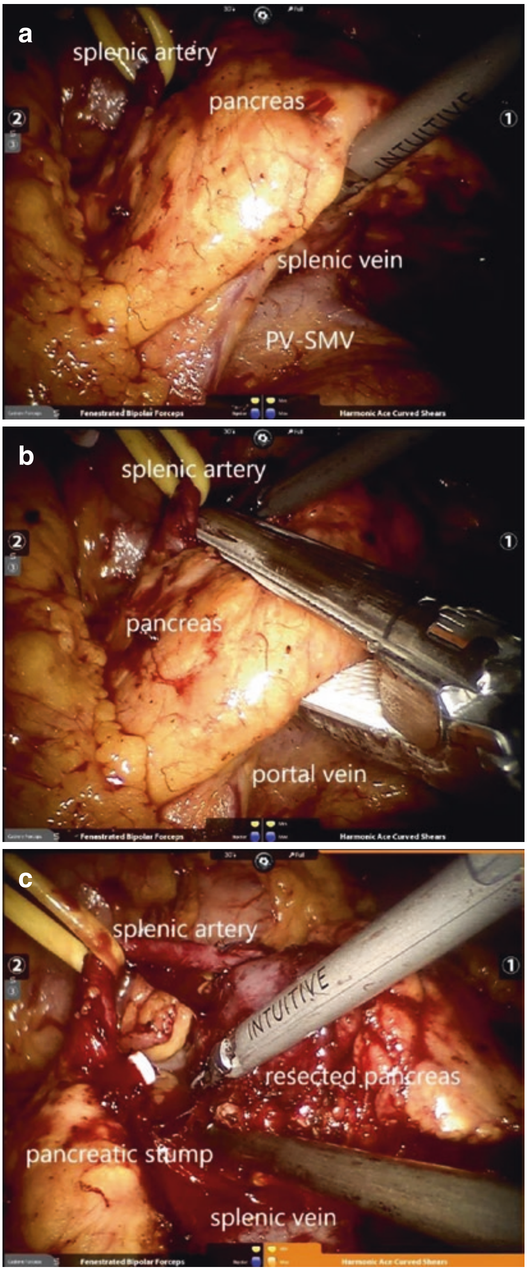

Fig. 17.6 (**a–c**) Division of the pancreas

17.3.5 Ligation of Splenic Vessels

As the superior and inferior borders of pancreas were dissected and splenic vessels were isolated, hem-o-loks were used to ligate splenic vessels. Ultrasonic scalpel was used to section splenic vessels at the origin. Details of procedure was shown in Fig. 17.7. If spleen preservation is needed, spleen vessels should be protected and dissected from the posterior surface of pancreas intact for normal blood supply of spleen in Kimura's approach of spleen-preserving distal pancreatectomy.

17.3.6 Removal of Resected Pancreas and Closure of Pancreatic Stump

Remove resected pancreas and spleen. The superficial retroperitoneum anterior to the adrenal gland, renal vessels, and Gerota's fascia should be dissected and resected en bloc with the pancreas. 4/0 prolene was used to close pancreatic stump by continuous interlocking suture. Flush the pancreatic stump and pancreatic bed with warm water to observe whether active hemorrhage existed. Cauterize the bleeding point with a harmonic scalpel if flushing water remained red (Fig. 17.8).

17.3.7 Specimen Extraction and Draining

A plastic bag is placed to extract the specimen through the 12-mm assistant port. The resection bed was irrigated by suction irrigator to verify hemostasis. Hemostatic gauze was placed in the resection bed. A round single or double lumen drainage tube was then placed into the resection bed near the pancreatic stump. Finally, the abdominal closure was completed with the robotic machine undocked (Figs. 17.9 and 17.10).

17.4 Pathology and Prognosis

The specimen of resection is the body and tail of pancreas, with no tumors found at the margin of the pancreas. The Pathologic diag-

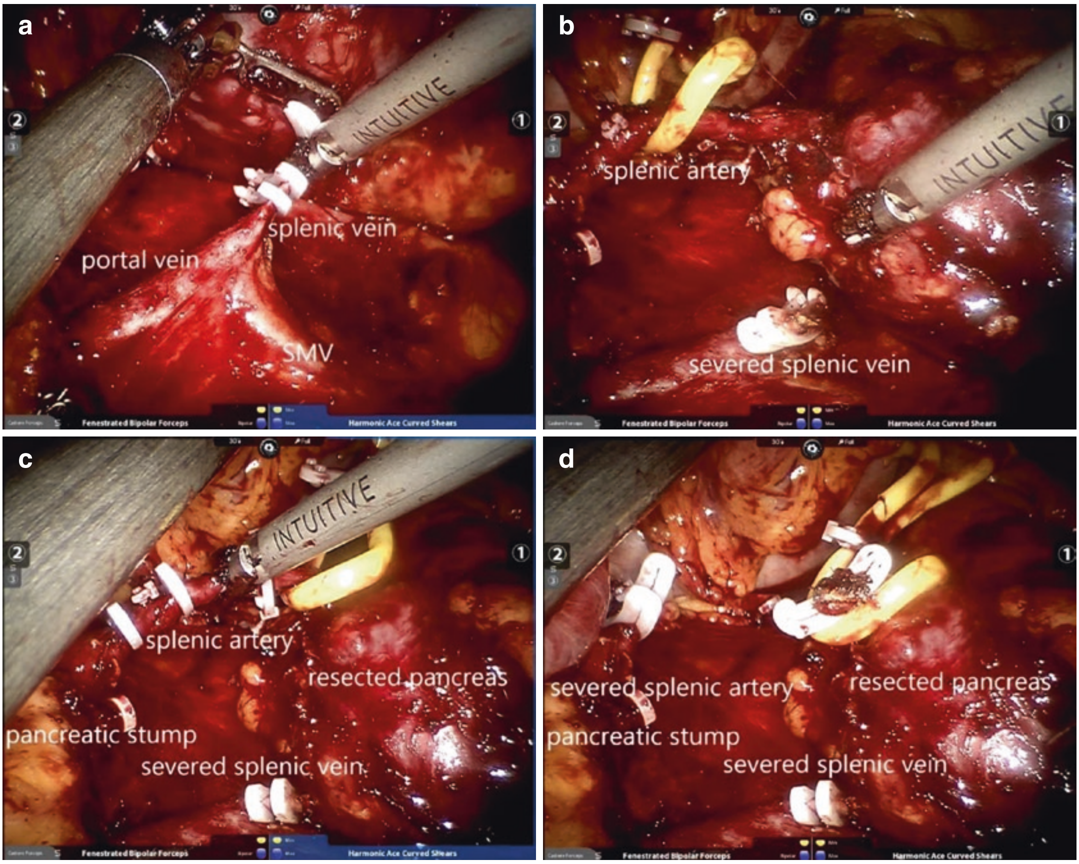

Fig. 17.7 (**a**–**d**) Ligation of splenic vessels

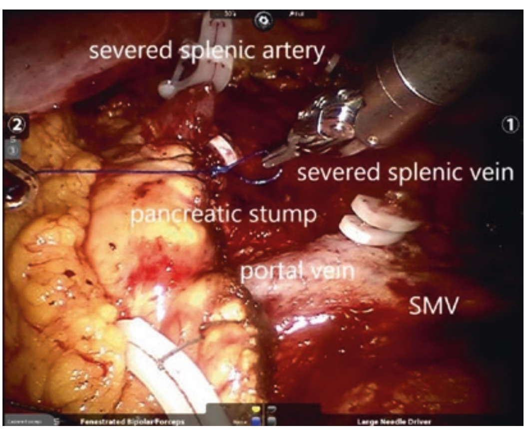

Fig. 17.8 Closure of pancreatic stump

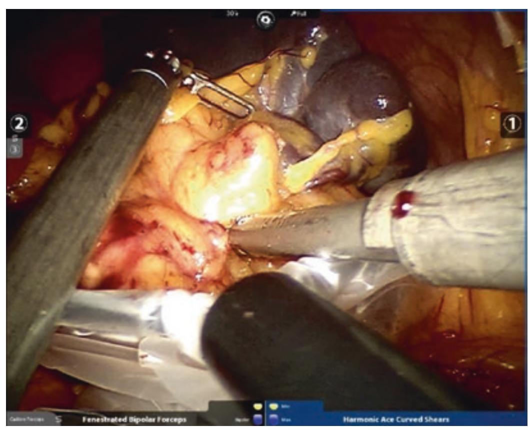

Fig. 17.9 The specimen of the tail of pancreas and spleen

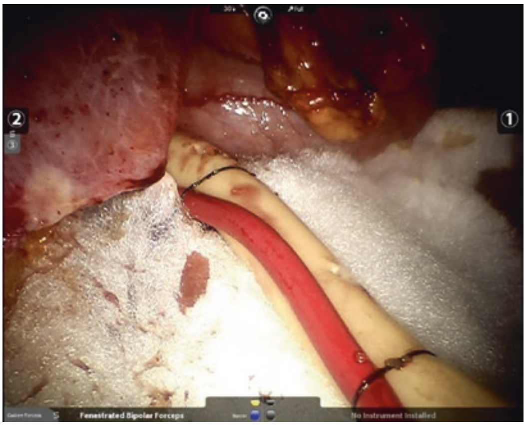

Fig. 17.10 Draining tube was placed in the pancreatic bed

nosis was mucous cystic tumors with focal low-grade intraepithelial neoplasia. The tumor was 3.5 × 3.0 × 2.0 cm in size, located within the pancreas and close to the splenic vessels. No malignant intravascular thrombi and nerve invasion were observed. Peripancreatic lymph nodes were all examined negative.

The patient recovered uneventfully, with removal of nasogastric tube and off-bed activity on day 2 after surgery. Somatostatin was given to inhibit pancreatic enzyme secretion. Amylase in abdominal drainage was collected for evaluation of pancreatic fistula. Postoperative CT scanning showed no significant abdominal infection. Oral intake was resumed on day 8 and the drainage tube was removed on day 10 after surgery. The patient was discharged at day 14 after the surgery. Follow-up of 6 months after surgery revealed no recurrence with tumor markers and reexamined CT.

Informed consent was obtained from all participating patients, and the ethics committee of Shanghai Ruijin Hospital affiliated to Shanghai Jiaotong University approved this study.

17.5 Comment

Robotic distal pancreatectomy is becoming mature. RDP with splenectomy is a safe and feasible surgical plan for patients with malignant pancreatic tumor. It provides smaller wounds and enhanced recovery, but similar overall morbidity and oncologic outcome or survival. Moreover, many patients with benign or low-grade malignant pancreatic tumors now can benefit from spleen-preserving RDP with higher spleen preservation rate, compared with open approach. For more information about spleen-preserving distal pancreatectomy, see *Chapter Spleen-preserving Distal Pancreatectomy*.

In this case, the conventional distal pancreatectomy with splenectomy was adopted for close relationship between the tumor and splenic artery and vein. If the tumor is considered to be pancreatic ductal adenocarcinoma, standardized lymphadenectomy should be performed by the dissection of lymph nodes in No.10 (located in the hilum of spleen), No.11 (along the splenic artery), and No.18 (along the inferior border of the pancreatic body and tail). A more extended lymphadenectomy with additional dissection of lymph node in No.9 (around the celiac artery) is not recommended according to the current research. As for patients with celiac axis involved in the locally advanced pancreatic cancer, DP with en bloc celiac axis resection, also known as Appleby operation, may be the only chance for curative treatment.

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18 Robotic-Assisted Laparoscopic Distal Pancreatectomy with Splenic Preservation

Shi-Wei Zhao, Jia-Bin Jin, and Cheng-Hong Peng

18.1 Introduction

Distal pancreatectomy is an operation which removes the portion of the pancreas extending to the left of the superior mesenteric vein/portal vein trunk and not including the duodenum and distal bile duct. The exact boundary line of transection depends on the location of the lesion. Distal pancreatectomy includes distal pancreatectomy and splenectomy (DPS) and spleen-preserving distal pancreatectomy (SPDP). These years more and more SPDP have been reported. The rich blood supply of spleen is offered by the branches of short gastric vessels and gastroepiploic vessels, so after the ligation of the splenic vessels, the spleen blood supply of nearly 90% patients can still be maintained. Therefore, SPDP can be accomplished by either of these two ways: (1) Kimura's procedure [1]. The branches of splenic vessels are ligated and then the distal part of pancreas is dissected while the trunk of splenic vessels and the spleen are preserved, which, technically speaking, is more difficult and risky. (2) Warshaw technique [2]. The splenic vessels are ligated and dissected with the left gastroepiploic vessels and the short gastric vessels being well preserved to keep the blood supply of spleen. However, it is still controversial about the advantages and disadvantages of these two procedures of SPDP. According to our clinical experience, for benign of early malignant tumors of the pancreatic body and tail, Kimura's procedure should be the first choice. With precise manipulation during the operation, the morbidity is believed to be decreased, meaning that this procedure is safe and feasible. However, Warshaw technique is rather a substitute choice to reduce surgical risk.

Due to various physiological functions, anatomy, and adjacent structures of the pancreas, minimally invasive pancreatic surgery is the one with the slowest progression in the field of minimally invasive hepatobiliary and pancreatic surgery.

In 1996, Cuschieri et al. performed the first laparoscopic distal pancreatectomy (LDP) [3]. Compared with open surgeries, it has so many advantages such as small wound and fast recovery. Besides, this procedure does not require the reconstruction of digestive tracts, which means it is less difficult and less risky, making it easier to perform with a rather affordable cost. Nowadays, the laparoscopy almost interferes with every surgical procedure of pancreatic diseases, among which LDP is the most performed and most mature one so far.

Melvin et al. first reported robotic distal pancreatectomy (RDP) in 2002 [4], predicting the pancreatic minimally invasive surgery has entered a new era. RDP is often used to treat benign lesions, as well as low-grade malignancy

S.-W. Zhao · J.-B. Jin · C.-H. Peng (✉)
Ruijin Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, China

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of the body and tail of the pancreas. Compared with laparoscopic surgeries, the advantages of robotic techniques are very obvious. However, the high expense is the most concern for the popularization of RDP. So far, there is only one retrospective comparative study of RDP and LDP. It is considered that RDP is only suitable for certain cases, even taking the high rate of spleen preservation and short postoperative hospital stay into consideration.

We found that there are more advantages for robot-assisted minimally invasive surgery of pancreas than that of liver and bile duct, thanks to the superior performance of the Da Vinci robotic surgical system: clear 3D images, Endo Wrist™ simulating devices with seven degrees of freedom and tremor filtration, providing better solutions for separation between pancreatic mass and surrounding tissues and retroperitoneal lymph node dissection. The robotic surgery system is the inheritance and development of laparoscopic techniques, but it should also be acknowledged that it is impossible to completely replace the laparoscopic technique, especially for distal pancreatectomy, as there are distinct characteristics between laparoscopic surgery and robotic surgery. However, we believe that the robotic surgery system has significant advantages for minimally invasive surgery of pancreatic tumors of the tail and body which are close to large blood vessels, spleen-preserving distal pancreatectomy and standard radical distal pancreatectomy.

18.2 Comparison Between Kimura's Procedure and Warshaw Technique

The difference between the two is that the former preserves the splenic artery and splenic vein while the latter relies on the gastroepiploic vessels and the short gastric vessels to supply blood to the spleen. In 2012, a report by G. Butturini explored two different ways of DP [5]. From 1999 to 2007, 43 patients who underwent Kimura's procedure and Warshaw technique were included as samples. The overall postoperative complication rate was 56%. Thirty-six of them underwent Kimura's procedure, and the remaining seven underwent Warshaw technique. There were no significant differences in pathologic findings and postoperative complication rates between the two groups. After 1 year of follow-up, the rate of gastric varices in the former group was 21.7% and that in the latter group was 60.0%. In a 2013 article, JP Adam compared 55 patients who underwent Kimura's procedure and 85 patients who underwent Warshaw technique [6]. The clinical characteristics of the two groups were similar except for the significant difference in tumor size (33.6 mm vs 42.5 mm; $P < 0.001$). They found no significant difference in mean operative time, mean blood loss, and conversion to laparotomy, but Kimura's procedure was significantly better than Warshaw technique in the success rate of spleen preservation (96.4% vs 84.7%; $P = 0.03$), while spleen-related complications occurred only in the Warshaw group (0% vs 10.5%; $P = 0.03$), four of whom finally underwent spleen resection (4.7%). The average hospital stay in the Kimura group was less than the Warshaw group (8.2 days vs 10.5 days; $P = 0.01$).

We can see that the Kimura's procedure is a more reliable method of spleen preservation than Warshaw technique. We try to analyze the reasons. First, the Kimura's procedure preserves the spleen vessels and provides a sufficient blood supply to the spleen. This may be one of the reasons why it has a higher success rate of spleen preservation. Secondly, there may be some selective bias for the retrospective analysis of the two method. Many surgeons tend to take the Warshaw technique for safety reasons when they are faced with the difficulty of separating the spleen. However, when the tumor is rather limited and the blood vessels are easier to dissect, Kimura's procedure is more preferred. Therefore, we should fully consider the actual situation in clinical decision-making, and further evaluate which kind of method the patient is suitable for with the spleen well preserved. In short, based on the clinical history and the results of imaging examination, a sufficient preoperative evaluation can be made to develop a suitable spleen-preserving program to meet the patient's needs within a safe range.

18.3 Case 1 (Kimura's Procedure)

The patient was a 30-year-old woman admitted to our hospital due to left backache after meal or strenuous exercise for 1 month. A mass of abdomen is discovered by physical examination. The abdominal computed tomography (CT) showed that the mass was in the tail of the pancreas (Fig. 18.1), and a cystadenocarcinoma was considered.

From these findings, a diagnosis of pancreatic tumor located in the tail was made, and robotic-assisted distal pancreatectomy (Kimura's procedure) was recommanded and performed.

18.4 Details of Procedure

18.4.1 The Importance of Preserving the Spleen in DP

For a long time, the splenectomy is often combined when performing distal pancreatectomy because the tail of the pancreas is closely related to the spleen and blood vessels which keep the separation difficult. This is the conventional way of distal pancreatectomy, which has been mentioned before as DPS. For patients with malignant diseases such as pancreatic body and tail cancer, in order to ensure the radical effect of tumor resection, DPS is a more appropriate procedure. However, for some patients with benign pancreatic diseases, such as benign tumors of the pancreas and cysts, it seems too aggressive to remove the spleen at the same time. With the further understanding of the function of the spleen, people gradually discovered that severe infection may occur after spleen resection and that the spleen may play an important role in the immune and anti-tumor functions. Therefore, with the maturity and development of surgical techniques, the demand for spleen preservation in patients with benign pancreatic lesions has been put on the agenda.

The earliest proposed spleen-preserving distal pancreatectomy (SPDP) was envisioned by Dr. AL Warshaw in 1989. He ensured the blood supply to the spleen by means of gastric retinal vessels and short-stomach vascular compensation. This procedure is called Warshaw method for distal pancreatectomy. The spleen and the blood vessels can be separated without considering the complex relationship between the tail of the pancreas and the spleen, so it is rather easier to operate. However, some people have questioned that the short gastric vessels alone cannot provide sufficient blood supply to the spleen, and that there is a risk of spleen ischemia and infarction. In November 1996, Prof. Wataru Kimura, a Japanese surgeon, proposed that SPDP with the preservation of spleen vessels can be performed for benign lesions in the tail of the pancreas. This procedure is called the Kimura's procedure to protect the spleen and pancreas. Compared with Warshaw technique, there is no risk of spleen ischemia, but the splenic vessels

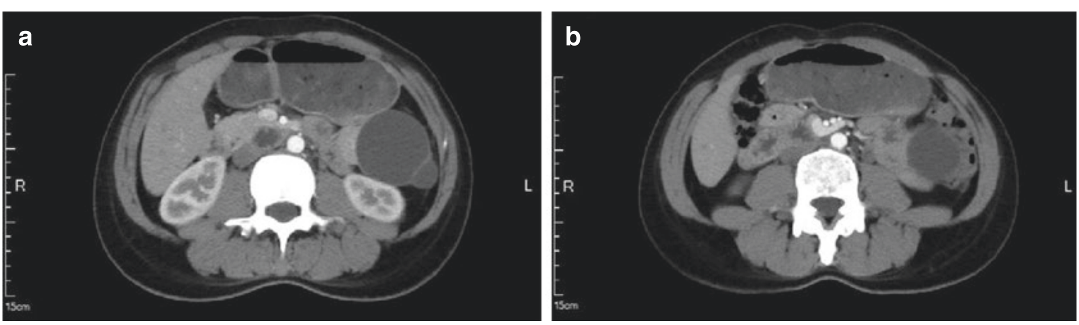

Fig. 18.1 (**a**, **b**) CT images showed a mass in the tail of the pancreas

need to be mobilised from the tail of the pancreas, which makes it highly demanding for surgeons. In short, Kimura's procedure and Warshaw technique have their own advantages and disadvantages, and the choice of methods for spleen preservation will be made according to different scenarios.

18.4.2 Indication of Kimura's Procedure

1. Benign or borderline tumors that cannot be removed simply, such as cystadenoma, neuroendocrine tumor, IPMN, SPT recurrent chronic pancreatitis or obstruction of pancreatic duct stones, and pseudocyst.
2. The patient denies a history of previous upper abdominal surgery, and there is no serious adhesion in the surgical area.
3. In general, the patient does not have serious cardiopulmonary diseases and can tolerate general anesthesia. The patient agrees to perform robot-assisted distal pancreatectomy and signs preoperative informed consent.

18.4.3 Contraindication of Kimura's Procedure

1. Mid- and late-stage pancreatic malignant tumors, or early malignant tumors with spleen vascular invasion, or the lesion are too large for minimally invasive surgery.
2. The patient has severe basic cardiopulmonary disease or poor cardiopulmonary function, or cannot tolerate pneumoperitoneum.
3. The patient has a history of abdominal surgery or has severe adhesions in the abdomen.

18.4.4 Steps

Intestinal preparation was performed according to the requirements of ODP before operation. General anesthesia with tracheal intubation is performed. The patient takes the Trendelenburg position. After the abdomen is insufflated to 15 mmHg of pressure, five ports are well placed. Our technique for RDP begins with the placement of five ports. During operation, the No. 1 robotic arm and the No. 2 robot arm are the main operating arms, while the No. 3 robot arm is commonly used to pull and expose the tissue. An accessory arm is placed between the No. 1 robot arm and the camera port.

1. Abdominal exploration

   The pancreas is exposed, and the surface of the peritoneal organs such as the peritoneum and the liver is thoroughly examined to exclude tumor metastasis and other surgical contraindications. A harmonic scalpel is used to open the gastrocolic omentum, splenocolic ligament, part of the splenogastric ligament, short gastric vessels, and posterior gastric vessels, and it lifts the stomach upward. Part of the short gastric vessels is removed, and the front of the tail of the pancreas can be revealed so that the relationship between the pancreatic tumor and the spleen could be further determined.
2. Separation of splenic vessels

   According to the position of the splenic artery pulsation, the pancreatic capsule is opened, and the splenic artery is separated by a separating forceps to make the splenic artery detached from the pancreas. The splenic vein of the tail of the pancreas travels more in the pancreatic parenchyma. It is difficult to well expose it and may cause massive hemorrhage if it is injured. Therefore, it is the biggest obstacle of the Kimura's procedure. According to the location of the superior mesenteric artery pulsation, the pancreatic capsule of inferior margin is cut with the harmonic scalpel and the neck of the pancreas is lifted to isolate the superior mesenteric vein. Then the root of the splenic vein is further separated and the splenic vein should be separated from the pancreas at least 2–3 cm from the tail of the pancreas. For patients with previous history of gastrointestinal anastomosis and difficulty in exposing the superior mesenteric vein, or tumor located in the tail of the pancreas, the pancreas can also be lifted at the proximal end of the tumor of the pancreatic body, and the splenic vein can be separated behind the pancreas to remove the splenic vein from the pancreas without separating the superior mesenteric vein.

3. Dissection of the pancreas

   Pull the tail of the pancreas to the left side, ligate or dissect of the branches between the pancreas and the splenic vessels with a harmonic scalpel or a vascular clamp until the tail of pancreas is completely dissociated while the splenic vessel trunks and the spleen are well retained. During the separation, it gradually detaches from the inferior margin of the pancreas to the tail of the pancreas. When separating in this area, care should be taken to avoid damage to the blood vessels in the inferior part of the spleen. Then, the branches of the splenic vessels which are emitted to the pancreas are respectively ligated and dissected along the inferior margin of the tail and the body of pancreas. There are no blood vessels in the gap of the peritoneal reflection, so the posterior side of pancreas should be separated along this plane. Finally, the superior margin of the pancreas is isolated, where small blood vessels are often encountered and need to be carefully ligated. After completely mobilising the tail of the pancreas, a post-pancreatic tunnel can be established 2 cm from the right side of the mass by separating the posterior border from the inferior margin to the superior margin of the pancreas with a harmonic scalpel. The pancreas is transected with a stapler (Endo-GIA, 60–2.5 mm) (white) to completely remove the tail and the mass. The pancreatic stump can be coated with bio-adhesive.

4. Extraction of the specimen and position of drainage

   Extend the accessory trocar site to make a transverse incision, enter the abdomen layer by layer, and remove the specimen, the robotic surgical system and the pneumoperitoneum. The intraoperative pathology consultation indicated that it was pancreatic mucinous cystadenoma. After the exclusion of active hemorrhage, a double-lumen drainage tube is placed on the stump of the pancreas.

18.4.5 Prevention of Complication

Massive intraoperative hemorrhage is the most common complication. Once it occurs, the bleeding blood vessels should be quickly clamped and ligated, and the procedure should be transferred to Warshaw technique, DPS, or ODP. If the patient has pancreatic fistula, normally there will not be so much leaked pancreatic juice, but sometimes it can last for a month or more. Generally, it can be cured after sufficient drainage, and no special treatment is needed. The patient can be discharged with an abdominal drainage tube.

18.5 Pathology and Prognosis

The pathologic diagnosis was mucinous cystadenoma, limited inside the pancreas. The size of the tumor is 6.0 × 5.0 × 1.0 cm, and it is thick up to 0.2–0.3 cm, with a smooth and gray wall.

The patient was discharged 11 days after the operation without complication. Six months after surgery, follow-up CT revealed no recurrence.

18.6 Comment

Kimura technique preserves well the blood supply of the spleen which leads to a good prognosis, but it has more risk of postoperative bleeding, which should be taken care.

18.7 Case 2 (Warshaw Technique)

The patient was a 22-year-old woman admitted to our hospital because of discovery of a mass in the upper abdomen occasionally 1 year ago. At that time, she was treated in the digestive department of the local hospital, suggesting that no obvious abnormality of the gastrointestinal tract was

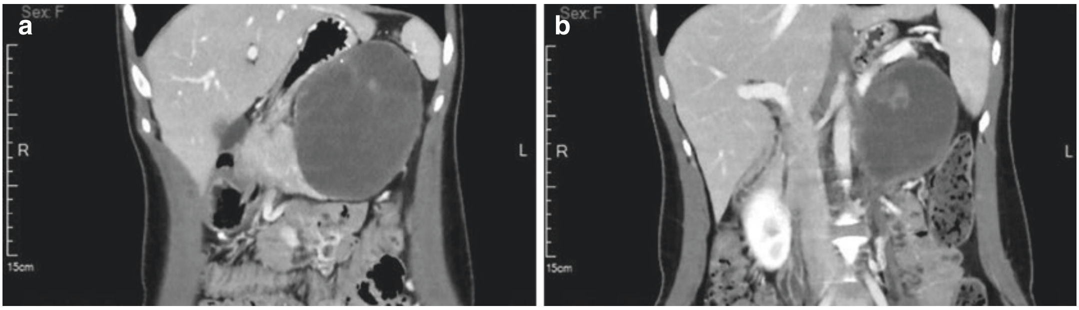

Fig. 18.2 (**a**, **b**) CT images showed a mass in the tail of the pancreas

found, and no further examination and treatment were performed. One month ago, the patient's physical examination showed that the pancreas was found to have cystic solid lesions. Then the patient underwent a CT examination, indicating that there was a cystic degenerative mass in the pancreatic body, considered as solid pseudopapillary tumor (Fig. 18.2), so the patient sought further treatment in our hospital. A diagnosis of pancreatic tumor located in the tail was made, and robotic-assisted distal pancreatectomy (Warshaw technique) was performed.

18.8 Details of Procedure

18.8.1 Steps

Intestinal preparation was performed according to the requirements of ODP before operation. General anesthesia with tracheal intubation is performed. The patient takes the Trendelenburg position. After the abdomen is insufflated to 15 mmHg of pressure, the camera port is well placed.

1. Abdominal exploration

   Reveal the pancreas, perform a comprehensive examination of the surface of the abdominal organs such as the peritoneum and liver, and exclude the tumor metastasis and surgical contraindications. Place the remaining Trocar holes according to the 5-hole method. A harmonic scalpel is used to open the gastrocolic omentum, splenocolic ligament, part of the splenogastric ligament, short gastric vessels, and posterior gastric vessels, and it lifts the stomach upward. Part of the short gastric vessels is removed, and the front of the tail of the pancreas can be revealed so that the relationship between the pancreatic tumor and the spleen could be further determined.
2. Separation of splenic vessels

   According to the position of the splenic artery pulsation, the pancreatic capsule is opened, and the splenic artery is separated by a separating forceps to make the splenic artery detaches from the pancreas. According to the position of the superior mesenteric artery pulsation, the inferior margin of the pancreas is opened with a harmonic scalpel, and the neck of pancreas is lifted to isolate the superior mesenteric vein. The root of the splenic vein is further separated to remove the splenic vein from the pancreas.
3. Dissection of the pancreas

   Pull the tail of the pancreas to the left side, ligate or dissect of the branches between the pancreas and the splenic vessels with a harmonic scalpel or a vascular clamp until the tail of pancreas is completely dissociated while the splenic vessel trunks and the spleen are well retained. Continue to dissociate the pancreas and use the hemolock clip to clamp the splenic vein and splenic artery behind it. Note that the site of the dissection should be where the splenic artery does not give rise to left gastroepiploic artery and the short gastric artery so that after the splenic artery is dissected, the arteries can be retrogradely perfused to supply blood to the spleen, thus avoiding postoperative spleen infarction. Then the tail of the pancreas including the mass is turned to the left, and the tissue behind the pancreas is continued to be dissociated. A post-pancreatic tunnel can be established 2 cm from the right side of the mass by separating the posterior border from the inferior margin to the superior margin of the pancreas with a harmonic scalpel. The pancreas is transected with a stapler (Endo-GIA, 60-2.5 mm) (white) to completely remove the tail and the mass. Observe the color change of the spleen.

4. Extraction of the specimen and position of drainage

   Extend the accessory trocar site to make a transverse incision, enter the abdomen layer by layer, and remove the specimen, the robotic surgical system, and the pneumoperitoneum. The intraoperative pathology consultation indicated that it was pancreatic mucinous cystadenoma. After the exclusion of active hemorrhage, a double-lumen drainage tube is placed on the stump of the pancreas, and another vacuum drainage is put near the lesser omentum. Final closure is made layer by layer.

18.9 Pathology and Prognosis

The pathologic diagnosis was pancreatic solid pseudopapillary tumor, limited inside the pancreas. The size of the tumor is 12.0 × 9.0 × 7.0 cm, and it is thick up to 0.2–0.3 cm.

The patient was discharged 15 days after the operation without complication. Six months after surgery, follow-up CT revealed no recurrence.

18.10 Comment

Warshaw technique is much safer, preserving the spleen as well. Saving the left gastroepiploic artery is important. Follow-up should focus to the possible splenic infarction.

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Part VI

Adenocarcinoma of the Pancreas: Palliative Surgical Therapy

19 Endoscopic Retrograde Biliary Drainage for Unresectable Pancreatic Cancer

Hao Weng and Xue-Feng Wang

19.1 Introduction

Pancreatic cancer is the worst malignant tumor of the digestive system. Endoscopic palliative treatment is used for patients with unresectable pancreatic cancer, including endoscopic nasobiliary drainage (ENBD), endoscopic retrograde biliary drainage (ERBD), and self-expandable metal stents (SEMSs) [1, 2]. It is conducive to prolong the survival time of patients and improve their life quality.

The average survival time of patients diagnosed with pancreatic cancer is lower than 6 months, and the 5-year survival rate is lower than 5%. Although symptoms are not obvious in early-stage pancreatic cancer, blood or lymphatic metastasis occurs frequently. Most of the patients are in the advanced stage at the time of diagnosis. Therefore, few patients are suitable for performing the surgical resection. In addition, the recurrence rate is high and the prognosis is very poor. Most cases have pancreatic adenocarcinoma. The growth of the tumor is accompanied by the compression and obstruction of the bile vessel and pancreatic vessel, resulting in pancreatic atrophy, obstructive jaundice, cancer pain, and other symptoms. It may also lead to serious complications and secondary symptoms, demonstrating loss of surgical opportunities. These complications or secondary symptoms are also the leading causes of death in patients with pancreatic cancer. However, there are some treatment methods for patients with unresectable advanced pancreatic cancer. The current palliative treatment, such as relieving the obstruction, controlling complications, and alleviating pain, can improve the quality of life of patients, prolong the life of patients, and achieve satisfactory therapeutic effects.

With the rapid development of medical technology and biomaterials technology, the use of endoscopy is no longer limited to diagnostic examination and its treatment technology is getting mature, which plays an important role in the palliative treatment of unresectable pancreatic cancer. The compression of duodenum and nipple, biliary duct, and pancreatic duct can be directly observed by virtue of endoscopic retrograde cholangiopancreatography (ERCP), which provides effectively the evaluation for the stage of pancreatic cancer and provides an effective scheme for the next treatment [3]. Endoscopic sphincterotomy, endoscopic nasobiliary drainage, and biliary stent implantation are developed based on this technique to achieve adequate drainage of biliary and pancreatic duct obstruction. On the basis of adequate drainage, photodynamic therapy (PDT) and intracavitary ablation have been further developed to improve the therapeutic effect of unresectable pancreatic cancer.

As many as 70–80% of patients with pancreatic cancer have symptoms of the common bile

H. Weng · X.-F. Wang (✉)
Department of General Surgery, Xinhua Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, China

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duct, causing obstruction, such as jaundice, skin itching, progressive cholangitis, liver dysfunction, and coagulation dysfunction secondary to vitamin K absorption disorder. ERCP is a good choice for the treatment of biliary obstruction due to its lower complications and costs compared with percutaneous transhepatic cholangial drainage (PTCD) and surgery. Before palliative decompression of the biliary duct, it should be confirmed that jaundice is caused by bile duct obstruction rather than extensive metastasis secondary to the hepatobiliary duct. A 3D computed tomography (CT) and a magnetic resonance cholangiopancreatography (MRCP) are needed to have a comprehensive understanding of the biliary system and to determine the location and extent of stenosis.

The main methods of endoscopic biliary drainage are endoscopic nasobiliary drainage (ENBD), endoscopic retrograde biliary drainage (ERBD), and self-expandable metal stents (SEMSs) [4, 5]. Some patients who perform ENBD suffer pharyngeal discomfort. Furthermore, long-term drainage may lead to bile loss, water and electrolyte disturbance, and malnutrition. Therefore, ERBD is used as a temporary drainage measure and should not be used for more than 1 month. It is rarely used in obstructive jaundice caused by pancreatic cancer. ERBD is a method for endoscopic treatment of common bile duct strictures. It is made of polyethylene and other materials, with an outer diameter of 5–12 Fr and a length of 3–20 cm, which is selected according to the extent and location of the disease. The proximal end of the tube is placed above the narrow segment, and the distal end is usually left outside the duodenal papilla. When patients receive ERBD, it has the possibility of stent obstruction, displacement, rupture, and intestinal injury caused by the stent. The average patency period of plastic bile duct stent is approximately 3–6 months. Once the plastic stent is blocked, it should be considered to replace in time. Those who have the conditions can also replace it regularly every 3 or 6 months. The characteristics of SEMSs are long-term patency, high drainage rate, and low complications in the treatment of malignant bile duct strictures. In patients with a survival time of greater than 6 months and receiving SEMSs, the time of performing ERCP is less, with a shorter hospital stay, and fewer complications than those in patients receive ERBD [178–181]. Other studies have shown that metal stents are more cost-effective for patients with a survival time of greater than 6 months, while plastic stents are more beneficial for patients with shorter survival time. The tumor growing in the mesh of the metal stent leads to biliary obstruction, which can be solved by placing a plastic stent or a metal stent in the metal stent cavity.

19.2 Case

The patient was an 84-year-old female admitted to our hospital with jaundice and abdominal pain for 3 months. Laboratory examinations showed an elevation of liver function tests: total bilirubin (TB) 207.7 μmol/L, direct bilirubin (DB) 163.3 μmol/L, aspartate amino-transferase (AST) 206 U/L, alanine amino-transferase (ALT) 866 U/L, alkaline phosphatase (ALP) 334 U/L, and r-glutamyl transpeptidase (r-GTP) 513 U/L. The tumor marker CA19-9 was 11022kU/L, others were normal.

The abdominal ultrasonography (US) and abdominal computed tomography (CT) showed a mass in the head of the pancreas, and a dilation of common bile duct and pancreatic duct. The tumor wrapped SMA and SMV. Pancreatic head adenocarcinoma was considered (Fig. 19.1). Due to the

Fig. 19.1 CT image showed a mass in the head of the pancreas

patient's old age and her late-stage tumor, a radical whipple operation was not considered. We decided to use endoscopic retrograde biliary drainage to relief her jaundice.

Informed consent was obtained from all participating patients, and the ethics committee of Xinhua Hospital, affiliated with Shanghai Jiao Tong University, School of Medicine, approved this study.

19.3 Details of Procedure

A side-view duodenoscope was successfully intubated into the second portion of the duodenum, a standard shortening maneuver was used to straighten the endoscope's body. The tip of endoscope was properly adjusted and major papilla was easily identified (Fig. 19.2).

Cannulation of the common bile duct was then be performed. However, the papilla was long and had a soft texture, which increased the difficulty of standard biliary cannulation. After 15-min cannulation attempts, selective biliary access was failed. To prevent post-ERCP-pancreatitis (PEP), we used needle-knife fistulotomy (NKF) technique (Fig. 19.3) and performed with a needle-knife sphincterotome (Triple-lumen Microknife XL, Boston Scientific, Natick, MA, USA). The tip of knife was anchored on the summit of the protuberant papilla, and then a puncture was made to create an endoscopic choledochoduodenal fistula. Subsequently, the fistulous opening was gently probed via a wire-guided sphincterotome to achieve deep biliary cannulation [6].

Finally, the guide-wire was successfully cannulated. After the catheter followed into the bile duct, cholangiography was performed. Radiological images show a stenosis site occurred at the lower part of bile duct caused by tumor oppression. The upper common bile duct and intrahepatic bile duct were extremely dilated (Fig. 19.4).

A self-expanding metallic stent with a diameter of 10 mm and length of 6 cm was inserted into the common bile duct in a transpapillary position. The lower tip of SEMS extends 5–10 mm into the duodenal lumen. X-ray image showed that the stent covered the whole obstruction part of lower bile duct. After the stent expanded, large amount of bile flowed out through the stent, which indicated that a good drainage result was achieved (Fig. 19.5).

19.4 Prognosis

The patient had no post-ERCP complication such as pancreatitis, cholangitis, or hemorrhage. She was discharged 4 days after the operation. Two weeks later, follow-up lab test showed a great

Fig. 19.2 Major papilla was long and soft, and common bile duct was hard to be cannulated

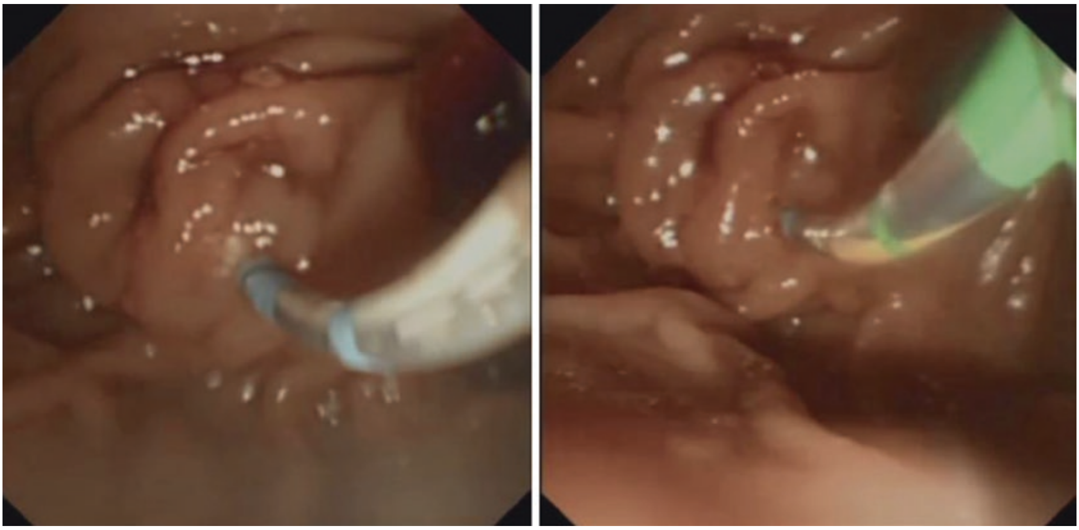

Fig. 19.3 NKF technique was used, leaded to successful cannulation

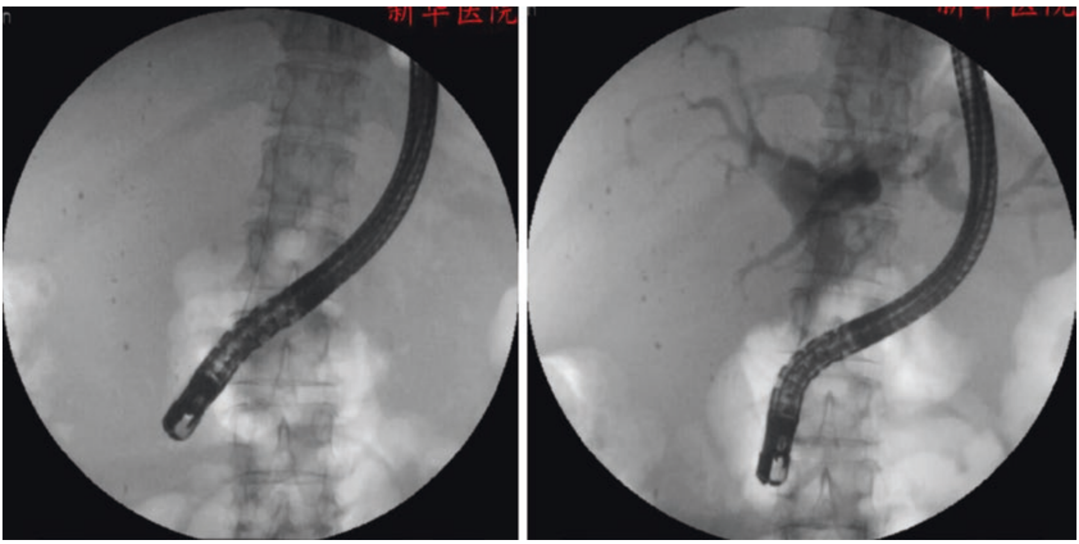

Fig. 19.4 Cholangiography showed obstruction at the lower bile duct

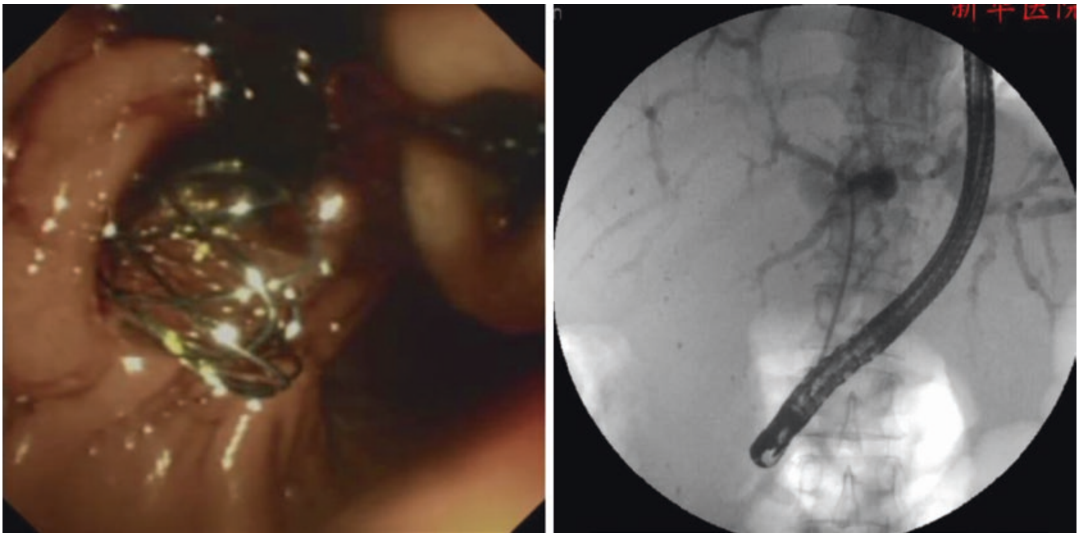

Fig. 19.5 A self-expanding metallic stent was inserted

improvement of liver function, with total bilirubin (TB) reduced to 67.4 μmol/L and direct bilirubin (DB) reduced to 32.1 μmol/L.

19.5 Comment

For those patients whose tumor cannot be radically resected, endoscopic retrograde biliary stent insertion provides a safe method to relieve jaundice with limited damage. It can effectively maintain patient's liver function and extend their life expectancy.

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20 Palliative Surgical Therapy: Palliative Bypass Procedure

Kai Qu, Qing Yao, and Chang Liu

20.1 Introduction

Pancreatic carcinoma (PC) is a highly malignant cancer featured by very poor prognosis. Radical surgical resection is the most curative way at present. However, owing to lack of symptoms at early stage and rapid progression, 80% of patients are considered not amenable to surgical resection because of locally advanced or metastatic condition when diagnosed. Up to a third of the remaining 20% of patients eligible for surgical exploration before operation are found to be unresectable during operation [1]. Unfortunately, most of patients are not amenable to toxic and side effects of radiotherapy or chemotherapy drug either. In addition, the sensitivity of pancreatic cancer cells to chemotherapy drug is very poor. So generally, therapeutic outcome of pancreatic cancer is dismal. What is worse, patients with PC often present with malignant obstructive jaundice and duodenal obstruction, the rate of incidence of which is 75% and 20%, respectively [1]. Jaundice would cause pruritus, nausea, coagulopathy, and, most severely, hepatorenal dysfunction and endotoxemia, which may directly lead to the death of patients. Duodenal obstruction leads to malnourishment and intractable vomiting [2]. Both obstructions negatively affect quality of life and prognosis. Therefore, aside from improving effectiveness of curative treatment to prolong survival, palliative treatment to relieve pain and improve quality of life is another significant aspect of treatment for patients with unresectable pancreatic carcinoma.

Palliative bypass procedure is mainly applied to relieve and prevent biliary and gastrointestinal obstruction for patients with unresectable pancreatic carcinoma. Besides, patients with other malignant cancers, for example, duodenal adenocarcinoma, distal cholangiocarcinoma, and periampullary carcinoma, also require similar method of treatment [3]. Bilioenteric and gastroenteric bypass (double bypass), as a classic combination, was reported by Mann et al. to be capable of achieving good long-term palliation that over 95% of patients remain free from gastric outlet obstruction and jaundice until death. This to a great extent helps to prevent cholangitis, abdominal pain, and liver failure, thus improving life quality of patients [3]. Moreover, the relief of obstructive biliary tract is necessary to initiate chemotherapy. As to preventing gastric obstruction, it was reported that the risk of secondary duodenal stricture following double bypass procedures was smaller than that following biliary bypass alone, which supported the benefit of prophylactic gastric bypass [1]. Therefore, if a patient needs a surgical biliary bypass, gastric bypass procedure will be routinely carried out for a prophylactic intention.

K. Qu · Q. Yao · C. Liu (✉)
The First Affiliated Hospital of Xi'an Jiaotong University, Xi'an, China

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20.2 Case

A 65-year-old male patient was admitted to the hospital with abdominal pain for 2 months. Blood tests showed high levels of CA19-9 tumor markers (1340 U/mL). Abdominal computed tomography with enhanced and vascular reconstruction revealed a space-occupying lesion in the head and neck of the pancreas; the findings suggest the presence of pancreatic cancer, which invades the hepatic artery, splenic artery, mesenteric vein, and portal vein. Pathological examination of endoscopic ultrasound biopsy specimens showed abnormal cells with the same morphology as adenocarcinoma. Positron emission tomography computed tomography revealed abnormally high levels of fluorodeoxyglucose metabolism limited to space-occupying lesions, suggesting malignant pancreatic lesions, pancreatic atrophy, and many small nodules around the pancreas. He was finally diagnosed with T4N2M0 locally advanced pancreatic cancer. Informed consent was obtained from this patient, and the ethics committee of The First Affiliated Hospital of Xi'an Jiaotong University approved this study.

20.3 Details of Procedure

20.3.1 Exposing and Treating the Bile Duct and Resection of Gallbladder

After entering the abdomen, explore and exposure the biliary tract. Open the hepatoduodenal ligament and expose the common bile duct. Use the oval clamp or curved hemostat to clamp the neck of the gallbladder and pull it slightly to the upper right. The peritoneum on the left side of the gallbladder neck was cut with a knife along the outer edge of the hepatoduodenal ligament, and the cystic duct was carefully and bluntly separated. During the separation process, the forceps clamped on the neck of the gallbladder can be continuously pulled so that the cystic duct is slightly tensioned for identification. After confirming the relationship between the gallbladder and the common bile duct, the traction of the gallbladder neck is relaxed, and the common bile duct is prevented from being pulled into an angle. Use two hemostats to clamp the cystic duct 0.5 cm from the common bile duct. Be careful not to clip the common bile duct, right hepatic duct and right hepatic artery to avoid accidental injury. The cystic duct was cut between the two clamps, the proximal end was ligated with a 4-0 silk thread, and the distal end was sutured with a 1-0 silk thread to avoid shedding.

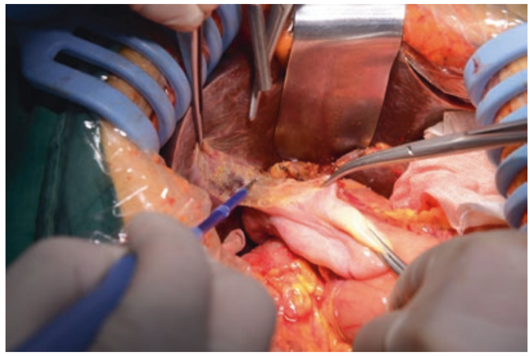

Fig. 20.1 Resection of gallbladder

The gallbladder artery is located in the deep tissue behind the cystic duct, and the distal end of the cystic duct is pulled upward. In the posterior upper triangular region, the gallbladder artery is found, and the relationship between it and the right hepatic artery is confirmed. After being distributed to the gallbladder, it is clamped, cut, and ligated on the side close to the gallbladder, and then the proximal end is added as a filament. Under the serosa at the junction of the gallbladder and the liver surface, 1–1.5 cm from the edge of the liver, the gallbladder serosa is cut, if there is acute inflammation recently, it can be cut with a finger or gauze ball. Separation of the loose space under the serosa of the gallbladder (Fig. 20.1).

20.3.2 Transection of Common Bile Duct and Upper Jejunum

In order to avoid the common bile duct blind syndrome, the common bile duct must be transected before establishing a new bypass. Before the transection, the distal end of the common bile

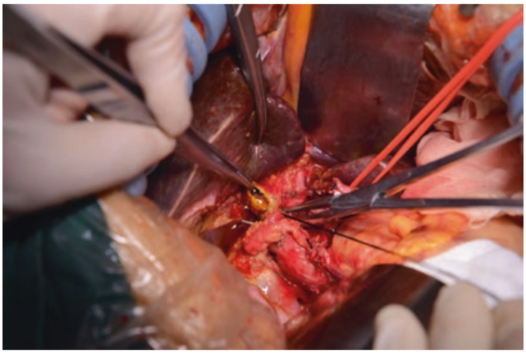

Fig. 20.2 Isolation and transection of common bile duct

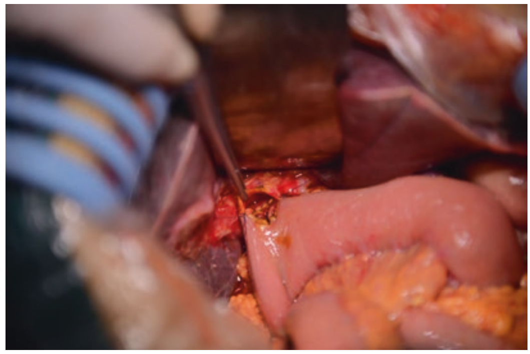

Fig. 20.3 Anastomosis of the posterior wall

duct should be determined to be unobstructed. The transverse site is preferably at the upper edge of the duodenum. The left common bile duct is the hepatic artery, and the back is the portal vein, which is adjacent to each other, with loose connective tissue connected. The transected bile duct should be determined according to the characteristics of the common bile duct wall and the adhesion of the common bile duct to the surrounding (Fig. 20.2).

Then, lift the transverse colon and follow the mesentery down to find the duodenal jejunum. Cut the jejunum about 15 cm away from the duodenal suspensory ligament, but pay attention to retain the first jejunal artery on the jejunum, cut off the second jejunal artery, separate and cut the ligament of the jejunum so that there is enough freeness in the distal part of the jejunum. There is no tension after the above-mentioned bilioenteric anastomosis.

20.3.3 Bilioenteric Anastomosis

The distal jejunum raised from the transverse mesenteric fissure is cut into a small opening on the lateral side of the mesentery of the sutured stump. Incise the jejunal loop on its antimesenteric aspect over the same length as the diameter of the bile duct. The direction of jejunum is parallel to the long axis of the intestine, and the size is matched with biliary ostium. Attach the jejunal mucosa to the intestinal wall with four interrupted sutures PDS 6/0, which will prevent it from slipping back. Now place the atraumatic orientation sutures in the middle of the anterior and posterior walls and the corner sutures, all with PDS 5/0. This defines the anterior and posterior walls and ensures even distribution of the anastomotic margins in the bile duct and jejunum. Since this anastomosis cannot be flipped over, the anastomosis of the posterior wall is performed first (Fig. 20.3).

Depending on the condition of the disease, it is advisable to place the T-shaped drainage tube in the anastomosis. The T-shaped tube is placed by suspending the purse on the jejunal wall about 12 cm away from the anastomosis before the anterior wall of the anastomosis is sewed, temporarily not being tied, and a small hole is cut in the center, thereby placing the T-shaped tube is placed into the left and right hepatic ducts through the anastomosis.

The bilioenteric anastomosis is carried out with interrupted sutures inside-out through all layers, with the knots located within the lumen. Depending on the diameter of the bile duct, this should require at least seven sutures with PDS 5/0 or 6/0. The anastomosis of anterior wall is carried out with interrupted sutures outside-in through all layers, employing the same technique as with the posterior wall (Fig. 20.4).

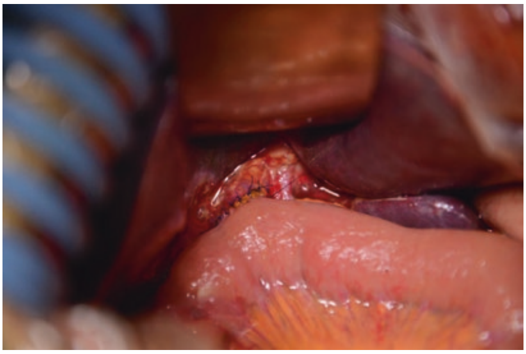

Fig. 20.4 Anastomosis of the anterior wall

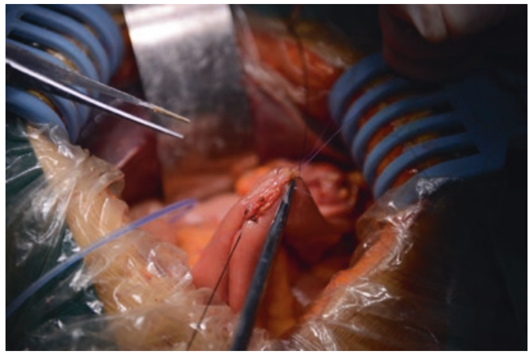

Fig. 20.5 Intestinal anastomosis

20.3.4 Gastrointestinal Anastomosis and Intestinal Anastomosis

The jejunum is lifted from the front of the colon, and the stomach wall of the proposed anastomosis is along the long axis in the direction of peristalsis (i.e., the proximal end is on the left side and the distal end is on the right side), and the anastomosis (about 5–6 cm in length) is proposed in the jejunum. The proximal mesangial surface and the stomach wall are each sutured with a muscle layer traction line, and then tied to prepare an anastomosis. Cut the gastric and intestinal wall muscle layers 0.5 cm along both sides of the suture, and suture the submucosal blood vessels. Then scissor the mucosa of stomach and intestine, and suture the posterior wall from the distal to proximal sections. Use the same method to suture the anterior wall. After the outer layer of the anterior wall was sutured with the silk muscle layer, the sarcolemma layer 8 or scorpion suture was used to fix the two points of the anastomosis.

The distal jejunum was lifted 60 cm to anastomose with the proximal end of the jejunum. The bile duct-jejunal arm is preferably 45–50 cm. If the arm is too short, the jejunal content may be reversed into the biliary tract. If it is too long, the intestinal fistula may be flexed to increase the intrabiliary pressure. The inner layer of the anastomosis was sutured by a full-thickness suture of the silk thread, and the outer layer was sutured with a broken suture muscle layer. After suturing, the proximal end of the jejunum and the upper part of the distal jejunum were sutured for 3–4 needles to make them synchronized. The intestinal contents were smoothly entered into the distal part of the jejunum from the proximal end of the jejunum (Fig. 20.5). The jejunal mesangial hole is sutured to avoid postoperative internal hemorrhoids. The transverse mesenteric hiatus is also closed.

20.4 Pathology and Prognosis

The study reported by Mann et al. reviewed the outcomes of combined biliary/gastric bypass as palliative treatment for unresectable malignancies. The results are as follows. Median hospital stay was 12 days. Median survival after operation was 9.5 months. As to long-term palliation of symptoms, 96% of patients ($n = 96$) remained free from jaundice and obstruction until death [3].

20.5 Comment

Pancreatic adenocarcinoma is highly malignant with poor prognosis and low quality of life. Although radical resection is still the only promising treatment, the rate for patients being deemed resectable is very low. What is worse, patients with PC often present with malignant obstructive jaundice and duodenal obstruction causing pruritus, nausea, pain, coagulopathy, and most severely, hepatorenal failure and endotoxemia. In this very case, it seems particularly important that palliative bypass procedures help relieve and prevent biliary and gastrointestinal obstruction, thus significantly improving quality of life. Moreover, bilioenteric and gastroenteric bypass (double bypass), as a classic combination, has shown good performance in achieving long-term palliation that over 95% of patients remain free from gastric outlet obstruction and jaundice until death.

However, patients with advanced pancreatic carcinoma are much less amenable to surgical bypass procedures due to chronic wasting of tumor and jaundice. Therefore, in spite of reducing the risk of recurrent obstruction, bypass procedures were still reported to have association with major morbidity and mortality as they cause greater surgical trauma [1]. As a result, minimally invasive endoscopic therapy is cumulatively being carried out instead as they are featured by quicker recovery, lower rates of morbidity, and reduced hospital stay, making it amenable for seriously ill and infirm patients. Disadvantages of endoscopic therapy include lower patency rates and more reinterventions [3].

As increasing evidences have reported success in performing gastric and biliary bypass palliation through laparoscopic approach, it seems feasible and reasonable to carry out laparoscopic bypass for selected patients, especially for those diagnosed unresectable at staging laparoscopy. In a similar way, surgical bypass could be taken into consideration if surgical exploration fails.

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Part VII

Surgical Treatments for Pancreatic Neuroendocrine Tumors

21 Central Pancreatectomy

Zhe Cao and Tai-Ping Zhang

21.1 Introduction

In 1910, Finney et al. reported the first central pancreatectomy, during which the left stump of the pancreas was anastomosed with the right stumps. The risk of this surgical process was high, so as the incidence of postoperative complications. In 1957, Guillemin performed central pancreatectomy with "Ω"-shaped jejunostomy in the patient with chronic pancreatitis, significantly reducing the incidence of complications such as pancreatic fistula [1]. In 1984, Dagradi reported the first case of central pancreatectomy for an insulinoma. It can not only preserve the normal pancreatic parenchyma as well as the structure of the gastrointestinal tract, biliary tract, and spleen, but also improve overall postoperative pancreatic endocrine and exocrine function, decrease the risk of infection and coagulation abnormalities.

Indications for central resection of the pancreas include [2, 3]: (a) tumor located between the left of the gastroduodenal artery and where the splenic vein and the inferior mesenteric vein meet, benign or low-grade pancreatic neck and body tumors, such as neuroendocrine tumors, serous cystadenomas, mucinous cystadenomas, solid pseudopapillary neoplasms, intraductal papillary mucinous neoplasms, and those that cannot be locally excised; (b) tumors with a diameter of 2–5 cm, closely related to the main pancreatic duct, and those with a higher risk of enucleation; (c) benign non-neoplastic lesions that are difficult to excise, such as lymphatic cysts, dermoid cysts, and hydatid cysts; (d) localized pancreatic duct stones or stenosis. This procedure is not recommended for malignant pancreatic neoplasms. The most significant postoperative complication is a pancreatic fistula, due to the presence of two pancreatic stumps after central pancreatectomy. The risk is higher compared to the classic pancreaticoduodenectomy (Whipple procedure) and distal pancreatectomy with splenectomy.

21.2 Case

A 50-year-old man complaining of repeated palpitations, hunger, and fatigue for one and a half year was admitted to the hospital. He also had dizziness, sweating, hand trembling occasionally with no loss of consciousness. Patient's blood glucose was 2.2–2.8 mmol/L during onset, and symptoms can be alleviated by eating food. His fasting blood glucose was 2.34 mmol/L, insulin was 947 pmol/L↑(13–161), C peptide was 9.68 ng/mL↑(0.6–3.4), HbA1c was 5.2%, and no other abnormalities were found. Contrast-enhanced CT scan (Figs. 21.1, 21.2, and 21.3)

Z. Cao · T.-P. Zhang (✉)
Peking Union Medical College Hospital, Beijing, China

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Fig. 21.1 CT scan showed that an 18 mm × 13 mm nodule is seen at the neck of the pancreas

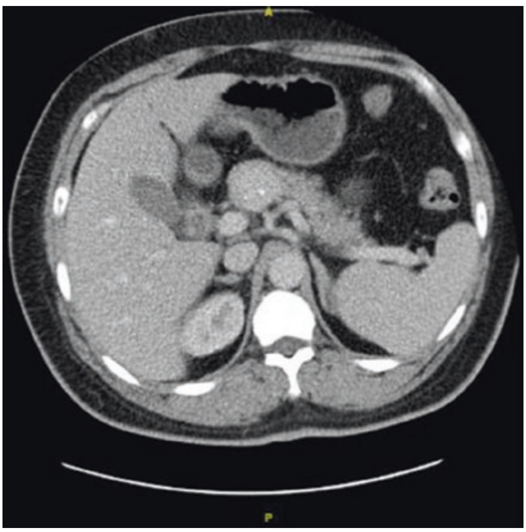

Fig. 21.2 CT scan showed that an 18 mm × 13 mm nodule is seen at the neck of the pancreas

showed that an 18 mm × 13 mm nodule is seen at the neck of the pancreas, and the nodule was enhanced during the arterial phase. Insulinoma was suspected. Ga-Exendin4-PET/CT showed a 1.3 × 1.2 cm abnormal increase of uptake at the pancreatic neck, average SUV was 7.1, highest of 16.3, indicating overexpression of GLP-1R. Again, insulinoma was suspected. Central pancreatectomy was performed in order to preserve the

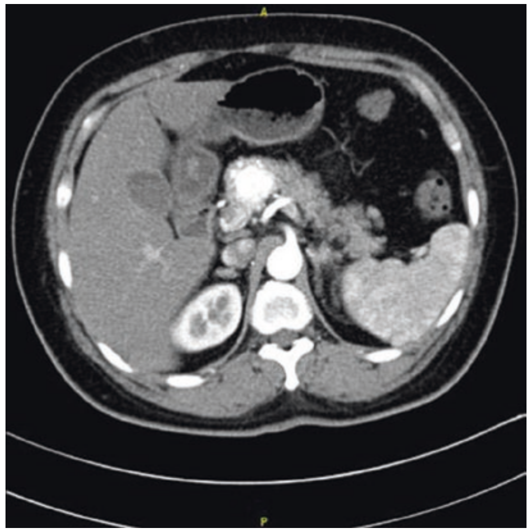

Fig. 21.3 CT scan showed that an 18 mm × 13 mm nodule is seen at the neck of the pancreas

endocrine function to the maximum extent, reduce long-term complications, and improve overall prognosis. Informed consent was obtained from all participating patients, and the ethics committee of Peking Union Medical College Hospital approved this study.

21.3 Details of Procedures

21.3.1 Expose the Central Part of the Pancreas

Incise the abdominal wall along the midline. Enter the abdominal cavity, and explore the liver, gallbladder, stomach, intestine, omentum, abdominal wall, and pelvic cavity. Incise the gastrocolic ligament and detach the large omentum from the transverse colon to enter the small omental sac. The stomach is retracted rostrally to reveal the central part of the pancreas (Fig. 21.4). The superior mesenteric vein has to be exposed carefully to avoid injuring the gastrocolic ligament and the short gastric vessels. When splenic arteries and veins are ligated and divided, blood can still be transported through the short gastric vessels to the spleen. If necessary, intraoperative ultrasound

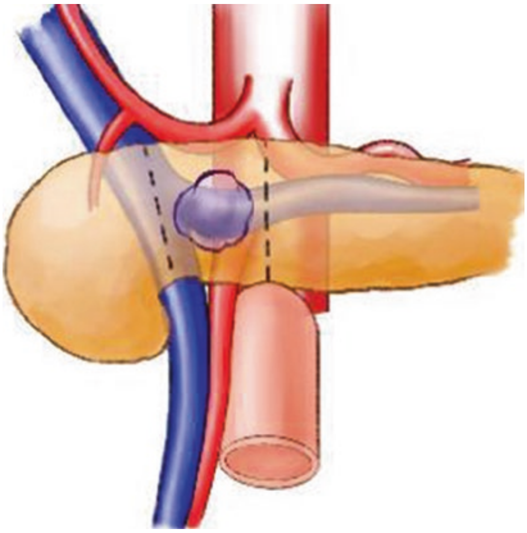

Fig. 21.4 To reveal the tumor in the central part of the pancreas

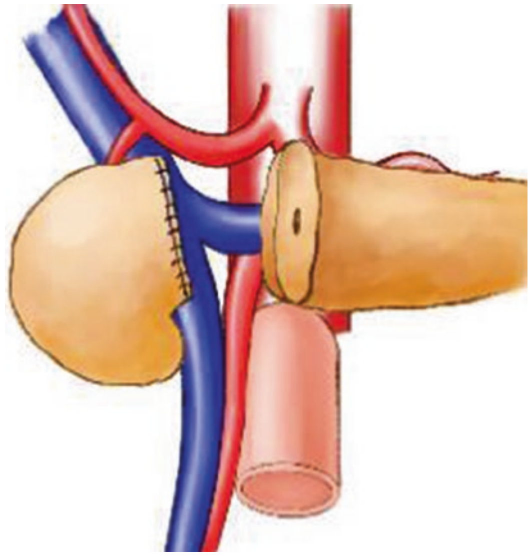

Fig. 21.5 The pancreas is mutilated 1–2 cm to both left and right of the tumor mass

can be used to determine the location and its relative position with the main pancreatic duct and major blood vessels.

21.3.2 Mobilize the Central Part of the Pancreas

For the upper part of the pancreas, mobilize the common hepatic artery, the initial segment of the gastroduodenal artery, and splenic artery. Then incise the posterior peritoneum along the inferior edge of the part of the pancreas, mobilizing the lower part of the pancreas, further exposing the superior mesenteric vein, splenic vein, and portal vein. This area with the superior mesenteric vein on the left and the hepatoduodenal ligament to the right is easily recognized when the lower part of the pancreas is exposed and is important for avoiding accidental injuries to the pancreatic and bile duct. Small branches lie between the superior mesenteric vein and the inferior edge of the pancreas, so special attention should be paid during the process. After penetrating a tunnel through the posterior of the pancreas through blunt dissection, the pancreas is mobilized and retracted anterorostrally.

21.3.3 Remove the Central Part of the Pancreas

Generally, the pancreas is mutilated 1–2 cm to both left and right of the tumor mass (Fig. 21.5). The proximal pancreas is divided by a linear cutter or ultracision, then the distal portion of the pancreas is gently lifted, and the loose tissue between the splenic vessels and the pancreas is separated by ultracision. The splenic vein is gradually separated from the pancreatic parenchyma, branch vessels are coagulated or sutured, and finally, the distal pancreas is excised. Bleeding can be controlled by either coagulation or stitches.

21.3.4 Reconstruct the Digestive Tract

The two commonly used methods for gastrointestinal reconstruction are pancreaticogastrostomy (PG) and pancreatojejunostomy (PJ). The latter is more commonly seen in clinical practice. There are also two types of pancreatojejunostomy. One is to close the proximal end of the pancreas and perform Roux-en-Y anastomosis on the

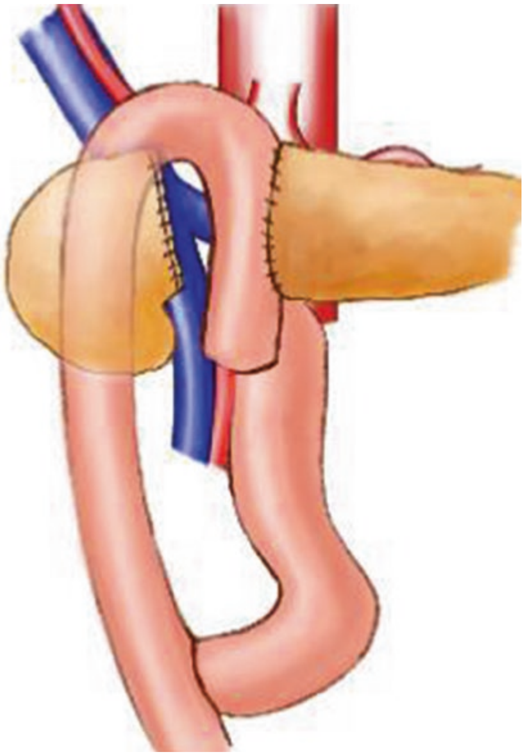

Fig. 21.6 Double anastomosis

distal pancreas with the jejunum. The other type does not close the proximal end of the pancreas but instead use the so-called double anastomosis or Ω anastomosis by performing Roux-en-Y anastomosis on both proximal and distal pancreas with the jejunum (Fig. 21.6). A linear cutter is used to traverse the jejunum about 15 cm away from the Treitz ligament. The distal jejunal loop is elevated from the back of the colon and placed into the stent tube through the distal end of the pancreatic duct, then end-to-side anastomosis of the pancreatic duct-jejunum mucosa is performed. The proximal end of the jejunum was anastomosed with the lateral jejunum 40 cm distant from the previous pancreas-jejunum anastomosed site. The 3-0 V-loc stitches are used. The specimens removed during the operation are sent to pathology.

21.4 Pathology and Prognosis

Pathological result suggested a pancreatic neuroendocrine tumor (G1, mitotic count of 0–1 per 10 high-power fields; immunohistochemical results: Syn (+), CgA (+), CD56 (+), Ki-67 (index 1%), Gastrin (−), TTF1 (−); lymph nodes: chronic lymphadenitis). The patient had a good prognosis and was discharged 14 days postoperatively. The patient's postoperative blood glucose returned to normal, and abdominal CT after 6 months showed no recurrence.

21.5 Comment

Pancreatic neuroendocrine tumors are rare tumors that are mostly benign. Therefore, treating patients with neuroendocrine tumors at the pancreatic neck by central pancreatectomy has a better prognosis and long-term quality of life compared to pancreaticoduodenectomy (Whipple procedure) and distal pancreatectomy. Sperti et al. had reported that in a study of 59 central pancreatectomy cases, no endocrine dysfunctions were observed after the surgery, and only 3 cases had developed exocrine dysfunction, though further evidence-based studies were required [4]. However, Goudard et al. showed that compared to pancreaticoduodenectomy and distal pancreatectomy, not only central pancreatectomy had a higher rate of developing postoperative complications, and the hospitalization time was also prolonged [5]. Therefore, surgeons must stick to the indications of central pancreatectomy, screen the patients comprehensively, and perform the operation under the guidance of experienced physicians in the professional pancreatic surgery centers.

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22 Duodenum-Preserving Pancreatic Head Resection

Jun Cao

22.1 Introduction

Duodenum-preserving pancreatic head resection (DPPHR) was first described in the 1970s by Beger in Germany to treat patients with chronic pancreatitis [1, 2]. In 1988, Takada performed the first duodenum-preserving total pancreatic head resection (DPPHRt) to treat benign or low-grade malignant tumors of the pancreatic head by preserving the duodenum with its intact blood supply from the pancreatic duodenal arterial arcade [3, 4]. The increasing use of high resolution CT/MR and endoscopic ultrasonography has increased the diagnostic and accuracy rates of cystic tumors of the pancreatic head in recent years. Most tumors are benign but with a risk of potential malignant transformation, or are low-grade malignant tumors [5]. Some of these patients need to be treated by surgery because of symptoms like abdominal pain, distension, and jaundice, or because of the possibility of malignant transformation [6, 7]. DPPHR was initially designed for chronic pancreatitis. Although many surgeons believe that DPPHR results in improvements in intermediate and long-term outcomes which include the length of hospital stay, quality of life, postoperative rehabilitation, and preservation of exocrine function compared to PD and pylorus-preserving pancreaticoduodenectomy (PPPD) [1, 2]. Although a multi-center, randomized, controlled, double-blind ChroPac trial published in 2017 showed DPPHR to result in no difference in quality of life compared with partial pancreatoduodenectomy for chronic pancreatitis [8], DPPHR has recently been used to treat benign or low-grade malignant tumors in patients who are completely different to those with chronic pancreatitis. These patients are predominantly young females with normal pancreatic functions. A significant proportion of these patients wish to undergo minimally invasive treatment, not only because of small incisions, but also because of organ-preservation. When compared with pancreaticoduodenectomy (PD), the standard operation for pancreatic head tumors, DPPHRt maintained the integrity of the duodenum and biliary system, with non-inferiority in the short- and long-term outcomes for benign or low-grade malignant tumors [9–11]. The rapid advancements in minimally invasive technology in the past two decades have led to the increasing use of laparoscopic pancreatic surgery. Laparoscopic PD and distal pancreatectomy (DP) are now technically feasible [8], although the long-term oncological outcomes remain unclear [12, 13]. Peng et al. [14] in 2012 and Mou et al. [15] in 2016 reported the minimally invasive DPPHR. Cao et al. [16] in 2018 reported laparoscopic DPPHRt as a novel minimally invasive surgery for benign or low-grade malig-

J. Cao (✉)
Sun Yat-sen Memorial Hospital, Sun Yat-sen University, Guangzhou, China

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nant tumors of the pancreatic head. A systematic review showed DPPHR significantly preserved the levels of exocrine and endocrine pancreatic functions, with no significant differences in the rates of pancreatic fistula, delayed gastric emptying, and hospital mortality when compared to PD, the standard treatment for tumors of the pancreatic head [17, 18]. DPPHR, by preserving the integrity of the duodenum and biliary system with conservation of the peripancreatic tissues, should better maintain the exocrine and endocrine pancreatic functions in the short and long terms. In addition, the operation avoids the complications following a biliary anastomosis.

22.2 Case

The patient was a 9-year-old girl admitted to our hospital because of recurrent abdominal pain stained for more than 2 years. Laboratory examinations showed liver functions such as total bilirubin (TB), direct bilirubin (DB), aspartate aminotransferase (AST), and alanine aminotransferase (ALT) were normal. Tumor markers including carcinoembryonic antigen (CEA), carbohydrate antigen (CA)19-9, CA72-4, and CA12-5 were all normal. The abdominal CT showed a mass in the head of the pancreas, without dilation of common bile duct or pancreatic duct. Pancreatic head benign or low-grade malignant tumor was considered (Fig. 22.1).

From these findings, a diagnosis of pancreatic head benign or low-grade malignant tumor was made and laparoscopic DPPHRt was performed.

Informed consent was obtained from all participating patients, and the ethics committee of Sun Yat-sen Memorial Hospital, Sun Yat-sen University approved this study.

22.3 Details of Procedure

22.3.1 Surgical Procedures of LDPPHRt

The patient was placed in a reversed Trendelenburg position with head up 30° and leg splitting. The trocars were inserted according to the 5-port-method. Pneumoperitoneum was established with carbon dioxide at 12 mmHg. The gastrocolic ligament was opened to explore the head and neck of the pancreas and to check the location of the tumor without making a Kocher's maneuver. The common hepatic artery (CHA) was looked for after removal of the group 8a lymph nodes. The CHA was dissected along its right side, separating and protecting the proper hepatic artery (PHA) and the gastroduodenal artery (GDA) after slinging these vessels with vascular slings. The uncinate process and pancreatic neck were dissected to expose the portal vein and the superior mesenteric vein (SMV). The portal vein-pancreas tunnel was built and the pancreatic neck and SMV were slinged with vascular slings. The capsule of the pancreas was cut open at the lower part of the pancreatic neck, and subcapsular dissection was carried out to the right, paying particular attention to visualize the pancreatic duodenal arterial arcade which passes along the duodenum. The lower part of the pancreatic head and uncinate process were separated to expose the inferior pancreatic duodenal arterial arcade which includes the anterior (AIPDA) and the posterior inferior pancreatic duodenal arteries (PIPDA). Care was taken to protect the branches which go into the duodenum. The pancreatic neck was transected with a Harmonic scissors in front of the SMV. The pancreas head was separated from the right and dorsal edges of the SMV. The upper part of the pancreatic head was separated to expose the distal common bile duct (CBD) which lies inside the pancreas. The pancreas was dissected from the left and the dorsal edges of the CBD to expose and protect the posterior superior pancreatic duodenal artery (PSPDA), which comes from the GDA, with its branches going into the distal CBD and the ampulla of Vater. The anterior superior pancreatic duodenal artery (ASPDA) has to be cut usually for further deep dissection. Finally, the main pancreatic duct to the ampulla of Vater was dissected, ligated, and cut off. The pancreatic head and uncinate process was totally resected and the specimen was removed. The blood supply to the CBD and duodenum was confirmed to be good (Fig. 22.2). The main pancreatic duct of the pan-

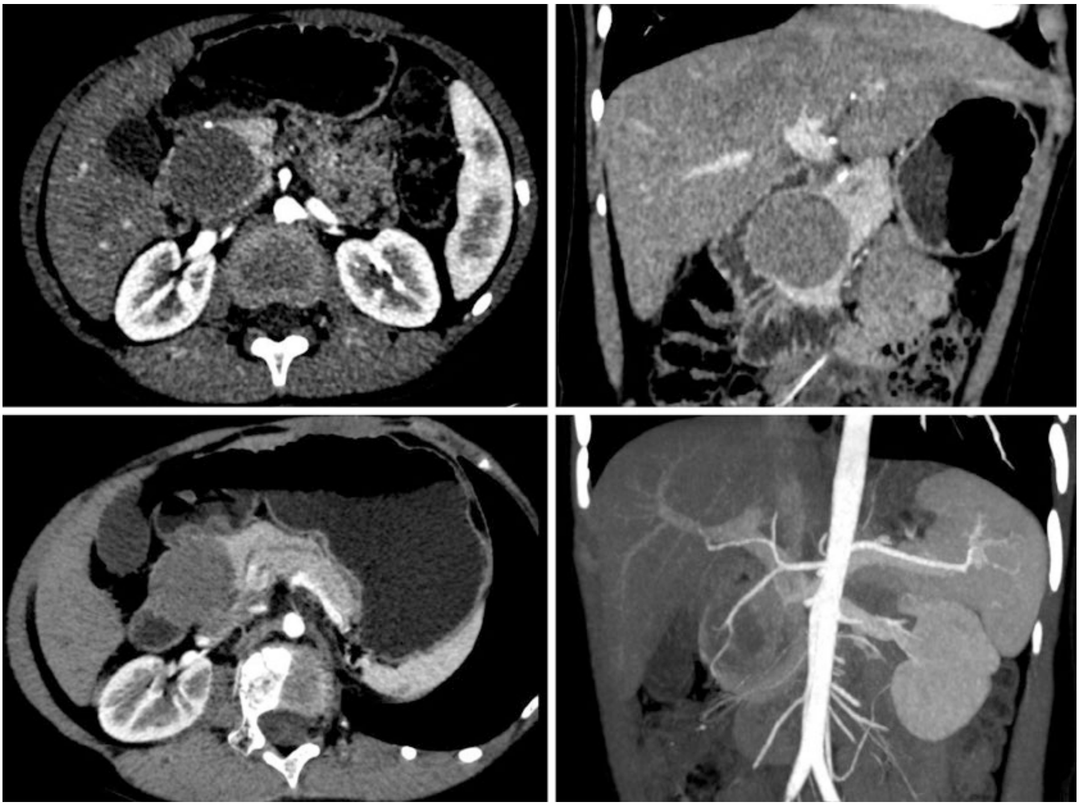

Fig. 22.1 CT image showed a mass in the head of the pancreas

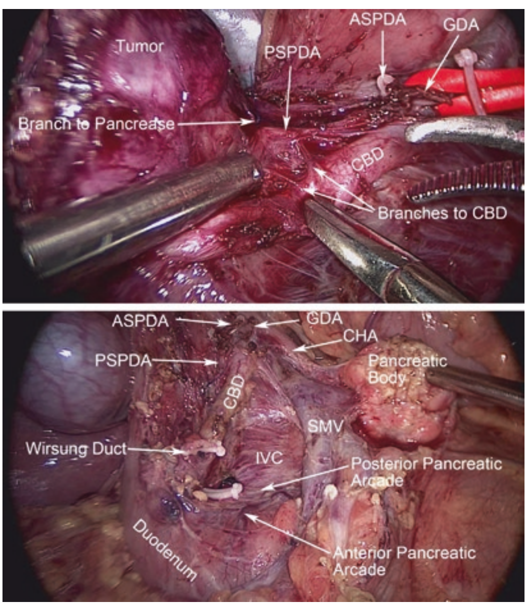

Fig. 22.2 The postoperative overview of the LDPPHRt

creatic body was found and an external ventricular drainage catheter was inserted. An end-to-side pancreaticojejunostomy (duct-to-mucosa) was done. The resected specimen was placed inside a bag and removed through a small lower abdominal incision. Two drainage catheters were positioned near the pancreaticojejunostomy and the CBD and brought out through two trocar port sites.

22.4 Pathology and Prognosis

The resected specimen is shown in Fig. 22.3. Pathologie diagnosis was intraductal papillary mucinous neoplasia (IPMN). The cutting margin was negative.

The patient recovered uneventfully and was discharged 5 days after the operation. 12 months after surgery, follow-up CT and tumor marker revealed no recurrence.

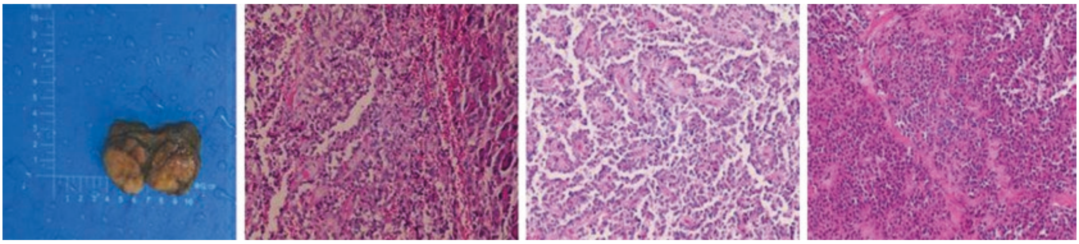

Fig. 22.3 Pathology

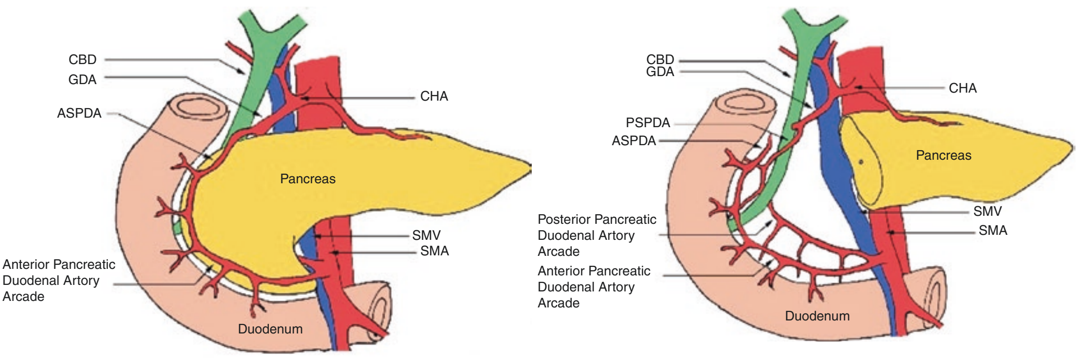

Fig. 22.4 The arterial arcades needed to be preserved

22.5 Comment

The anterior and posterior pancreatic duodenal arterial arcades are composed of the PSPDA, ASPDA, AIPDA, and PIPDA. They provide blood supply to the descending and horizontal parts of the duodenum. Preservation of these arterial arcades, especially the PSPDA and its branches which supply blood to the distal CBD and the ampulla of Vater, is the key to success in the LDPPHRt procedure (Fig. 22.4). The complex anatomy of the arcades and their branches make total pancreatic head resection challenging. Autopsy shows the anterior pancreatic duodenal arterial arcade runs typically in the capsule of the pancreas, 0.5–1.5 cm away from the duodenum. Subcapsular dissection of the pancreatic parenchyma preserves the anterior arcade and its branches which go into the duodenum. The posterior pancreatic duodenal arterial arcade runs in the mesopancreas, 1.5–2.0 cm away from the duodenum (Fig. 22.5). By avoiding the performance of Kocher's maneuver, the mesopancreas remains intact to preserve the posterior arcade, especially the communicating branch between the PSPDA and PIPDA. Laparoscopy provides a good view of these tiny vascular structures for accurate dissection. The total pancreatic head resection is carried out using a medial to lateral approach with the following precautionary steps: (1) DO NOT making a Kocher's maneuver; (2) Dissect along the GDA to expose the PSPDA to preserve its branches which go into the CBD and ampulla of Vater; (3) The PSPDA passes first along the right edge and then the back of the CBD, so dissecting the pancreas along the left and dorsal sides of the CBD is safe; (4) Dissecting the uncinate process and then the pancreatic neck to expose the portal vein and SMV, and to build the portal vein-pancreas tunnel; (5) Do subcapsular dissection at the lower part of the pancreatic head to the right to preserve the inferior pancreatic duodenal arterial arcade.

Fig. 22.5 The arterial arcades needed to be preserved

Acknowledgment Some of the contexts were reused with permission from our previous papers [16].

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Part VIII

Surgical Treatment of Pancreatic Cystic Neoplasms

23 Surgical Treatment of Mucinous Cystic Neoplasms of the Pancreas

Yuan Fang and Wen-Hui Lou

23.1 Introduction

The definition of mucinous cysts was first raised by Compagno and Oertel [1] in 1978, identifying it as a mucin-producing cysts with malignant potential that occur in the body or tail of pancreas and usually in the perimenopausal women [2]. In 2000, the World Health Organization (WHO) proposed the standard definition of MCNs by their well-demarcated cystic lesions, lined by a mucin-producing columnar epithelium and ovarian stroma, which can distinguish MCNs from mucinous intraductal papillary mucinous neoplasms (IPMNs) [3].

With the progress in cross-sectional abdominal imaging, the diagnosis of MCNs has always been increasing [4]. In a 15-year pancreatic cystic lesion surgical study, MCNs comprised about 20% of all the PCNs [5]. The risk of high-grade dysplasia or invasive cancer within an MCN has varied from 10% to 39% [6–11]. For the treatment of MCNs, it is highly recommended to resect all the MCNs because of their malignant potential [11, 12].

But it is a fact that studies about the specific risk factors for developing malignant MCNs are not well elucidated [13]. The previous study on the malignant MCNs is usually limited by single-center and small sample sizes and focused on pathologic diagnosis postoperatively rather than preoperative prediction to optimize the clinical strategy. Some of the research evaluated the preoperative serum tumor marker such as CA19-9 for the prediction of malignancy [6, 14]. Measurement of MCN cyst fluid for carcinoembryonicantigen (CEA) can help to predict whether a cyst is mucinous origination (MCN and IPMN), but these markers cannot distinguish MCNs from other pancreatic malignancy [15].

On the other hand, cross-sectional imaging can provide the best preoperative diagnosis of the malignancy until now. Most MCNs have been reported in the body and tail of pancreas (89–99%), while the location in the pancreatic head may indicate of malignancy [16]. Although the tumor size seems to be a risk factor of being malignant [17–19], there is no clear cutoff of the tumor size which was recommended in the past (4 cm) as a predictor of malignancy. Ironically, MCNs with the size less than 3 cm also showed malignancy. So now from the perspective of pancreatic surgeon, tumor size is not the criteria for making the clinical strategy of MCNs [20].

As to the surgery method option, patients preoperatively diagnosed to have MCNs may be candidates for formal oncologic resection rather than parenchyma-sparing procedure, if the

Y. Fang · W.-H. Lou (✉)
Zhongshan Hospital, Fudan University, Shanghai, China
e-mail: Lou.wenhui@zs-hospital.sh.cn

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intraoperative pathology shows no features of malignancy [21].

23.2 Case

The patient was a 33-year-old woman admitted to our hospital because of upper abdominal pain and left back pain for 2 months, with the abdominal CT of the other hospital showing there was a cystic lesion (3 cm × 2 cm × 1.5 cm) in the pancreatic body. The other parameters were normal, including tumor marker CA19-9.

The abdominal computed tomography (CT) of our hospital showed a round, thick-walled cystic lesion (3 cm × 2 cm × 1.5 cm) in the body of the pancreas. The wall and separation of the mass enhanced in the arterial and venous phase of CT (Fig. 23.1a, b).

The abdominal magnetic resonance imaging (MRI) showed the similar image, with mixed signal in T1WI and high signal in T2WI and enhancement of wall and separation in arterial and venous phase (Fig. 23.2a–d). From these radiology findings, a diagnosis of pancreatic cystic lesion, probably mucinous cystic neoplasm

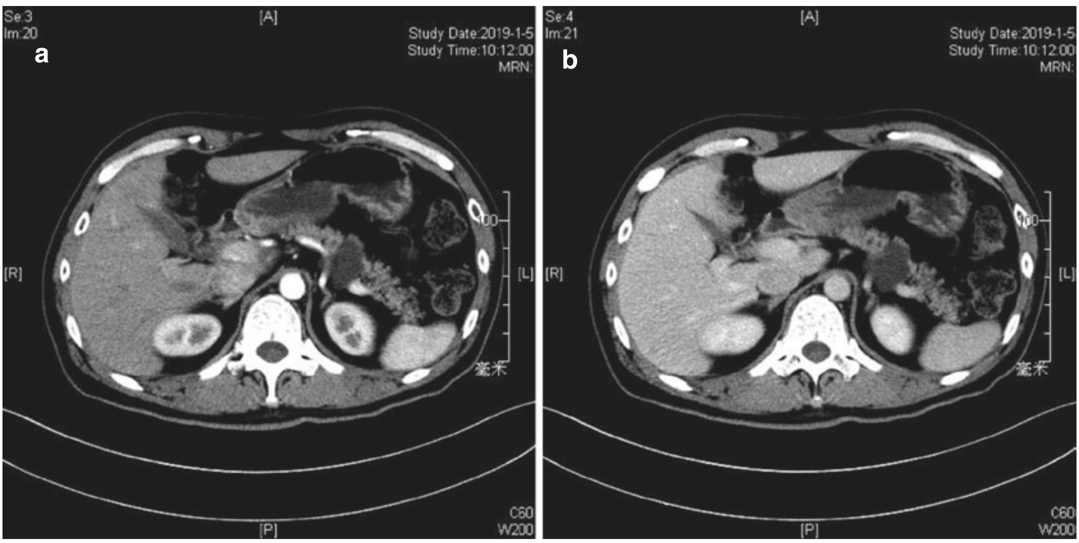

Fig. 23.1 (**a**, **b**) Arterial and venous phase of abdominal CT

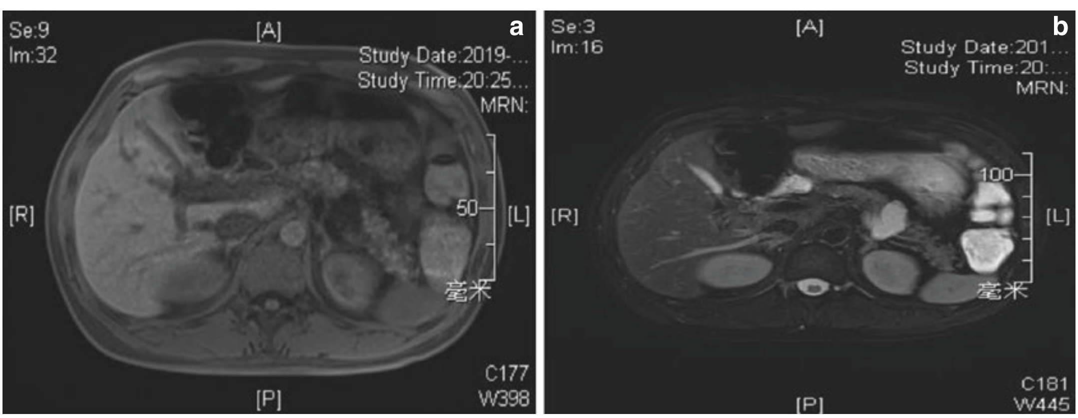

Fig. 23.2 (**a**, **b**) T1WI and T2WI of abdominal MRI. (**c**, **d**) Arterial and venous phase of abdominal MRI

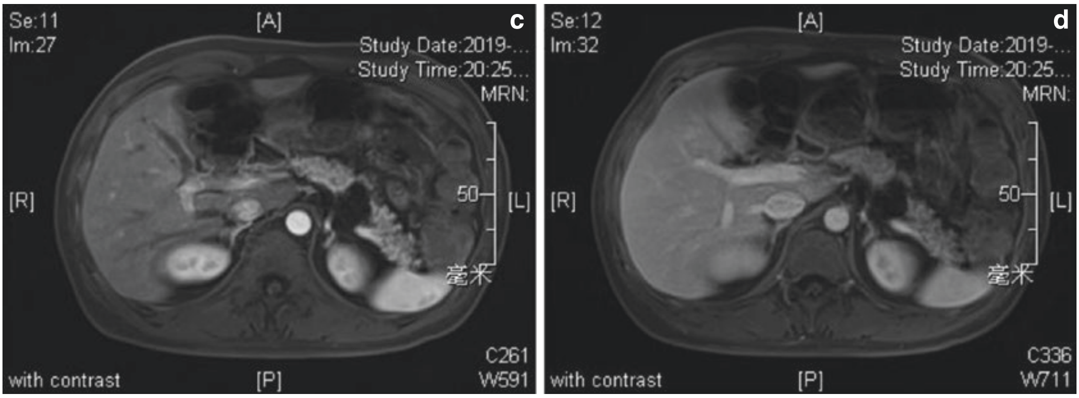

Fig. 23.2 (continued)

located in the pancreatic tail was made and laparoscopic spleen-preserving distal pancreatectomy was performed.

Informed consent was obtained from all participating patients, and the ethics committee of Zhongshan Hospital, Fudan University approved this study.

23.3 Details of Procedure

The patient was positioned in dorsal decubitus, slightly inclined, with legs apart. The surgeon took the position between the patient's legs, with the first assistant to the right, and the second assistant to the left (optics). Five trocars were used as shown in Fig. 23.3.

The surgery began with dissection of the greater omentum from the greater curvature of the stomach (Fig. 23.4). The short gastric vessels were dissected to open the omental bursa. After dissection of the posterior wall of the pancreas, the splenic artery and vein were dissected and isolated (Figs. 23.5, 23.6, and 23.7).

In cases of spleen-preserving distal pancreatectomy, the Kimura technique [22] was always used. The small branches of splenic vein and artery were ligated by using Hem-o-lok clip (Fig. 23.8). Proximal pancreatic stump closure was performed using a 60 mm thick tissue stapler (Endo GIA, Echelon-Ethicon) (Fig. 23.9).

After completely resecting the body and tail of the pancreas, the specimen was removed and put into an Endobag, through a small incision after expansion of the site where the 12-mm trocar was positioned in the left flank. After hemostasis (Fig. 23.10), a drainage tube was positioned at the stump of proximal pancreas.

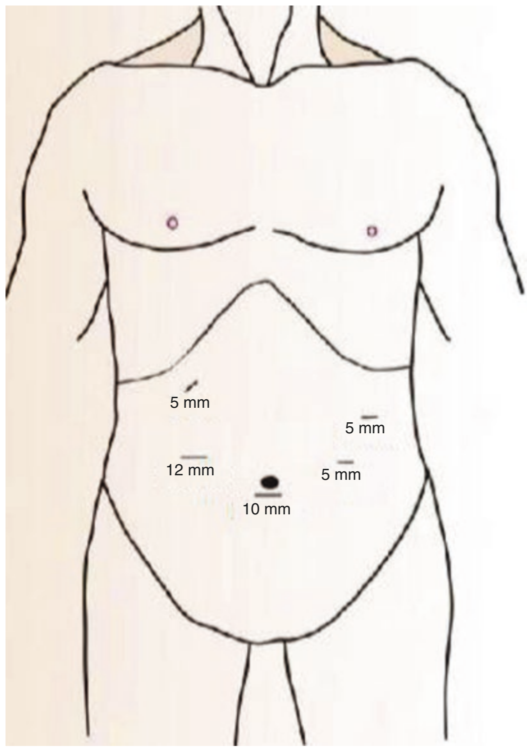

Fig. 23.3 Trocar positioning of the surgery

Drainage fluid was measured every three days and was sent to the laboratory to implement an amylase assay starting on the third day. If the

Fig. 23.4 Dissection of the greater omentum to expose the tumor

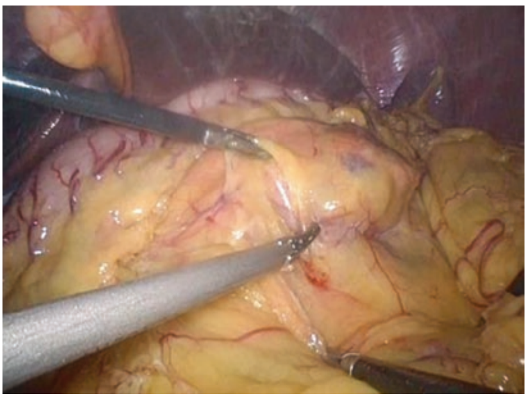

Fig. 23.5 Dissection of the posterior face to expose tunnel behind pancreas

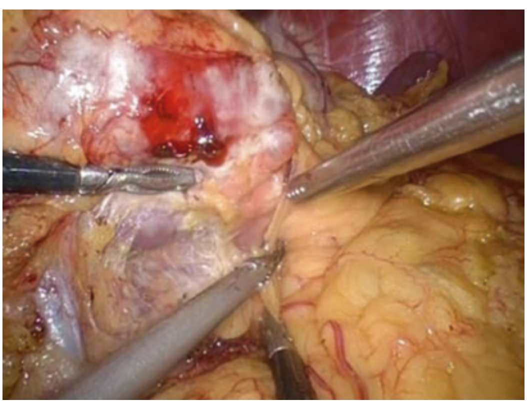

Fig. 23.6 Dissection of the splenic vein

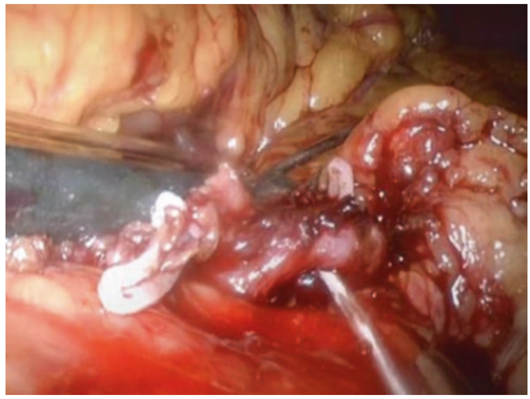

Fig. 23.7 Dissection of the splenic artery

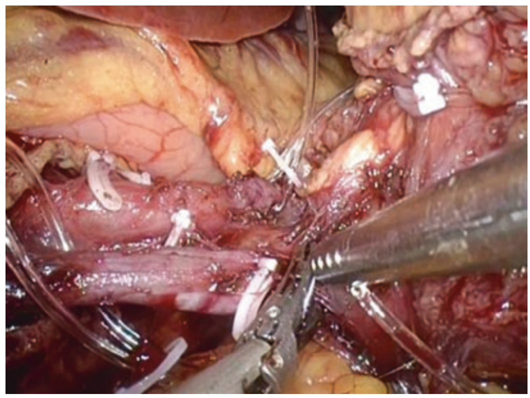

Fig. 23.8 Ligature branches of the splenic vein and artery

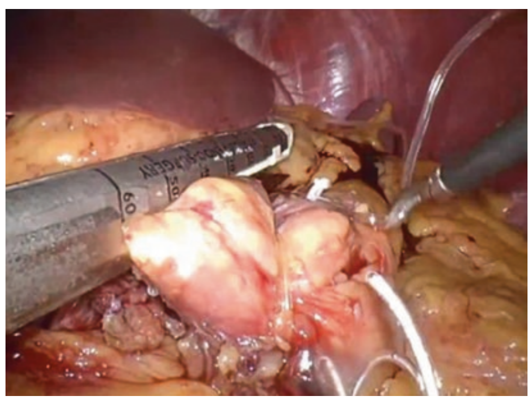

Fig. 23.9 Proximal pancreatic body stapling

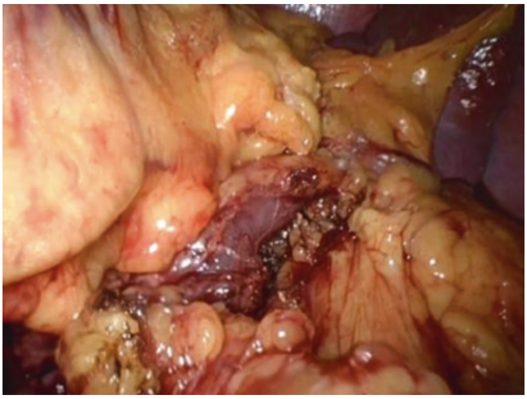

Fig. 23.10 Hemostasis and reviewing of surgical field

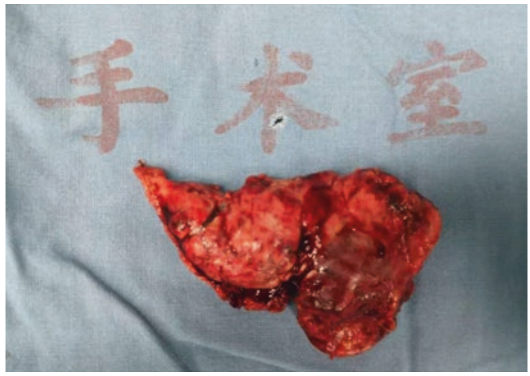

Fig. 23.11 The resected specimen of pancreas

amylase level was more than three times higher than that in the serum, pancreatic fistula (PF) was diagnosed. POPF was classified according to the ISGPF standard (International Study Group of Pancreatic Fistula), treatment including antibiotics, intervention-guided drainage was performed individually.

23.4 Pathology and Prognosis

The resected specimen is shown in Fig. 23.11. Pathologic diagnosis showed the cystic lesion was lined by a mucin-producing simple columnar epithelium and ovarian stroma, indicating mucinous cystic neoplasm, the cutting margin was negative and splenic hilar lymph node was negative (0/4). Immunohistochemistry (IHC) staining showed Muc-5AC(+) and Muc-6(+), both of which indicate of the mucinous origination. Stroma ER and PR staining were positive. The patient recovered uneventfully and was discharged 15 days after the operation. 6 months after surgery, follow-up CT and tumor marker revealed no recurrence.

23.5 Comment

Since 1978 MCN was distinguished from SCN and defined its potential for malignancy, pathologists and surgeons continued studying the origination and biological behaviors of this mucinous-secreting pancreatic neoplasm. In 1990 diagnostic standard of MCN was based on the postoperative pathology that comprises ovarian stroma, which can distinguish MCNs from IPMN [12]. Moreover, MCN occurs almost mostly in women and is located in the body and tail of the pancreas with the single mass. This demographic and clinical characteristic is very different from IPMN, whose patients are much older, often in male and in the head of the pancreas [23].

According to the previous study on MCN, there were noninvasive MCNs that are classified into 3 grades: low-grade dysplasia, intermediate-grade dysplasia, and high-grade dysplasia [24]. There were about 3.9–34.4% of MCN that will become an invasive carcinoma, whose 5-year survival is about 30–50% and prognosis is much better than pancreatic ductal adenocarcinoma [13]. Although serum tumor maker elevation and radiographic findings such as larger tumor size and solid mass with mural nodule are indications of malignancy, the preoperative differential diagnosis between benign and malignant MCN is still very difficult [3]. Endoscopic FNA is currently the optimized preoperative diagnostic method but still have the possible of pathologic false negativity. As mentioned above, surgical resection is recommended for all patients with suspected MCN.

The standard pancreaticoduodenectomy and distal pancreatectomy are preferred for surgical treatment of MCN [19]. Although the use of enucleation has been reported, most of the pancreatic surgeons prefer to perform the standard anatomic resection for most of the MCN patients.

Central pancreatectomy can only be considered in younger patients in whom preservation of islet cell can avoid postoperative diabetes [25]. The laparoscopic resection has been used in high volume pancreatic centers with satisfied morbidity and mortality. After surgical resection, patients probably do not need abdominal imaging follow-up [26]. However, those patients with invasion pathology subgroup are recommended to have CT or MRI every 6 months to monitor the possible local recurrence and distant metastases [27].

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24 Surgical Treatment of Serous Cystadenomas Neoplasm of the Pancreas

Feng Cao and Fei Li

24.1 Introduction

Serous cystadenomas neoplasms (SCNs) of the pancreas is a relatively uncommon cystic lesion, firstly reported by Compagno in 1978 [1]. Approximately 60% of the SCNs affect women with the mean age at presentation of 60 years old. SCN may generate in any portion of the pancreas but most frequently occurs in body and tail. In rare cases, SCNs can involve almost the full length of the pancreas. The diameter of the tumor ranges from less than 1 cm to more than 20 cm, with the mean size of 4–5 cm on resection [2, 3].

Most SCNs are asymptomatic and are presented as an incidental finding at routine physical examinations. Symptoms are usually resulted from local mass effect, including abdominal pain, palpable mass, nausea, and vomiting. Jaundice, caused by common bile duct obstruction, is unusual even in tumors located in pancreatic head. A multi-center, retrospective study including 598 patients with a diagnosis of SCNs showed that nonspecific abdominal pain and diabetes mellitus was reported in 29% and 7% of patients, respectively. In addition, biliopancreatic symptoms including typical pancreatic pain, acute pancreatitis, jaundice, and steatorrhoea occurred in 7% of cases [4]. In some SCN cases, symptoms due to local invasion of adjacent organs and metastases occur.

To date, five types of SCNs have been described: microcystic serous neoplasm, macrocystic serous neoplasm, solid serous neoplasm, von Hippel–Lindau (VHL)-associated serous cystic neoplasm, and mixed serous-neuroendocrine neoplasm [5]. All types of SCNs are made up of cuboidal, glycogen-rich, epithelial cells which secrete serum-like watery fluid. Computed tomography (CT) is a useful tool to make the diagnosis of SCNs which reveals a well-circumscribed, multilocular mass, occasionally with evident prominent central stellate scar with sunburst-type pattern of calcification. On enhanced CT, SCNs are usually hypervascular. Cysts from SCNs do not communicate with pancreatic duct system.

Most of the SCNs are benign tumors, malignant SCNs are extremely rare. "Aggressive" appearances are the important imaging features of malignance. On the CT scan, the tumor can adhesion to or invade into adjacent structures, including regional lymph node, vascular and digestive tract. Although SCNs may not result in fatal metastases, clinically significant consequences can be produced due to the tumor location and growth pattern. In patients with symptoms, such as abdominal pain, jaundice, or malignance cannot be excluded, surgical treatment should be considered [2, 3].

F. Cao · F. Li (✉)
Xuanwu Hospital, Capital Medical University, Beijing, China
e-mail: feili36@ccmu.edu.cn

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Tumor location is the key factor for determination of different surgical approach. The most commonly performed surgical approaches are pancreaticoduodenectomies or distal pancreatectomies. Considering the preservation of exocrine and endocrine function of pancreas, nowadays, parenchyma-sparing surgeries are increasingly performed. These local resections include enucleations and segmental resections, which can be performed laparoscopically in selected cases, depending on the location of the tumor and especially the distance between the tumor and the main pancreatic duct.

24.2 Case

This is a 72-year-old female patient with the chief complain of "persistent epigastric pain for 1 month." Laboratory tests including blood routine, liver and kidney function, and tumor markers are normal. The general condition of this patient is relatively good with ASA grade II and ECOG 1 point.

The CT showed a sharply defined cystic mass in the pancreatic tail with no dilation of main pancreatic duct or common bile duct. The maximum diameter of the mass is about 5 cm. Separation can be observed inside the cyst. On enhanced CT scan, slight enhancement can be seen in the septation (Fig. 24.1). Calcification and star scar are not found in this case. After adequate preoperative evaluation, we performed laparoscopic distal pancreatectomy for this patient. Informed consent was obtained from all participating patients, and the ethics committee of Xuanwu Hospital approved this study.

24.3 Details of Procedure (Fig. 24.2)

24.3.1 Patient Position and Trocar Placement

Patient is in the supine position, and the two legs are apart. Five ports are placed and the 10 mm one on upper edge of the umbilicus can be used as an observation port. A 10 mm 30-degree laparoscope is used in this patient. The surgeon stands on the right side, while first and second assistant are on the left side and between the two legs of the patient, respectively.

24.3.2 Exposure of the Pancreas [6]

Pancreatic body and tail can be exposed after cutting the gastrocolic ligament using ultrasonic dissector. The gastroepiploic vessels should be preserved. In this case, the spleen is removed, and the short gastric arteries are divided. If a splenic preserving surgery is planned, these vessels should be preserved. Adhesion between pancreas and posterior gastric wall should be fully separated to completely expose the pancreas.

24.3.3 Mobilization of the Pancreas [6]

Mobilization of pancreas starts with incision of the posterior peritoneum along the inferior pancreatic border. Left gastroepiploic vessels and splenocolic ligament are divided, colonic splenic flexure is stretched inferiorly, and explore the lower pole the spleen. Similarly, we divide the posterior

Fig. 24.1 CT reveals a sharply defined cystic mass in pancreatic tail

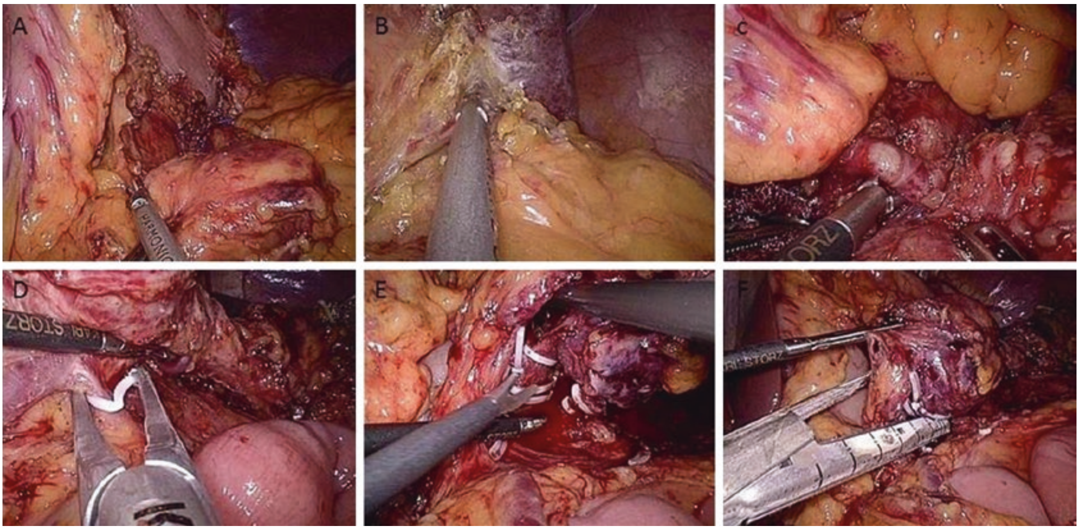

Fig. 24.2 (**a**) Divided the superior border of pancreas, and identify the root of splenic artery; (**b**) divided the pancreatic inferior border, and identify the confluence of splenic vein and superior mesenteric vein; (**c**) divided the splenic artery; (**d**) the inferior mesenteric vein sacrificed; (**e**) the splenic vein clamped using Hem-O-lock; (**f**) pancreatic parenchymal transection using Endo-GIA

peritoneum along the superior pancreatic border and the root of the splenic artery is explored. In this case, left gastric vein is drained into splenic vein and is sacrificed. After complete mobilization of body and tail of pancreas, intraoperative ultrasound is used to detect the relative relationship between the tumor and splenic vessels.

24.3.4 Isolation of the Splenic Vessels

To alleviate splenic congestion, we divide splenic artery ahead of splenic vein. The splenic artery is identified along the pancreatic superior border. After complete dissociation of the root of splenic artery, Hem-O-lock is used to clamp the vessel. Then, we divide the splenic vein along the inferior border of the pancreas. Splenic vein is easily injured, leading to uncontrollable bleeding. Extreme attention should be paid during circumferential dissection. In this case, the inferior mesenteric vein is drained into splenic vein. We divided it firstly. Then, the splenic vein is clamped by Hem-O-lock. In some cases, the vessel can also be dissected by endoscopic stapler.

24.3.5 Pancreatic Parenchymal Transection

After the splenic vessels dissection was completed, we performed the pancreatic parenchymal transection using endoscopic stapler. Routinely, we do not reinforce the staple line by suturing. Parenchymal transection can also be achieved by using ultrasonic scalpel or Crushing method, the main pancreatic duct should be identified and oversewn.

24.3.6 Medial to Lateral Dissection

After transecting the pancreatic parenchymal, the specimen is grasped anteriorly to allow further excision. Since this is a benign tumor, the removal of retroperitoneal tissue is unnecessary. Medial to lateral dissection approach toward the splenic hilum is used in this patient. Once the splenic hilum is arrived, the perisplenic ligaments are dissected to free the specimen. Remove pneumoperitoneum and take out specimen through median incision of upper abdomen.

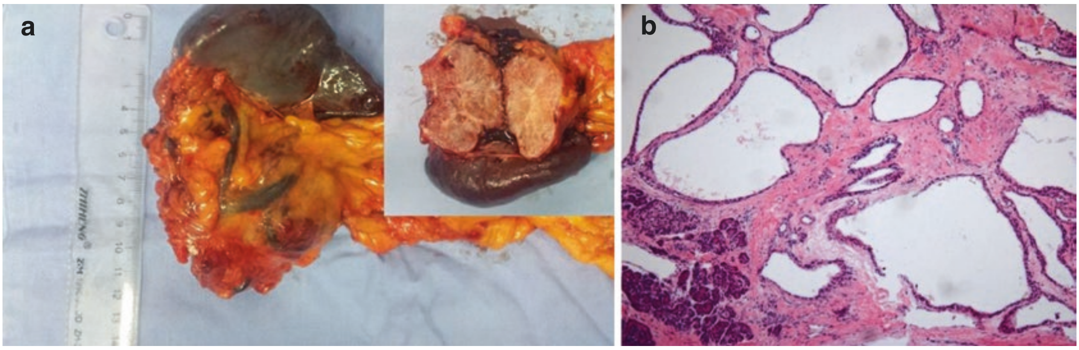

Fig. 24.3 (**a**) The resected specimen; (**b**) microscopic images of the resected SCNs

24.3.7 Drainage Placement

Reconstructing pneumoperitoneum, no active hemorrhage is detected in surgical field. A drainage tube is placed at the severed end of pancreas and splenic fossa.

24.4 Pathology and Prognosis

The resected specimen is shown in Fig. 24.3a. The pathologic examination reveals that the mass is lined by a single layer of cuboidal and flattered epithelial cells with almost clear cytoplasm. Nuclear atypia and mitoses are not found (Fig. 24.3b). Immunohistochemical staining reveals that epithelial markers, such as CK 7, 8, 19, are positive.

The patient recovered uneventfully and is discharged 15 days after the operation. Ten months after surgery, follow-up CT and tumor marker reveal no recurrence.

24.5 Comment

Surgical indication for SCNs is still controversial. Only observation should be given for most SCNs in terms of the benign biological behavior. However, resection should be performed when symptomatic or malignance cannot be excluded. Some surgeons advocate resection when the tumor size is relatively large (more than 4 or 5 cm).

Once surgery is decided, organ-preserving approach (Beger procedure, enucleation, central pancreatectomy, distal pancreatectomy with splenic preservation) is preferred in SCN patients with no evidence of malignance. Lymphadenectomy is unnecessary. In our case, we perform the distal pancreatectomy without splenic preserving since the volume of distal pancreas is very limited. Pancreatic fistula after distal pancreatectomy is the most common complication. To date, there is no definite method to reduce this complication. Fortunately, according to ISGPS definition, most of the patients suffer from grade A pancreatic fistula, and no additional treatment is required. Mini-invasive approach including laparoscopic and robotic surgery has been more and more used in pancreatectomy with promising results. In future, the study of biological behavior of SCNs should be strengthened to confirm the best surgical indications.

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25 Surgical Treatment of Solid Pseudopapillary Neoplasm of the Pancreas

Xiao-Sheng Zhong and Zhi-Jian Tan

25.1 Introduction

For patients with benign pancreatic head mass and low malignant tumors or chronic pancreatitis, pancreaticoduodenectomy is traumatic with multiple organs resection and digestive tract reconstruction, which affects postoperative internal and external secretion function significantly [1]. In order to solve this problem and improve the prognosis of patients, Dr. Beger reported the first duodenum-preserving pancreatic head resection (DPPHR) in 1972 [2].

Currently, it applies to the following two types of patients: chronic pancreatitis, benign pancreatic head mass or low malignant tumors.

Due to the complexity of the operation and high technical requirements, laparoscopic DPPHR (Fig. 25.1) should be carried out in a large pancreas center with a doctor experienced in laparoscopic pancreas operations.

In the pancreatic head resection with preservation of the duodenum and bile duct, the most important part is the protection of pancreatic head artery arch and bile duct blood supply. If the pancreatic head artery arch is damaged, it is very likely to cause biliary ischemic stenosis and duodenal perforation.

Pancreatic head artery arch: The anterior pancreaticoduodenal artery arch is composed of the anterior superior pancreaticoduodenal artery (ASPDA) and the anterior inferior pancreaticoduodenal artery (AIPDA) [3, 4].

The posterior superior pancreaticoduodenal artery (PSPDA) is emitted from gastroduodenal artery (GDA) and extends along the posterior side of common bile duct from upper left to lower right, then it is divided into two branches, one extends towards Vater papilla along the right side of common bible duct to nourish bile duct and papilla, the other branch extends behind common bile duct, forming the posterior pancreaticoduodenal artery arch with posterior inferior pancreaticoduodenal artery (PIPDA) [5].

In the laparoscopic DPPHR, since there are many important pancreaticoduodenal arteriovenous branches in the post-pancreatic fusion fascia, we do not do the routine Kocher expansion operation so as to maximize the protection of duodenal blood. In the resection of the head of the

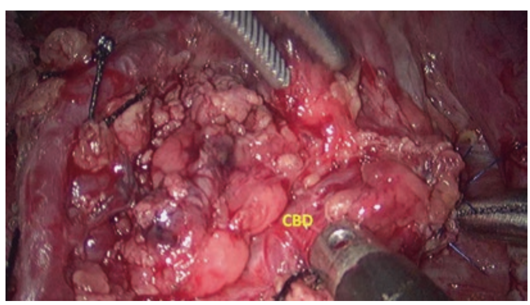

Fig. 25.1 The protection of pancreatic head artery arch and bile duct blood supply (CBD: common bile duct)

X.-S. Zhong · Z.-J. Tan (✉)
Guangdong Province Traditional Medical Hospital, Guangdong, China

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pancreas, we will retain at least 0.5–1 cm pancreatic tissue of the inside of the duodenum, while, during the surgical separation of the common bile duct, a small amount of pancreatic tissue around the common bile duct will be preserved to avoid postoperative biliary tract deficiency blood [6].

25.2 Case

We describe a case of LDPPHR that developed in a 31-year-old woman. The main presenting complaint was epigastric pain. Abdominal computed tomography showed a huge mucinous cystic neoplasm in the pancreatic head (Fig. 25.2). The tumor markers CA19-9 and CEA were normal. Preoperative liver function was Child–Pugh A class.

Informed consent was obtained from all participating patients, and the ethics committee of Guangdong Provincial Hospital of Chinese Medicine approved this study.

25.3 Details of Procedure

25.3.1 Patient Position and Trocar Distribution

Supine position, legs are separated, and head is 15–20° high with low feet in the operation to facilitate the exposure of pancreas and the surgical operation. The specific Trocar distribution is shown in Fig. 25.3, and the Trocar is placed around the pancreas in an arc form.

Fig. 25.2 CT image showed a huge mucinous cystic neoplasm in the pancreatic head

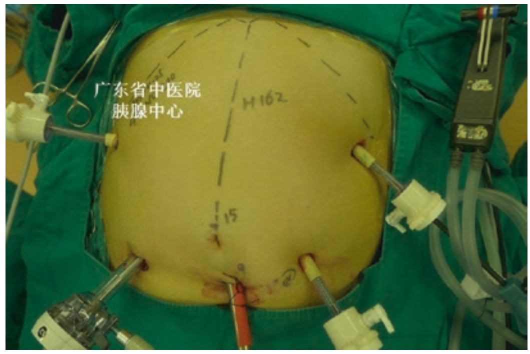

Fig. 25.3 The Trocar distribution

25.3.2 Resection

1. Open the gastric collateral ligament, fully free colonic hepatic flexure, reveal the duodenal descending part and transverse colon mesenteric root, use ultrasonic knife to separate the adhesion of the gastric antrum and pancreas, fully expose the pancreatic head (Figs. 25.4 and 25.5). Explore the tumor and use laparoscopic ultrasound to locate tumor, pancreatic duct, superior mesenteric vein (SMV), and portal vein (PV), and estimate the extent to be removed.
2. Dissect and reveal the main part of the SMV, which is located at the upper part of the colon and the lower edge of the pancreas. Dissect and suspend the GDA and the common hepatic artery, free the portal vein in the section which is above the upper margin of pancreas, extend thoroughly the front tunnel of the portal vein at the rear of pancreatic neck (Figs. 25.6 and 25.7).
3. Dissection of the head of the pancreas and duodenum: Set up traction band on the AIPDA and cut the small branches of the AIPDA to the pancreas (Fig. 25.8), remove the gap between the pancreas and the horizontal duodenum. Continue to dissect and reveal the PIPDA and set up traction band, and then dissect the gap between the horizontal and

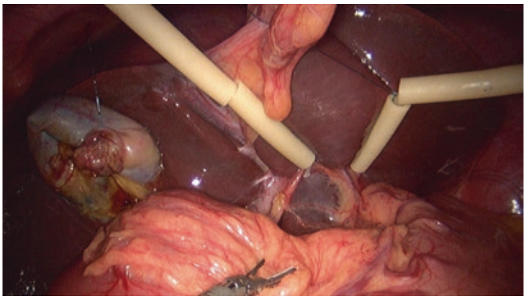

Fig. 25.4 Overhang the liver

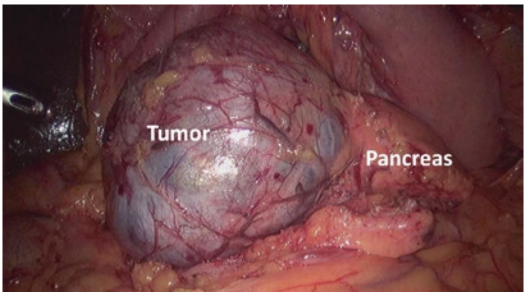

Fig. 25.5 Explore the tumor

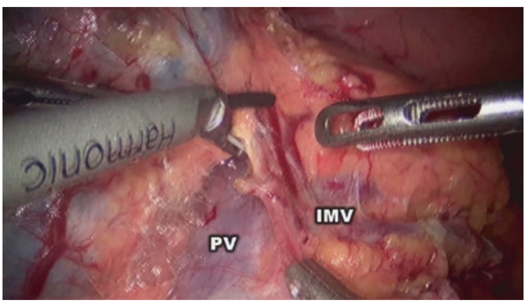

Fig. 25.6 Dissect SMV-PV (PV: portal vein; IMV: inferior mesenteric vein; SMV: superior mesenteric vein)

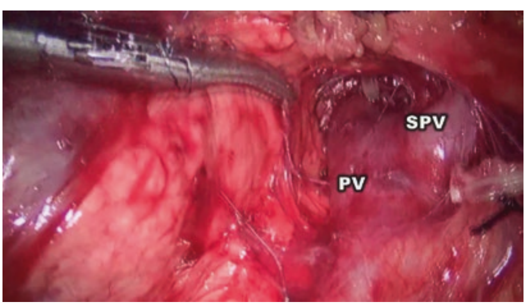

Fig. 25.7 The front tunnel of the portal vein at the rear of pancreatic neck (PV: portal vein; SPV: splenic vein)

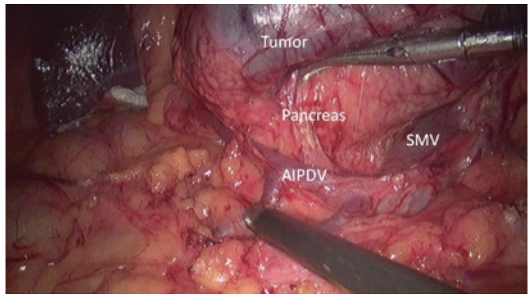

Fig. 25.8 Pancreatic head artery arch (AIPDV: anterior inferior pancreaticoduodenal vein; SMV: superior mesenteric vein)

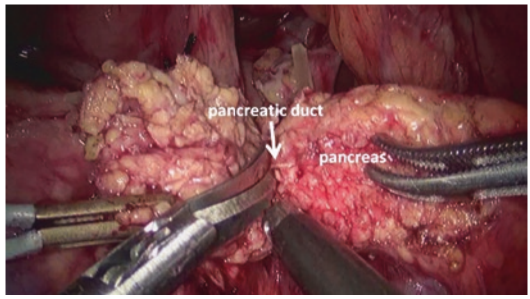

Fig. 25.9 Disconnection of the neck of the pancreas

descending parts of duodenum and pancreas. The most important part of the operation is the protection of AIPDA and PIPDA. In the chronic pancreatitis, the separation between the duodenum and the pancreas is difficult, and AIPDA and PIPDA are retained by leaving a small amount of pancreatic tissue inside the duodenum.

4. Disconnection of pancreatic uncinate process: Pull the SMV to the left side through the traction band, dissect the gap between the pancreatic uncinate process and SMV/SMA. After the uncinate process pancreas is sufficiently dissected, pull the tongue-shaped pancreatic uncinate process forward (ventral side).
5. Disconnection of the neck of the pancreas (Fig. 25.9): Non-invasive vascular clamp blocks the GDA, the ultrasonic knife is used to disconnect the neck of the pancreas, the scissors is used to disconnect the pancreatic duct sharply, cut the edge of the pancreatic neck to be sent to pathology test, and stop the pancreatic section bleeding.

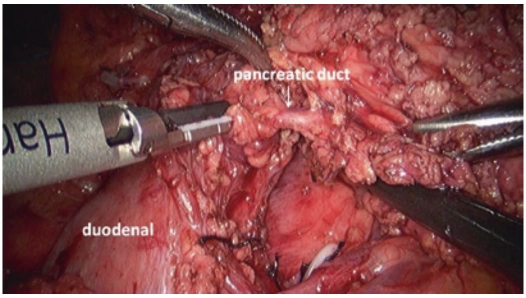

Fig. 25.10 Dissection of the main pancreatic duct

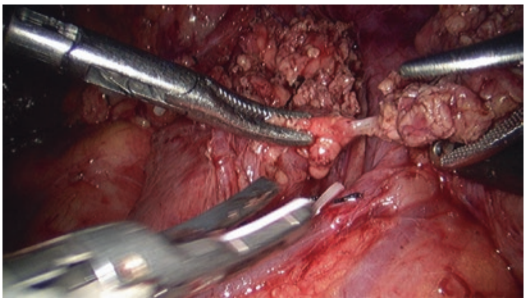

Fig. 25.11 Cut the main pancreatic duct

6. Dissection of the common bile duct, main pancreatic duct, and cut the main pancreatic duct: Dissect the gap between the horizontal and descending portions of the duodenum and the head of the pancreas to the side of the mouth, and reach the common channel of the common bile duct and the main pancreatic duct outside the duodenal wall near the ampulla. Dissect the common channel of the common bile duct and the main pancreatic duct (Wirsung tube) (Figs. 25.10 and 25.11). The distance of the dissection of the common bile duct is about half of the circle. Excessive dissection of the common bile duct may lead to blood vessel obstruction of the bile duct wall and may cause common bile duct stricture.

   Ligate and cut the main pancreatic duct near the junction with the bile duct. The broken end of the main pancreatic duct is sent to the frozen pathology. When the main pancreatic duct is cut, please be careful not to let the pancreatic juice overflow.

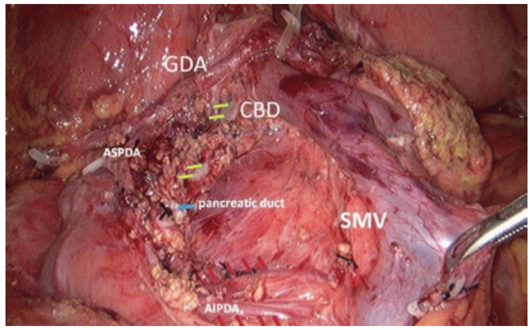

Fig. 25.12 ASPDA: the anterior superior pancreaticoduosal artery; AIPDA: the anterior inferior pancreaticoduodenal artery; CBD: common bile duct; GDA: gastroduodenal artery; SMV: superior mesenteric vein

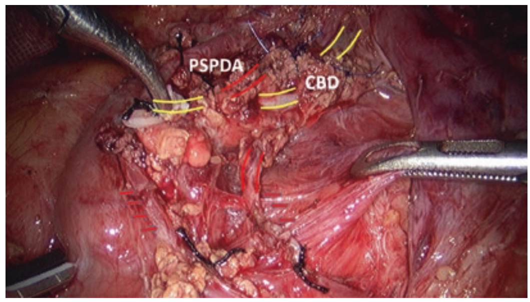

Fig. 25.13 CBD: common bile duct; PSPDA: posterior superior pancreaticoduodenal artery

7. Pull the ASPDA and the PSPDA, and preserve the arteries, cut the pancreatic parenchyma along the bile duct, and completely remove the pancreatic head. Biliary and duodenal pancreatic parenchyma should be preserved (Figs. 25.12 and 25.13).

25.3.3 Reconstruction

Dissect the jejunum at 15 cm from Treitz ligament, lift the jejunum to the upper part of the colon through the opening of transverse colon mesentery to the right side of middle colon artery, perform Roux-en-Y anastomosis of the pancreatic duct-jejunum (pancreatic duct-jejunum mucosa anastomosis, wire, discontinuous/continuous, stent tube) (Figs. 25.14 and 25.15), suture and reinforce (4-0 large needle prolene

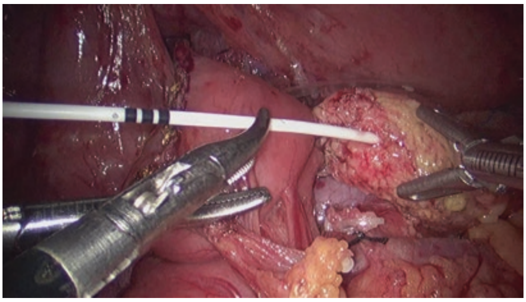

Fig. 25.14 Pancreatic stent tube

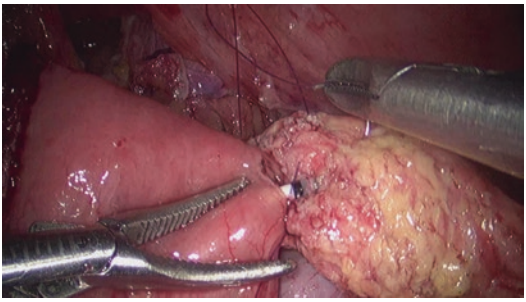

Fig. 25.15 Pancreatic duct-jejunum mucosa anastomosis

line) the gap between the pancreatic parenchyma and the anterior and posterior wall of the jejunal sarcoplasmic muscle layer, perform jejunal side–side anastomosis to the proximal jejunum at the distance of 35 cm from the anastomosis of the pancreas.

Close the transverse colon mesenteric crack, and drainage tube is placed both in front of and behind the pancreatic intestine anastomosis, respectively.

Cut horizontally 3 cm on the pubis and take out the specimen.

25.4 Pathology and Prognosis

The pathology confirmed the solid pseudopapillary tumor of pancreas (Fig. 25.16). The patient discharged one week after operation with no pancreatic leakage. Get endoscopic retrograde cholangiopancreatography (MRCP) three months after operation, it shows there is no bile duct stricture.

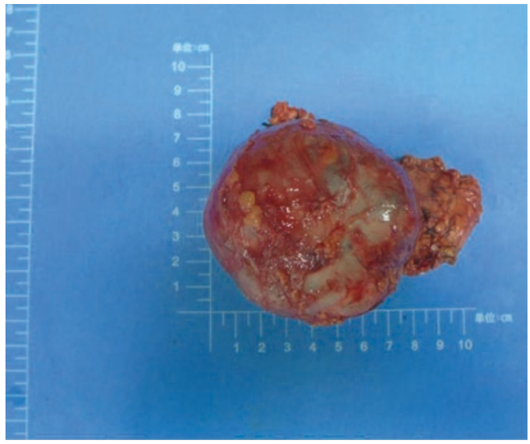

Fig. 25.16 Pathology and prognosis: solid pseudopapillary tumor

25.5 Comment

Solid pseudopapillary tumors, which are characterized by a well encapsulated mass with low malignant, occur predominantly in young females and the occurrence proportion in the pancreatic head, pancreatic body, and pancreatic tail is quite equal. They grow slowly and most of them show no symptoms. They can be found during physical examination. As the tumor gradually expands, it oppresses the adjacent organs or the tumor sac pressure is increased, causing upper abdominal pain or abdominal mass. In a few cases, obstructive jaundice, gastrointestinal bleeding, and acute pancreatitis may occur.

It is a low malignant tumor. All solid pseudopapillary tumors are recommended to be treated with surgical treatment. According to the surgical concept and the operator's sophistication, you can choose laparoscopic surgery, robotic surgery, or open surgery. According to different tumor locations, common surgical procedures include Whipple, total pancreatic head resection with retention of duodenal, segmental resection of the pancreas, pancreatic tail resection (preservation of spleen or not), simple pancreatic tumor removal, total pancreatectomy, etc.

Laparoscopic pancreaticoduodenectomy has been carried out routinely in our center. We performed laparoscopic duodenum-preserving pancreatic head resection (LDPPHR), which resected the total pancreatic head by preserving the duodenum, bile duct, and papilla with end-to-side pancreaticojejunostomy (duct-to-mucosa).

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Part IX

Surgical Treatment of Complications and Recurrences After Pancreatoduodenectomy

26 Surgical Treatment of Postoperative Hemorrhage

Hong-Tao Tan, De-Xing Guo, and Bei Sun

26.1 Introduction

Pancreaticoduodenectomy (PD) is one of the standard surgical procedures for the treatment of the lesion in the head of the pancreas, the lower common bile duct, the duodenum, and the periampullary region. The postoperative complications include pancreatic fistula, postoperative hemorrhage, intra-abdominal infections, delayed gastric emptying, and so on. The mortality after PD was reduced to less than 5% with the development of minimally invasive instruments, the improvement of surgical skills, and the completion of perioperative management. Although the incidence is low, pancreatic postoperative hemorrhage (PPH) is even critical with a mortality rate of 30–50% [1, 2]. Therefore, the early diagnosis and surgical treatment of PPH has become one of the key issues of pancreatic surgeons.

In 2007 the International Study Group for Pancreatic Surgery (ISGPS) defined PPH as the hemoglobin reduced ≥30 g/L after pancreas surgery and/or the hemodynamic changes occurred. According to hemorrhagic time, PPH was classified into early hemorrhage (<24 h) and delayed hemorrhage (≥24 h), according to the hemorrhagic site, PPH was classified into intraluminal (gastrointestinal) hemorrhage and extraluminal (abdominal) hemorrhage and according to the severity of hemorrhage, PPH was classified into Grade A (early mild), Grade B (early severe and late mild), and Grade C (late severe). The mild bleeding is referred to small or moderate bleeding with mild clinical symptoms observed by drainage tube, nasogastric tube, or ultrasound examination and the hemoglobin decreased less than 30 g/L, which only needed fluid resuscitation or blood transfusion generally without vascular interventional embolization or re-operation. The severe bleeding is referred to massive blood loss with apparent clinical symptoms and hemoglobin reduced more than or equal to 30 g/L which were manifested as hypovolemic shock, and vascular intervention embolization or re-operation was required [3, 4].

PPH includes arterial hemorrhage, capillary hemorrhage of pancreatic section, and anastomotic ulcer bleeding. The hemorrhagic arteries contain the gastroduodenal artery (49.5%), the common hepatic artery (20.8%), the proper hepatic artery (10.9%), the splenic artery (7.9%), the superior mesenteric artery (7.9%), and other arteries (3.0%) [3] (Fig. 26.1). Early hemorrhage is often associated with preoperative obstructive jaundice, malnutrition, coagulopathy, inaccurate hemostasis, incomplete closure of anastomosis, and inaccurate ligation which results in increased blood loss in the surgical site. Appropriate reduction of bilirubin levels, completion of nutrition status and coagulation function preoperatively,

H.-T. Tan (✉) · D.-X. Guo · B. Sun
The First Affiliated Hospital of Harbin Medical University, Harbin, China

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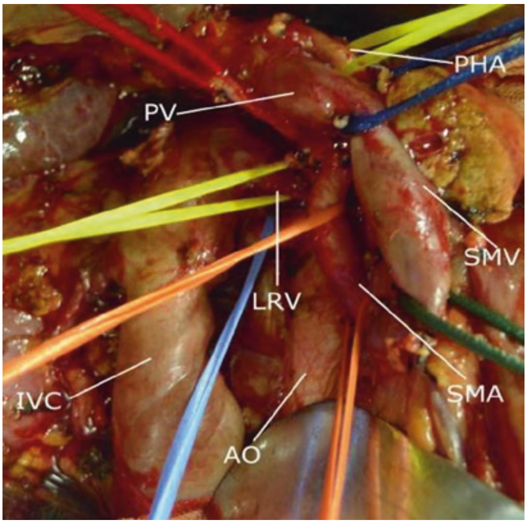

Fig. 26.1 The hemorrhagic arteries. *PV* portal vein, *PHA* proper hepatic artery, *SMA* superior mesenteric artery, *SMV* superior mesenteric vein, *LRV* left renal vein, *IVC* inferior vane cava, *AO* abdominal aorta

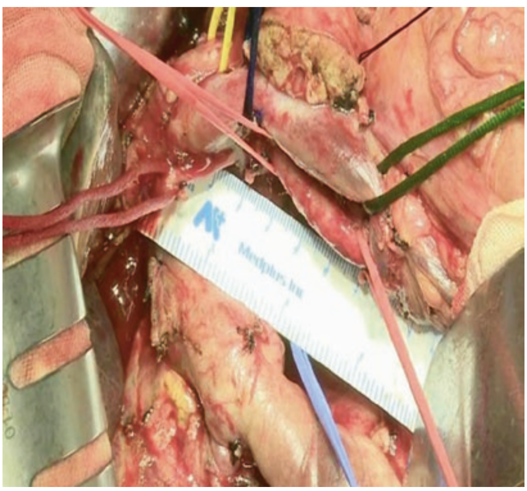

Fig. 26.2 Refined excision and hemostasis intraoperatively

and refined excision and hemostasis intraoperatively may contribute to reduce the risk of early PPH (Fig. 26.2). The causes of delayed hemorrhage include: (1) Owing to anastomotic fistula or ulceration of pancreatojejunostomy, choledochojejunostomy, and gastrointestinal anastomosis, the digestive fluid erodes peripheral blood vessels to produce signs of bleeding; (2) Postoperative complications such as pancreatic

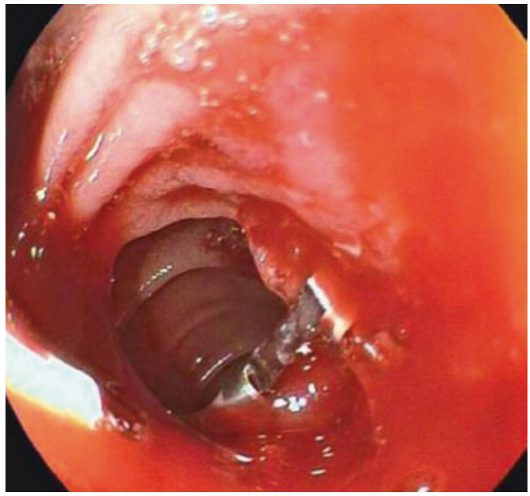

Fig. 26.3 The endoscopy is used for gastrointestinal anastomotic hemorrhage

fistula (POPF), intro-abdominal infections (IAIs), and abscess will directly lead to the bleeding of exposed blood vessels and vascular stump in the surgical site or indirectly lead to abdominal hemorrhage of the pseudoaneurysm; (3) Unreasonable placement of the drainage tube and the long-term compression of the blood vessels may also cause bleeding [4, 5].

The diagnosis of PPH depends on clinical manifestations, physical examination, laboratory tests, and imaging examinations. Confirmation of the bleeding site is the most important issue, which provides guidance for early clinical intervention. The common imaging examinations include endoscopy, digital subtraction angiography (DSA), computed tomography angiography (CTA), and laparotomy. DSA and CTA have a high diagnostic value for active arterial bleeding. DSA that can identify the bleeding site is the "gold standard" for the diagnosis of postoperative hemorrhage [6, 7], and although it should be preferred especially for patients with pseudoaneurysm or hemodynamic stability, its diagnostic value for intermittent bleeding is relatively low. CTA is often used as a common examination of PPH, and has a more favorable predictive value for delayed hemorrhage [6–8]. The endoscopy is only used for highly suspected intraluminal

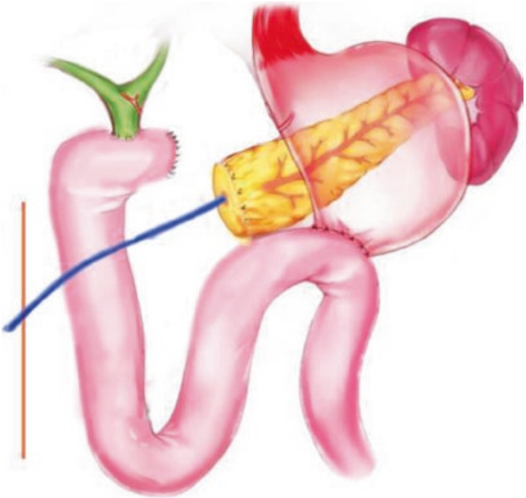

Fig. 26.4 Extra-pancreatic drainage

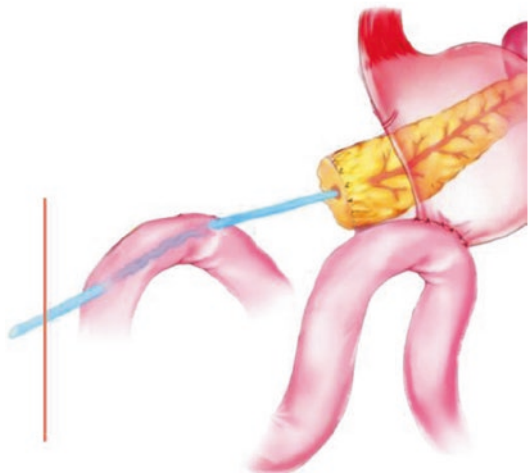

Fig. 26.5 Bridging internal and external drainage

hemorrhage, such as gastrointestinal anastomotic hemorrhage (Fig. 26.3) and stress ulcer bleeding. Laparotomy should be applied early for the suspected extraluminal hemorrhage or uncertain bleeding sites by imaging examination.

The treatment of PPH includes conservative treatment, endoscopic hemostasis, transcatheter arterial embolization, endovascular stent, and re-operation. Although endoscopic and vascular interventions are less invasive, surgical hemostasis is still an irreplaceable method for hemodynamic instability. Reasonable open surgery is required to stop bleeding quickly and treat other complications of the abdominal cavity to ensure the safety of patients [9]. Sometimes pancreatic fistula is the critical cause of PPH and hemorrhage is only an appearance, so that the treatment of complicated hemorrhage with pancreatic fistula and abdominal infection commonly including extra-pancreatic drainage (Fig. 26.4), bridging internal and external drainage (Fig. 26.5), pancreaticogastric anastomosis (Fig. 26.6), Roux-en-Y pancreaticojejunostomy (Fig. 26.7), and the residual pancreatectomy may be applied during re-operation. Routinely placing abdominal drainage tube and maintaining unobstructed drainage will reduce the incidence of pancreatic fistula and the risk of abdominal infection, thereby reduce the incidence of PPH.

Fig. 26.6 Pancreaticogastric anastomosis

26.2 Case

The patient was a 61-year-old man admitted to our hospital because of the persistent dull pain in the upper abdomen with the skin and sclera yellow stained and the dark urine with “black tea” color for more than 1 month. The patient had 5 kg body weight reduction and white colored stool but no fever. Laboratory examinations showed elevation of total bilirubin (57 μmol/L), direct bilirubin (24.6 μmol/L), indirect bilirubin (32.4 μmol/L),

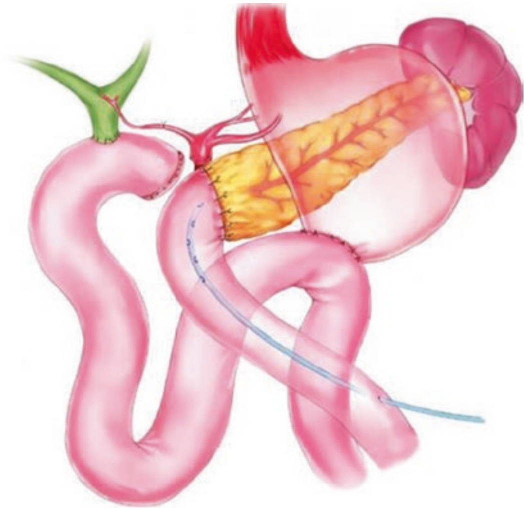

Fig. 26.7 Roux-en-Y pancreaticojejunostomy

Fig. 26.8 The CT showed a mass in the head of pancreas

alanine aminotransferase (ALT) (152.2 U/L), aspartate aminotransferase (AST) (141.8 U/L). The tumor marker CA19-9 and CEA were 22.24 ng/mL and 1.26 ng/mL, respectively. Abdominal enhanced computed tomography (CT) showed a mass in the head of pancreas with biliary obstruction (Figs. 26.8 and 26.9). The patient was diagnosed as pancreatic head cancer with biliary obstruction and underwent pancreaticoduodenectomy. The Child reconstruction with pancreatic duct to mucosa pancreaticojejunostomy and intra-pancreatic duct drainage were placed.

The patient's vital signs were stable after surgery and there were no obvious abnormali-

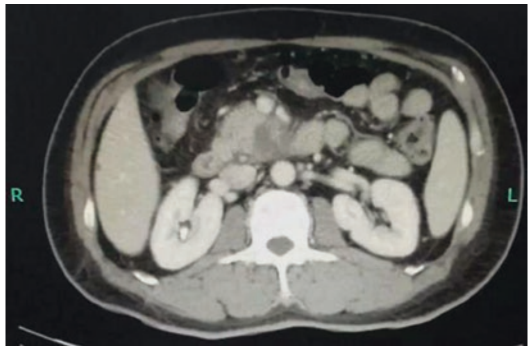

Fig. 26.9 The CT showed a mass in the head of pancreas

ties of abdominal drainage. However, on the postoperative day 6 (POD6), the patient was observed blood like fluid about 200 ml from the left sided abdominal drainage tube and his blood pressure was 130/76 mmHg, blood oxygen was 95%, heart rate was 75 beats/min and breathing rate was 27 times/min. Laboratory tests of the hemoglobin levels of POD1, POD3, and POD5 were 121 g/L, 102 g/L, and 94 g/L, respectively, which showed a gradual downward trend and indicated the possibility of sentinel bleeding. The patients were given fluid resuscitation, blood transfusion, and other symptomatic treatment. The DSA guided angiographic stent implantation was performed successfully in emergency.

Informed consent was obtained from all participating patients, and the ethics committee of The First Affiliated Hospital of Harbin Medical University approved this study.

26.3 Procedures

The abdominal hemorrhage occurred on POD6 and the abdominal drainage tube was observed blood like fluid about 200 ml. Considering delayed hemorrhage, the emergency DSA guided angiography was performed to identify the bleeding site. The patient was placed in a supine position, routinely disinfected with a sterile towel and local anesthesia of the right inguinal region.

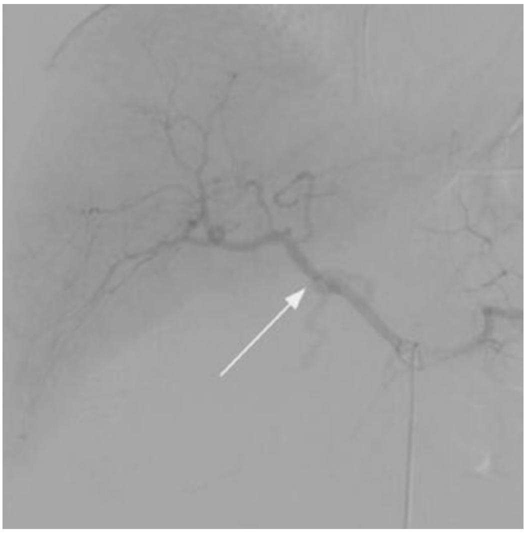

Fig. 26.10 The DSA guided angiographic stent implantation

Fig. 26.11 No obvious contrast agent extravasation

Puncture the right femoral artery and place the 5F vascular sheath and loach filaments for angiography at the beginning of the celiac trunk. In the remaining section of gastroduodenal artery (GDA), the contrast agent was extravasated; therefore, the DSA guided angiographic stent implantation was accompanied (Fig. 26.10).

Since the patient had no signs of pancreatic fistula or abdominal infection, we determined to perform endovascular stent implantation by placing the hepatic duct at the distal end of the common hepatic artery, reaching the beginning of the celiac trunk under via guide wire and defining the bleeding site, then selecting a Viabahn stent graft of 6 mm-5 cm, releasing the stent under the path, displaying the total common hepatic artery and covering the remained GDA section. The arterial patency was good, and there was no obvious contrast agent extravasation (Fig. 26.11). Withdraw the guide wire and seal the puncture point. The total blood loss is about 10 ml.

The surgical treatments of PPH are various by postoperative time, hemorrhagic site and severity of hemorrhage [2] (Fig. 26.12). If the severity of bleeding is defined as grade A, the conservative treatment will be feasible. Furthermore, grade B/C PPH depends on whether hemodynamic status is stability. Endoscopic hemostasis will be preferred for hemodynamically stable intraluminal bleeding of gastrointestinal anastomosis or stress ulcer. Open surgery should be performed for the patients with abdominal hemorrhage derived from the pancreatic section, the pancreatic anastomosis or cholangiojejunostomy bleeding and combined with POPF and/or IAIs. Open surgery should be performed. If necessary, the gastric and intestinal lumen should be exposed and detect the hemorrhagic site during the surgery. A small number of patients with delayed abdominal hemorrhage without POPF or IAIs are treated with transcatheter arterial embolization (TAE) or endovascular stent-graft implantation (EVSG) when they are technically feasible. For instability of hemodynamic status and failure of endoscopic or interventional treatment, the choice of emergent open surgery is indispensable to stop postoperative hemorrhage.

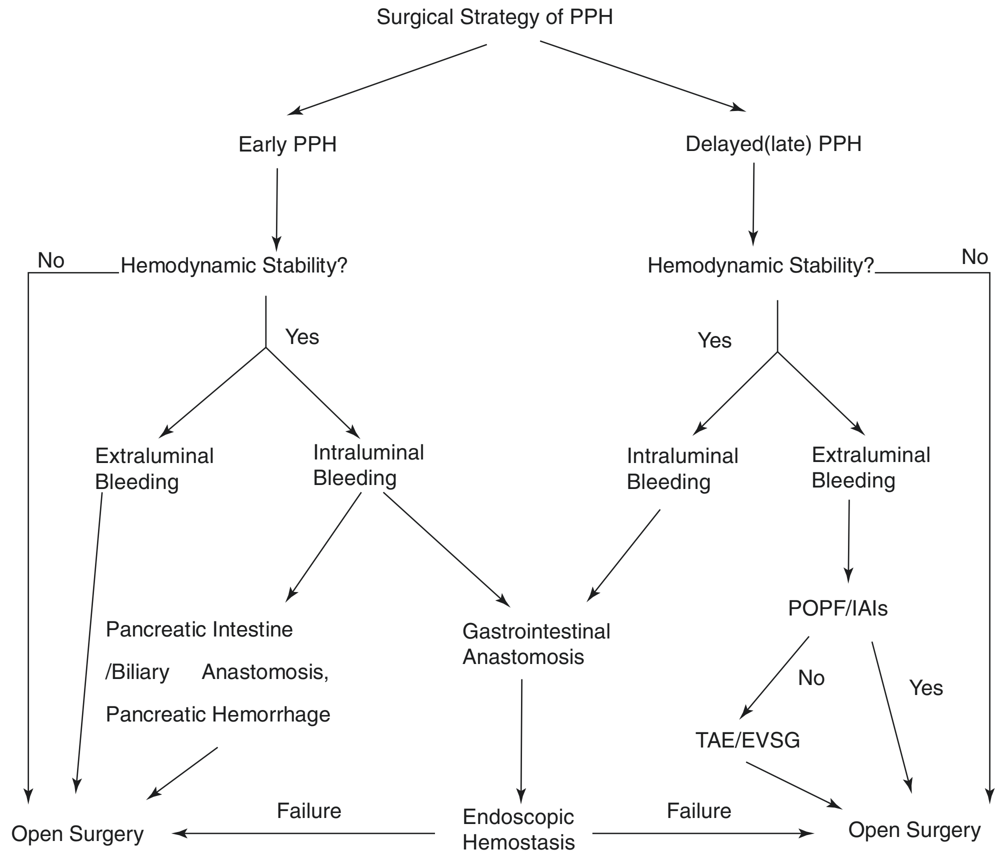

Fig. 26.12 Surgical Strategy of PPH

26.4 Comment

PPH is critical for patients and pancreatic surgeons with an elevated mortality. The early diagnosis and accurate treatment are indispensable to improve prognosis and reduce mortality. Sometimes, it is difficult for pancreatic surgeons to choose the appropriate time and the appropriate intervention methods. Since the cause of early PPH is mostly technical, so as to prevent unnecessary bleeding after surgery, pancreatic surgeons are recommended: (1) Improve the nutritional status and liver function of patients, and correct coagulation dysfunction preoperatively; (2) Improve intraoperative techniques such as tissue processing, refined excision, and precise hemostasis; (3) Accurate ligation or suture for important arteries and veins and their branches such as GDA, SMA, SMV. The intraoperative naked blood vessels should be protected with the omentum or ligament; (4) It is necessary to carefully check the anastomosis after stapler closure. The tissue press is too tight to cause the anastomosis to crack and too loose to make the anastomosis stop bleeding [2, 4].

The delayed PPH requires multidisciplinary diagnosis and treatment and extra attention should be paid to sentinel hemorrhage which has been proved to be an independent risk factor for PPH, increasing the mortality rate of patients [10]. Postoperative pancreatic fistula, intro-abdominal infection, and hemorrhage can form a vicious cycle of critical life; therefore, they should be highly valued. Unobstructed drainage is the key point of the treatment of pancreatic fistula. If bleeding is critical, it is necessary to follow the principle of protecting life first. It is recommended to use the sandwich compression filling drainage method with accurate placement of the drainage tube and proper management of the drainage tube in case of possible secondary adherent tissue injury. In addition, for patients with stress ulcer and anastomotic ulcer bleeding, it is also important to strictly control blood pressure and gastric pH value.

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27 Surgical Treatment of Pancreatico-enteric Anastomosis Stenosis and Post-operative Chronic Pancreatitis

Xu-An Wang and Fang-Liang Xie

27.1 Introduction

Pancreaticojejunostomy stricture (PJS), which has been less studied and no treatment consensus till now, is a late complication after pancreaticoduodenectomy (PD). However, the incidence is increasing since the postoperative survival time after PD was prolonged. The incidence of PJS reached about 2–5% [1–3], which was very low, only one paper reported the incidence rate of 11.3% (27/237) [4]. PJS mainly occurs in patients with benign diseases such as IPMN and chronic pancreatitis underwent PD, but the high risk factors were not apparent. Coiffi et al. [4] reported the diagnosis and treatment of 26 patients with PJS, of which 19% are chronic pancreatitis, 32% are IPMN, and 26% are ampullary malignant tumors with PD. There was little analysis of PJS in pancreatic cancer and other malignant tumors, there is only one study described the incidence of PJS after PD in 310 malignant tumors, which is 1.93% [5].

The median interval time of PJS after PD was 34 months (3–62 months) [6]. The clinical manifestations are mainly recurrent episodes of abdominal pain and acute pancreatitis, accompanied by clinical symptoms of pancreatic endocrine and exocrine function such as weight loss and diarrhea. It can be attacked several times or even more than ten times a year. The main basis for the diagnosis is abdominal CT-scan and MRCP, which can show the expansion of the main pancreatic duct at the distal end of the anastomosis, or with intraductal stones. Regarding the exact definition of PJS, there is currently no consensus in the international community. However, for patients with recurrent abdominal pain and acute pancreatitis after PD, it is recommended to perform CT or MRCP examination to rule out the possibility of the disease.

A clear treatment model to PJS has not yet to be established caused by the small population of patients. We proposed a three-stage treatment strategy: (1) Conservative treatment: For patients with initial onset, especially for patients underwent PD for pancreatic head cancer, or asymptomatic cases found PJS in imaging examinations, invasive treatment is not recommended.

Conservative treatment can be taken with the treatment of acute pancreatitis, and supplementation of pancreatic enzyme. (2) Endoscopic treatment: Patients with ineffective conservative treatment, or with frequent seizures, balloon dilatation of the pancreaticojejunostomy (PJ) and pancreatic duct stent placement by ERP or enteroscopy-assisted ERP or EUS-guided rendezvous techniques ERP is recommended for examination and treatment. However, due to

X.-A. Wang (✉) · F.-L. Xie
Xinhua Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, China

The First People's Hospital of Lianyungang, Xuzhou Medical University, Jiangsu, China

Y.-b. Liu (ed.), *Surgical Atlas of Pancreatic Cancer*, https://doi.org/10.1007/978-981-32-9864-4_27

complex digestive tract reconstruction and anatomical structure changes, finding pancreaticojejunostomy anastomosis (PJA), pancreatic duct intubation, balloon expansion, and stent placement is very difficult; thus, the overall success rate of endoscopic treatment is relatively low. (3) Surgical treatment: PJS revision is believed to be an effective treatment and it is the only therapeutic option for patients who have failed endoscopic treatment. The general principle of surgery is to "Release the obstruction, Pancreatic duct drainage, Deplete the stones in the pancreatic duct and Improve pancreatic internal and external secretion function." PJ resected followed by an end-to-side PJ, PJ resected followed by pancreaticogastrostomy (PG), longitudinal pancreaticojejunostomy (or modified Puestow procedure), and total pancreatectomy are usually four kinds of surgical methods. In this case, we recommend a new surgical approach named as single purse-string duct-to-mucosa PG.

27.2 Case

The patient was a 62-year-old woman who had underwent PD and end-to-side PJ 13 years ago was admitted to our hospital because of recurrent abdominal pain and acute pancreatitis for 9 years. She had no yellow skin and sclera stained, but with a weight loss of more than 20 kg. Laboratory examinations showed an elevation both of the serum amylase and the urinary amylase, which were 401 U/L and 4452 U/L, respectively. The liver function test showed albumin (ALB) was 33.4 g/L, total bilirubin (TB) 19.2 μmol/L, direct bilirubin (DB) 8.5 μmol/L, aspartate aminotransferase (AST) 10 U/L, alanine aminotransferase (ALT) 14 U/L, alkaline phosphatase (ALP) 44 U/L, and r-glutamyl transpeptidase (r-GTP) 8 U/L. The blood test showed the WBC was 4.20 × 109/L, RBC was 2.98 × 1012/L, PLT was 146 × 109/L, and HB was 90 g/L. All the tumor markers were normal.

The endoscopic ultrasonography (EUS), abdominal computed tomography (CT) showed a narrow anastomosis of PJ and a dilation of the main pancreatic duct (Fig. 27.1a). Same image was revealed by the abdominal magnetic resonance image (Fig. 27.1b,c). Based on these findings, a diagnosis of PJS was made. The endoscopic treatment failed because the endoscopy could not pass through the reconstructed digestive tract. Thus a surgical intervention was carried out, and the PJ was resected, followed by PG reconstruction.

Informed consent was obtained from all participating patients, and the ethics committee of Xinhua Hospital, Shanghai Jiaotong University School of Medicine approved this study.

27.3 Details of Procedure

27.3.1 Separate the Adhesion Around the PJA

A supraumbilical midline incision extending to the xiphoid and 2–3 cm below the umbilicus was made. After the abdominal cavity was opened, the adhesions to the abdominal wall should be carefully separated. To palpate the area of PJA, there were too much adhesions surrounding it such as the inferior border of the liver, the transverse colon, the gastric wall, and the posterior adhesions were hepatojejunostomy, common hepatic artery, portal vein, superior mesenteric vein, superior mesenteric artery, and spleen vein. It will be very difficult to identify and explore the PJA caused by the recurrent acute pancreatitis.

Firstly, the superior adhesion of the PJA was separated. In order to not injure the PJA and hepatojejunostomy, the separation was performed along the liver border (Figs. 27.2, 27.3, and 27.4). After the superior PJA was explored, the inferior adhesion was separated, the transverse colon adhered very firmly to the PJA; thus, the PJA might be injured for protecting the transverse colon (Fig. 27.5). Then, the posterior of the PJA was explored by mobilizing the gastric wall (Fig. 27.6) to handle the distal pancreas beside the PJA (Fig. 27.7), during the separation, the posterior portal vein, superior mesenteric vein, superior mesenteric artery, and spleen vein must be protected (Figs. 27.8 and 27.9).

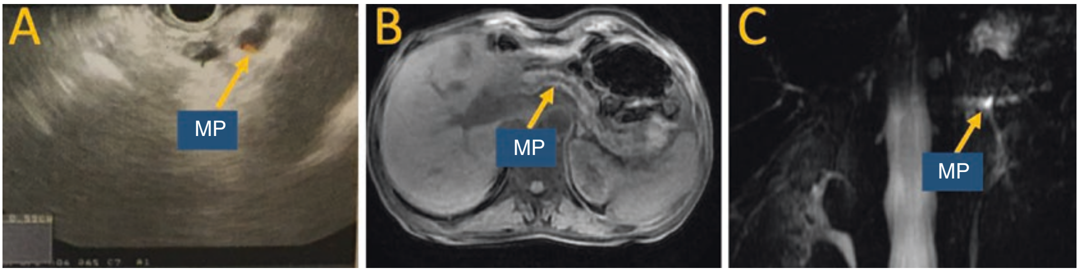

Fig. 27.1 Images showed a dilated main pancreatic duct

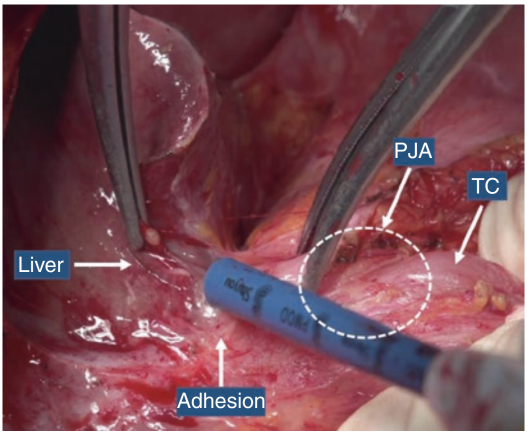

Fig. 27.2 Separation of the superior adhesion of PJA

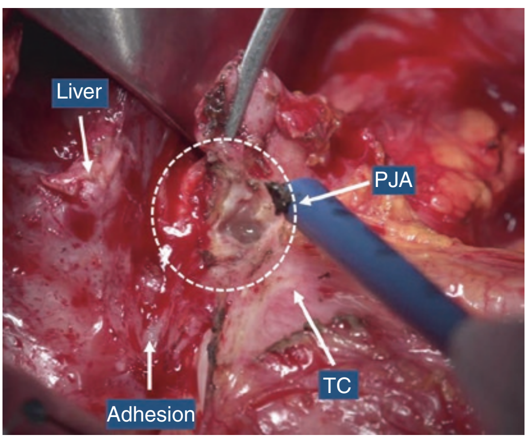

Fig. 27.3 Separation of the superior adhesion of PJA

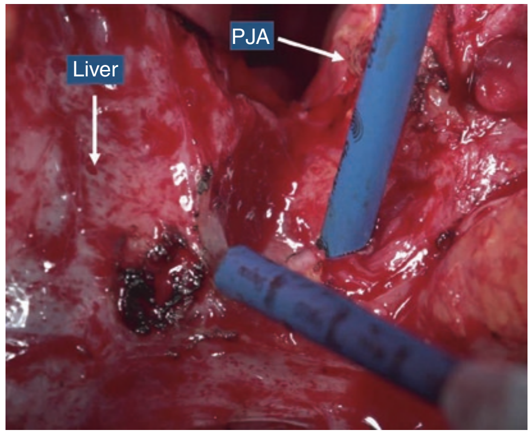

Fig. 27.4 The superior adhesion of PJA was separated

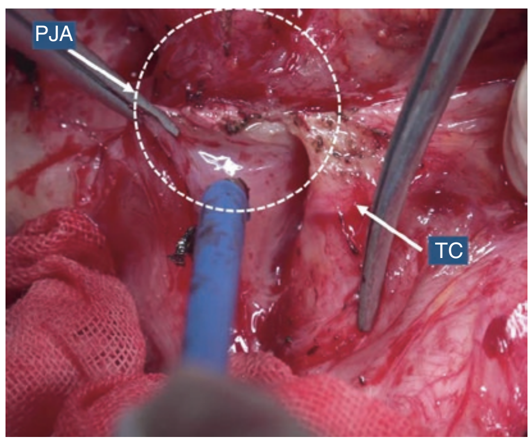

Fig. 27.5 Separation of the inferior adhesion of PJA

Finally, the PJA was totally mobilized and ready to be resected (Fig. 27.9). During this procedure, attention should be paid to the hard, fragile, and bleeding tissues (Fig. 27.10).

27.3.2 Resection of the PJA

The jejunum was transected about 2 cm beside the PJA by a liner cutter (Fig. 27.11), while the

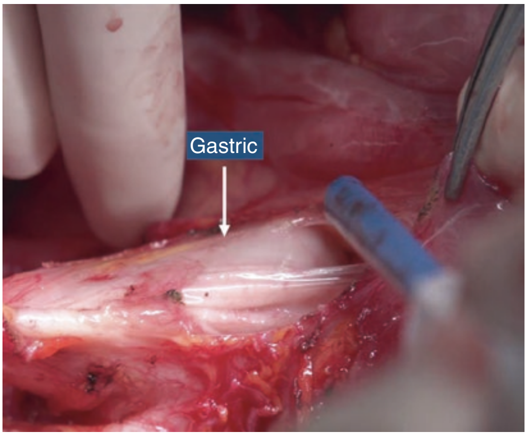

Fig. 27.6 Mobilize the gastric wall

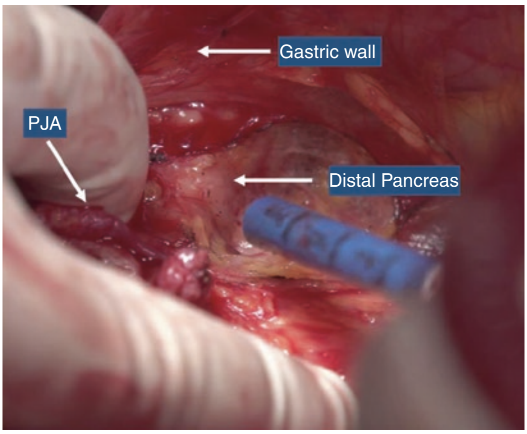

Fig. 27.7 Separate the distal pancreas beside the PJA

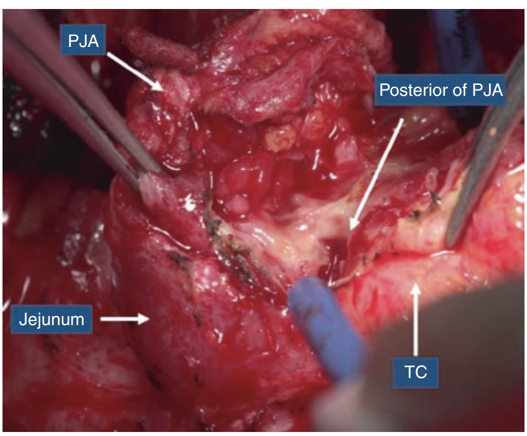

Fig. 27.8 Separate the posterior of the PJA

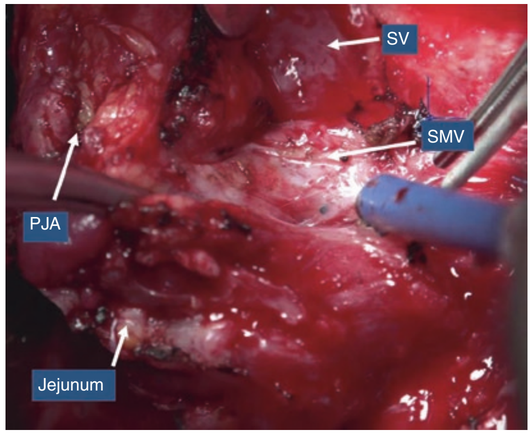

Fig. 27.9 Separate the posterior of the PJA

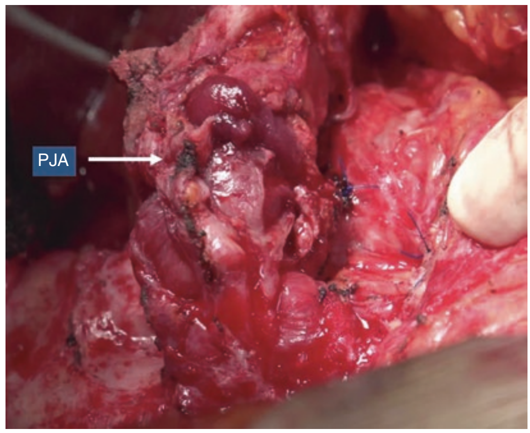

Fig. 27.10 The PJA was totally free mobilized

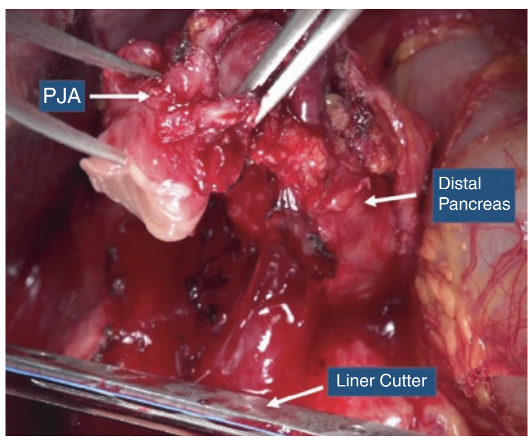

Fig. 27.11 The jejunum was transected about 2 cm beside the PJA

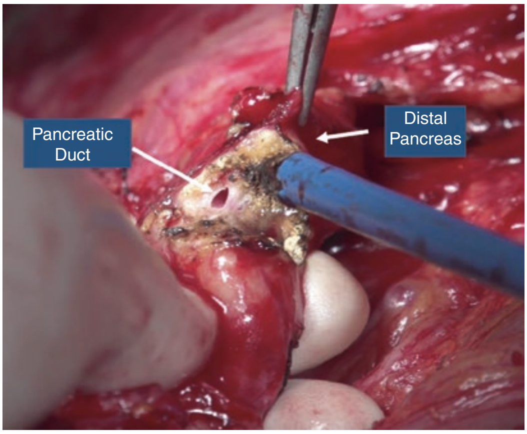

Fig. 27.12 The distal pancreas was transected about 2 cm beside the PJA

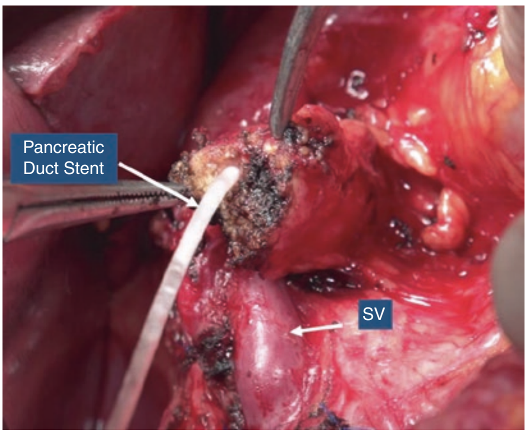

Fig. 27.13 A stent was inserted into the pancreatic duct

distal pancreas was transected 1–2 cm beside the PJA and a stent was inserted into the pancreatic duct and sutured with it (Figs. 27.12 and 27.13). The specimen was sent to the frozen pathology and no tumor recurrent was found.

27.3.3 Reconstructed the Pancreatico-enteric Anastomosis by Pancreaticogastrostomy

The single purse-string duct-to-mucosa PG [7] was performed for this case.

- Step 1: A 2 cm diameter seromuscular layer was excised on the posterior wall of the stomach opposite to the pancreatic stump, around which a single purse-string suture of 2-0 polydioxanone was placed (Fig. 27.14).

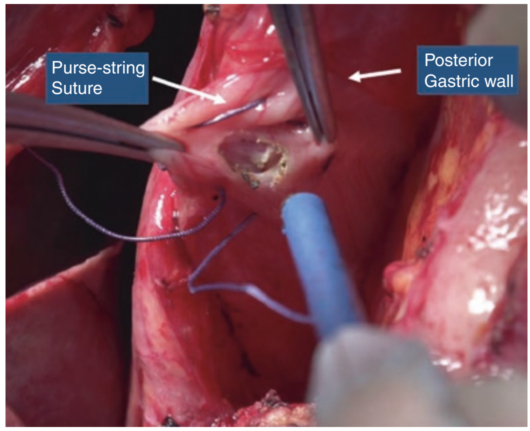

Fig. 27.14 A single purse-string suture was placed

- Step 2: Then the anterior gastric wall was opened and the gastric lumen was washed. After that a small hole (the size equal to the diameter of the pancreatic duct) was made in the center of the posterior gastric mucosa layer (where the seromuscular layer was excised in step 1).
- Step 3: The pancreatic duct with silicone stent was pulled into the gastric lumen (Fig. 27.15), while the pancreatic stump was placed between the gastric mucosa and seromuscular layer and pancreatic parenchyma was trans-fixed with the mucosa layer.
- Step 4: Finally, the purse-string suture placed in the seromuscular layer was tied (Fig. 27.16).

27.4 Pathology and Prognosis

The pathology of resected specimen diagnosis was local granulomatous tissue formation at the PJ anastomosis. Main pancreatic duct chronic inflammation (active), with polyposis and stenosis. Lymphocytes, plasma cells, and neutrophil infiltration in pancreatic parenchyma with fibrous tissue hyperplasia and partial acinar atrophy.

The patient recovered uneventfully without abdominal pain and acute pancreatitis recurrent after 2 years follow-up. And her body weight increased 5 kg.

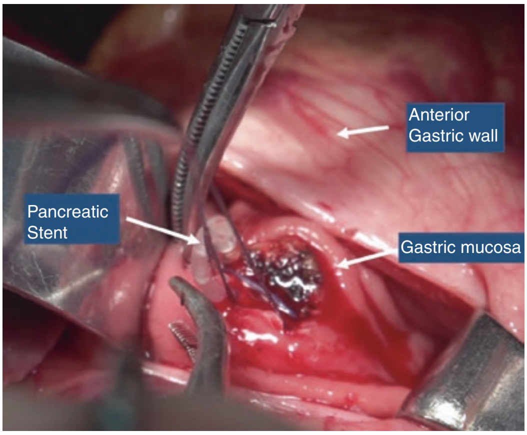

Fig. 27.15 The pancreatic duct and the stent were pulled into the gastric lumen

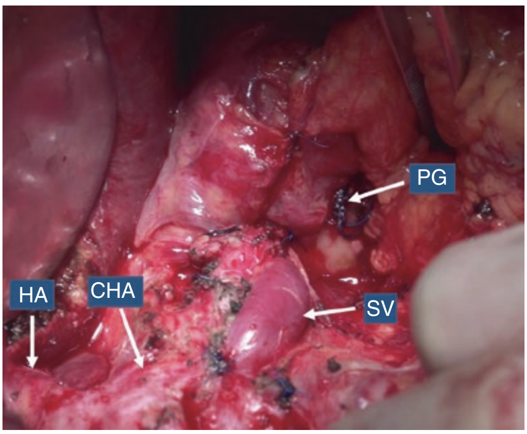

Fig. 27.16 The duct-to-mucosa PG finished

27.5 Comment

Surgical approach is the only option for the patient with PJS who failed the conservative and endoscopic treatment. But the process was very difficult, the PJ and surrounding tissues were very fragile and easily bleeding caused by repeated episodes of acute pancreatitis. Besides this, the transverse colon and the cholangiojejunostomy anastomosis could be hardly adhered to the PJ, which were easily damaged when dissecting the PJ. Thus, it should be very careful to explore the PJ. When the PJS was resected, as refer to the reconstruction method, we usually recommend PG reconstruction, especially the duct-to-mucosa PG. Because it is easier to perform than a new PJ reconstruction and could be examined and treated by gastric endoscopy if the anastomosis stricture happened again. Another advantage of the duct-to-mucosa PG is that the pancreatic stump was placed between the gastric mucosa and seromuscular layer; thus, the pancreatic stump and PG anastomosis bleeding could be avoided.

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28 Surgical Treatment of Pancreatic Fistula after Pancreatoduodenectomy

Yong-Su Ma, Wei-Kang Liu, and Yin-Mo Yang

28.1 Introduction

Pancreaticoduodenectomy (PD) is a major operation for many diseases such as pancreatic head cancer, middle and lower common bile duct carcinoma, Vater carcinoma, duodenal malignant tumor. Because of the wide resection, surgical trauma, long operation time, PD leads to high incidence of postoperative complications and perioperative mortality.

Postoperative pancreatic fistula (POPF) is a common and dreaded complication following pancreatic surgery with an incidence of 3–45% [1]. Pancreatic fistula may lead to intraperitoneal infection, bleeding, sepsis, and other complications if it is not properly handled. Besides, it carries a mortality risk of 1% for all patients with POPF.

International Study Group on Pancreatic Fistula (ISGPF) formulated the diagnostic criteria for POPF in 2005, in order to standardize the diagnosis of pancreatic fistula, which have been widely used in the clinical diagnosis of pancreatic fistula since then. A large series from Heidelberg reported that POPF-associated mortality in patients with interventional drainage alone was 0% compared with 37% after surgical intervention [2]. Based on the results of this study, in 2016, ISGPF updated the diagnostic criteria for POPF. It is now redefined as a drain output of any measurable volume of fluid with an amylase level >3 times the upper limit of institutional normal serum amylase activity, associated with a clinically relevant condition related directly to the postoperative pancreatic fistula [1]. In brief, the grade A POPF has now been assigned the term "biochemical leak," and POPF is stratified as only B and C grades. Grade B POPF requires a change in the management of the expected postoperative pathway, including persistent drainage >3 weeks, clinical relevant change in management of POPF, percutaneous or endoscopic drainage, angiographic procedures for bleeding, and signs of infection without organ failure. Grade C requires reoperation or leads to organ failure and death attributable to the pancreatic fistula.

The currently recognized prognostic factors related to POPF include soft texture of pancreas, small diameter of pancreatic duct (< 5 mm), high intraoperative blood loss (> 400 ml), and high-risk pathological types [3].

A "step-up" approach to POPF management is usually suitable as the patients remain clinically stable [4]. Minimally invasive drainage techniques such as ultrasound or CT guided drainage reduced the need for unplanned relaparotomy in patients with POPF. If a POPF-related hemorrhage occurs, angiography usually is necessary. When minimally invasive drainage is

Y.-S. Ma · W.-K. Liu · Y.-M. Yang (✉)
Peking University First Hospital, Peking University, Beijing, China

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ineffective or angiography fails to identify the site of bleeding for hemostasis, surgery is the only option left.

Surgical options include completion pancreatectomy, peripancreatic drainage, disconnection of anastomosis with preservation of a pancreatic remnant (DAPPR), internal or external wirsungostomy, and salvage pancreaticogastrostomy. The pancreas-preserving strategy of using DAPPR, internal or external wirsungostomy, and salvage pancreatogastrostomy seems to be the preferred treatment option with a better in-hospital mortality, the rate of relaparotomy, and long-term endocrine insufficiency [5]. A systemic review reported the success rate of pancreas-preserving strategy was near 94% and the further reintervention rate was 25% [6].

DAPPR procedure preserves pancreas remnant but closes the pancreatic duct without creating an anastomosis. It may increase the risk of pancreatitis in the remnant and thus predispose to further septic or hemorrhagic episodes. Pancreatogastrostomy may be an alternative strategy but the technical feasibility has not been evaluated in large studies.

External wirsungostomy was simple and less invasive and can be considered as a reasonable treatment option for urgent salvage relaparotomy (Fig. 28.1). The "two-step" approach including the external wirsungostomy and a secondary PJ reconstruction was associated with excellent long-term results with no endocrine insufficiency and should be one of the techniques primarily considered [7, 8].

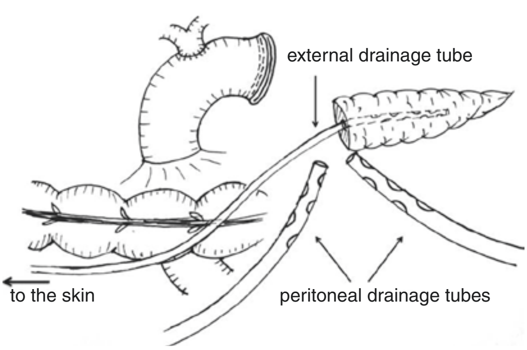

Fig. 28.1 Illustration of the external wirsungostomy procedure, Reproduced with permission from [9]

Completion pancreatectomy is associated with a high mortality rate as high as 55% and insufficient endocrine function although it may serve as an ultima ratio to cope with deleterious complications [10]. Simply peripancreatic drainage should not be adopted for severe POPF since it runs a greater risk of reoperation (30%) and perioperative mortality (47.9%) [5]. Moreover, the attempt with a simply drainage procedure may eventually lead to completion pancreatectomy in some cases.

28.2 Case

A 61-year-old male with a body-mass index (BMI) of 24 kg/m^2 was admitted with upper abdominal pain and weight loss for 3 months. Lab examinations showed a slight elevation of liver function tests: total bilirubin (TB) 35.5 μmol/L, direct bilirubin (DB) 22.4 μmol/L, aspartate aminotransferase (AST) 64 U/L, alanine aminotransferase (ALT) 54 U/L, r-glutamyl transpeptidase (r-GTP) 88 U/L. The tumor marker carbohydrate antigen 199 (CA 199) was 175 U/mL, carcinoembryonic antigen (CEA) of 5.1 ng/mL, and others were normal.

The abdominal ultrasound and abdominal computed tomography (CT) revealed biliary obstruction and an approximately 3 × 2.5 × 2.5 cm round-like solid mass in the left upper abdomen (Fig. 28.2). He was ultimately diagnosed with pancreatic carcinoma. Staging workup showed no evidence of vessel invasion and metastatic disease.

The patient underwent classic PD procedure (Fig. 28.3). A retrocolic pancreaticojejunostomy (PJ) was created using a duct-to-mucosa technique. The pancreatic parenchyma was soft, and the pancreatic duct was 2 mm in diameter. Estimated blood loss was 200 mL. Two 18F drains were placed above and below the hepaticojejunostomy (HJ) and PJ.

His diet was advanced to solids by POD6 and discharged on POD9. He re-presented to our hospital on POD12 with fever and severe abdominal pain. Abdominal examination revealed diffuse peritonitis and abdominal wall rigidity. A CT scan demonstrated diffuse peripancreatic inflammation and pancreatic fistula (Fig. 28.4).

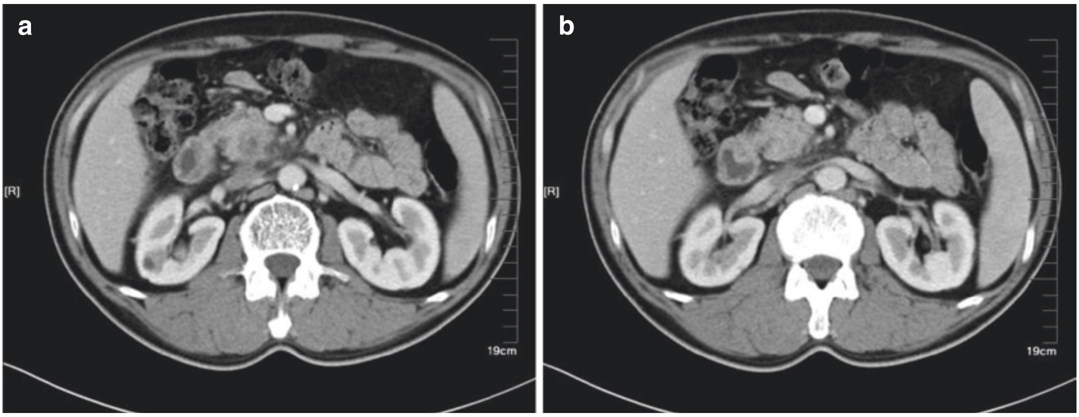

Fig. 28.2 (**a**, **b**) CT image showed a mass in the head of the pancreas

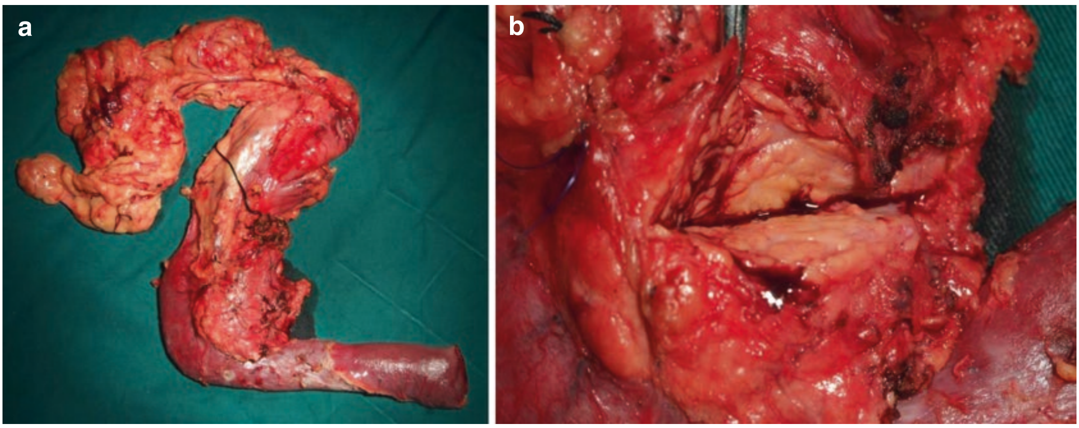

Fig. 28.3 (**a**, **b**) The resected specimen of PD

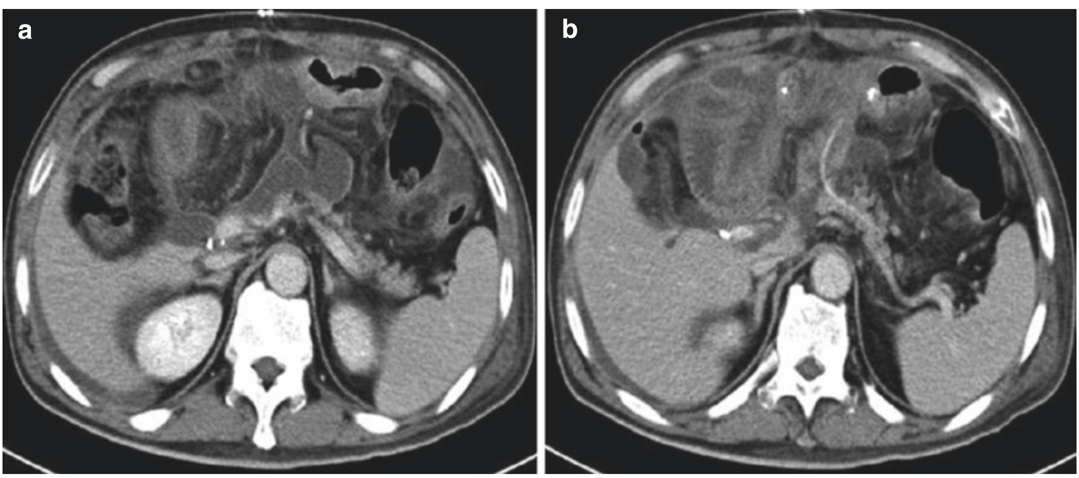

Fig. 28.4 (**a**, **b**) CT image showed pancreatic fistula after PD procedure

Emergent operation proceeded immediately and found a 2 cm rupture at the anterior wall of PJ. External wirsungostomy procedure was performed. Insufficient PJ was disconnected and the open jejunum was closed by segmental resection with a stapler. Thereafter, radical debridement of the peripancreatic region including removal of necrotic tissue was mandatory. A 6Fr tube was inserted to pancreatic duct and passed through the abdominal wall onto the skin. The patient recovered well after surgery without new POPF and symptoms of insufficient exocrine function. 10 months later, the bridging technique for re-PJ was performed, and patient was discharged on POD5 without major complications.

Informed consent was obtained from all participating patients, and the ethics committee of Peking University First Hospital approved this study.

28.3 Details of Procedure

28.3.1 Technique of the External Wirsungostomy

In the salvage operation after POPF, the essential step is the total disconnection of the insufficient PJ. Thereafter, the open jejunum was segmental resected and closed by a linear stapler. A short resection of a necrotic segment of pancreatic stump was performed when necessary. The downstream HJ on the same loop should remain untouched by the stapler. Radical debridement of the peripancreatic region including removal of necrotic tissue is mandatory.

A 6Fr polyethylene tube is inserted into the main pancreatic duct according to the diameter of the duct to make sure sufficient drainage of pancreatic juice without periductal leakage. The drainage tube is fixed to the pancreatic remnant using 4-0 Prolene sutures and passed through the abdominal wall onto the skin (Fig. 28.1). Two drains are placed besides the pancreatic stump exteriorized in both flanks.

28.3.2 Repeat Pancreaticojejunostomy

The re-PJ procedure is scheduled in average of 6 months since the last operation. Tumor progression should be excluded before surgery. Re-PJ may be unnecessary if the pancreatic juice secretion ceased spontaneously without evidence of stasis.

The pancreatic polyethylene tube was used as a guide to find the pancreatic stump and the main pancreatic duct. The proximal end of the jejunum should be identified and used to construct the repeat end-to-side duct-to-mucosa pancreaticojejunal anastomosis. In this case, a bridge technique for re-PJ reported by Ma was performed as the dense adhesion in surgical site [9]. The external drainage tube with a dense sinus tract around it should be identified and isolated at the distal end after adhesiolysis (Fig. 28.5a, b). The sinus tract around the polyethylene tube is to be used

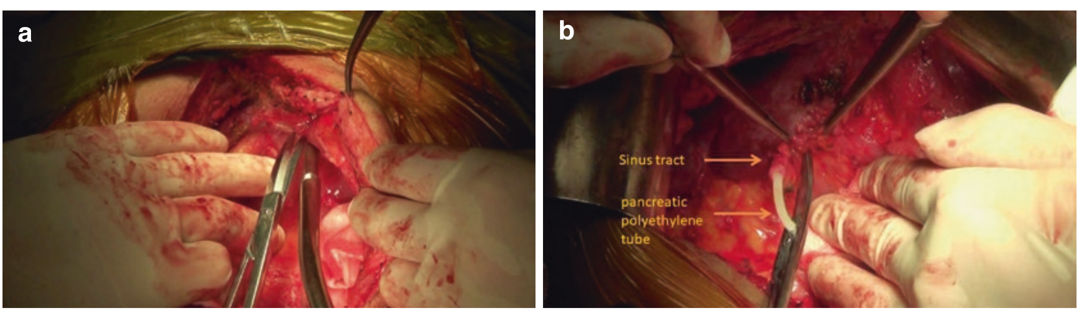

Fig. 28.5 (**a**) Separation of abdominal adhesions. (**b**) Isolation of external drainage tube. (**c**) A purse string suture on the jejunum. (**d**) External tube was put into the jejunum. (**e**) The anastomosis is strengthened by interrupted 4-0 Vicryl sutures. (**f**) The bridging technique for repeat pancreaticojejunostomy

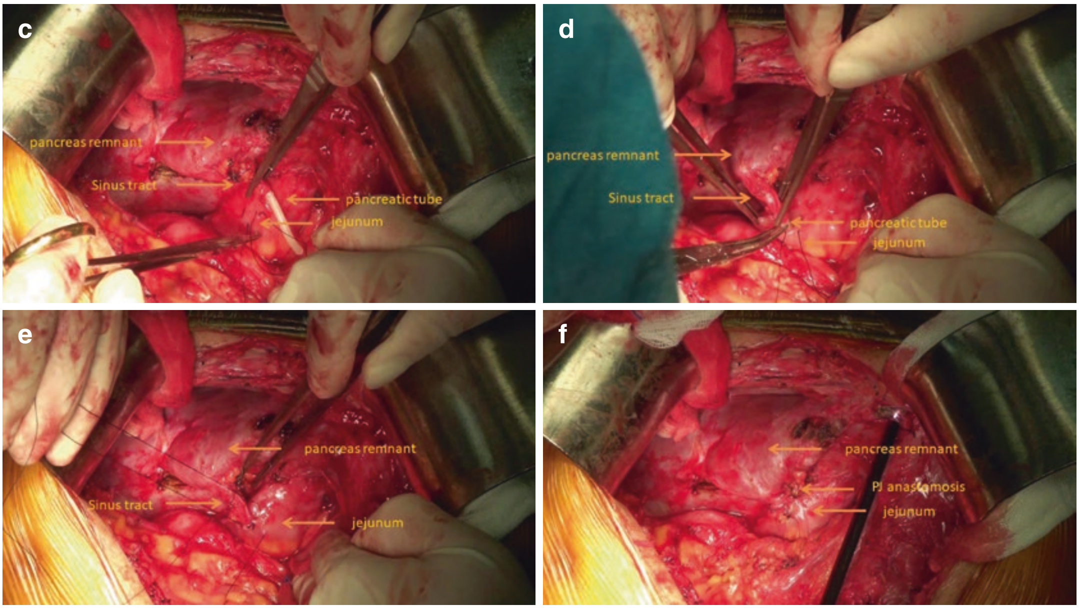

Fig. 28.5 (continued)

for anastomosis with the jejunal loop. A small, full thickness jejunostomy is made by electrocautery at the anti-mesenteric side. The original polyethylene tube is put into the jejunum as an internal stent. A purse string suture is placed in the whole layer of the jejunum around the stent to fix it into the jejunum (Fig. 28.5c, d). Finally, the anastomosis is strengthened by interrupted 4-0 Vicryl sutures of the jejunal seromuscular layer and the sinus duct (Fig. 28.5e, f) [9].

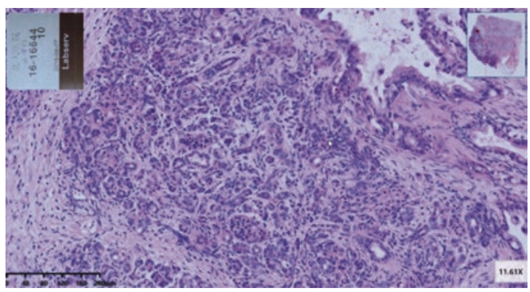

Fig. 28.6 Pathological examination reveals moderate to poor differentiated pancreatic duct adenocarcinoma

28.4 Pathology and Prognosis

The resected specimen is shown in Fig. 28.3. Pathology diagnosis was poor to moderately differentiated pancreatic duct adenocarcinoma (Fig. 28.6), no portal vein or SMV infiltration was detected. The cutting margin of bile duct, pancreatic margin, gastric and jejunum margin was negative. 2 of 10 lymph nodes were positive.

The patient was discharged 5 days after the re-PJ procedure. 3 months after surgery, follow-up CT (Fig. 28.7) revealed no recurrence.

28.5 Comment

External wirsungostomy is easy and safe to perform at salvage relaparotomy with an acceptable in-hospital mortality and long-term endocrine insufficiency. As severe local inflammation in surgical site, external wirsungostomy could avoid complicated procedures and reduce operation duration. The stent drains away the pancreatic juice, decreasing the risk of chemical irritation to

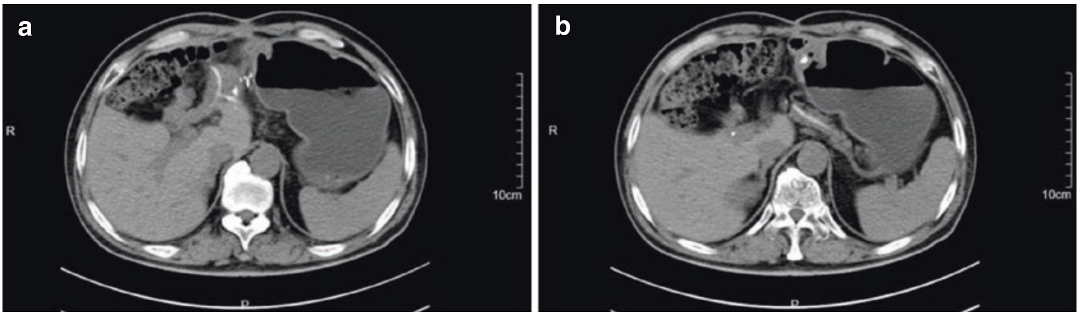

Fig. 28.7 (**a**, **b**) CT plain scan shows stent in the re-PJ anastomosis

blood vessels and surrounding tissues. It maintains the pancreatic endocrine and exocrine function when the pancreatic anastomosis is surgically resumed.

The bridge technique for re-PJ should be considered, while the dense adhesions in the surgical site make the traditional duct-to-mucosa PJ difficult to complete. However, it takes 5–6 months in average to perform a re-PJ procedure to restore pancreaticodigestive continuity [7]. Moreover, carrying a drainage tube obviously impair the quality of life. In this scenario, whether a further operation after external wirsungostomy is necessary is still controversial. More cases and longer follow-ups are both needed to further validate its safety and feasibility.

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Part X

Pancreatic Anastomosis

29 Binding Pancreaticojejunostomy

Xu-An Wang, Jian-Wei Wang, Jiang-Tao Li, Ying-Bin Liu, and Shu-You Peng

The pancreatico-enteric anastomosis has always been a great concern in pancreatoduodenectomy (PD), even been called "Achilles heel." Pancreatic surgeons are interested in improving the anastomosis technique to prevent the pancreatic fistula rate. More than a hundred of anastomosis techniques were reported, all represent variations on two fundamental techniques: PJ (end-to-side duct to mucosa PJ and end-to-end invaginating PJ) and PG (end-to-side duct to mucosa PG and end-to-side invaginating PG). We reviewed the history of pancreatico-enteric anastomosis and divided it into three historical stages, as well as summarized the characteristics of each stage [1]. The early stage is exploratory period (from 1898 to 1940), the characteristics of this stage are: (1) No consensus of the need for reconstruction of the pancreatic stump. (2) Only sporadic pancreatico-duodenal anastomosis or PJ is reported. (3) Animal experiment for PG, not clinically used. (4) Anatomical PD was clarified. The middle stage is maturity period (from 1941 to 1980), the characteristics of this stage are: (1) The two kinds of reconstruction sequences after PD were set up. (2) PJ became the mainstream anastomosis, several kinds of techniques were reported. (3) A few clinical studies compared the results of the different reconstruction techniques of the PJ anastomosis. (4) Several kinds of techniques for PG were introduced and performed for patients.

The recent stage is great development period (from 1981 to now), the characteristics of this stage are: (1) More than one hundred of techniques of pancreatico-enteric anastomosis were introduced in this period. (2) The analysis was normalized. Systematic analysis and randomized clinical trial were used to explore the value of different techniques of the anastomosis. (3) The clinical value of PG was confirmed. In this chapter, we would like to introduce the different kind of binding anastomosis techniques that were used by our team.

29.1 Introduction

Why soft pancreatic texture is a key risk factor for pancreatic fistula after PD? It might well be the sutures that tend to lacerate the fragile pancreatic parenchyma. This was the background of the establishment of BPJ, we had described it our previous articles [2–4]. If sutures were not performed carefully and properly, then the suture itself might lacerate the pancreas and the pancreatic fistula would occur from the point where the suture is placed (Fig. 29.1). And recently, the use

X.-A. Wang · Y.-B. Liu (✉)
Xinhua Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, China

J.-W. Wang · J.-T. Li · S.-Y. Peng
The Second Affiliated Hospital of Zhejiang University School of Medicine, Shanghai, China

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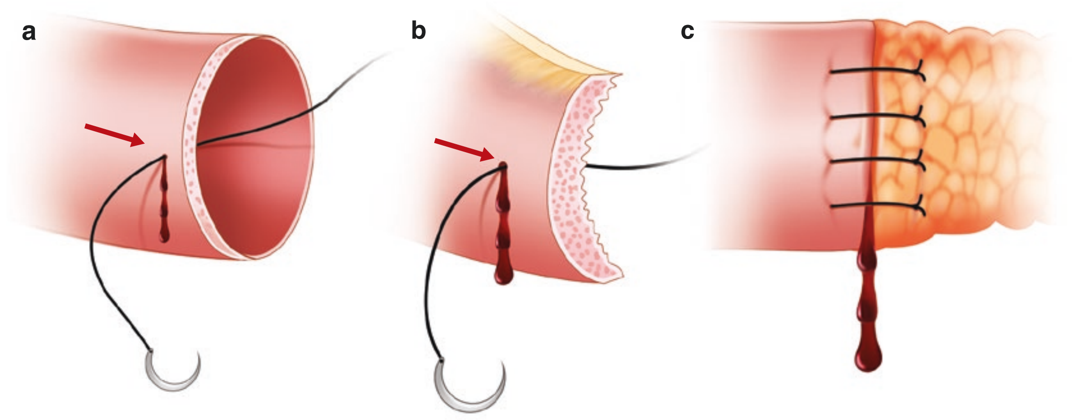

Fig. 29.1 pancreatic fistula from the needle hole (Reproduced with permission from [4])

of atraumatic sutures which the size of the thread is similar to the needle hole, thus the needle hole can be filled up with the suture and no space around the thread leaved in the needle hole, might be one of the reason that decreasing the pancreatic fistula rate. So, it occurred to us that the pancreatic fistula can start at the point where a needle penetrates a pancreatic ductule, or the suture lacerates the fragile pancreatic parenchyma. The resultant minor leak in pancreatic juice gradually leads to a gross anastomoses leakage as a consequence of autodigestion around the anastomoses. Such a hypothesis forms the basis of the binding pancreaticojejunostomy (BPJ) [2–4], where the needle holes do not appear on the surface of the anastomosis and the anastomotic seam between the sutured structures is substituted by a circular gap between the intussuscepting jejunal stump and the intussuscepted pancreatic stump. The gap is easily sealed up by compression from outside with a binding ligature to achieve a watertight closure.

29.2 Details of Surgical Procedures

The detailed processes were described as our previous papers [2–4], we divided the processed into five main steps: preparation of the jejunum for binding anastomosis, preparation of the pancreas stump, two stumps sutured, intussusceptions, and binding.

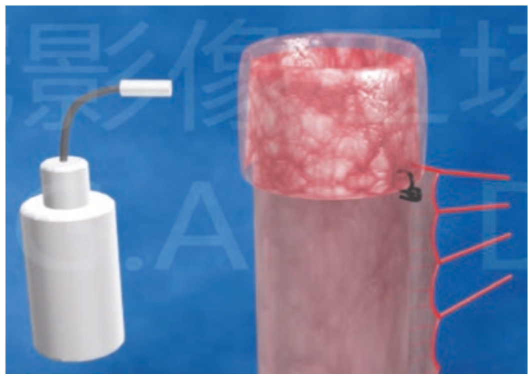

Fig. 29.2 The jejunum is everted for 3 cm with its mucosa destroyed

29.2.1 Preparation of the Jejunum for Binding Anastomosis

The stump of the jejunum is everted for 3 cm; this can be achieved by suturing the jejunal cut edge to a point at the jejunum 6 cm from the edge. Two such sutures are done and tied loosely, rendering 3 cm of the jejunum everted with its mucosa exposed, which then is destroyed by electric coagulation or by 10% carbolic acid and rinsed immediately with 75% alcohol and normal saline (Fig. 29.2).

29.2.2 Preparation of the Pancreas Stump

The remnant of the pancreas is isolated for a distance of 3 cm, usually two to three small veins between the pancreas and the splenic vein are dissected and ligated. After adequate isolation when the isolated pancreatic remnant is raised forward, the splenic artery and splenic vein can be seen and separated by a small area of pancreas which is the site for fixing the posterior cut edge of the jejunum.

29.2.3 Two Stumps Sutured

The pancreatic stump and the everted jejunum are brought together and sutured continuously or intermittently with silk in a circular fashion, care is taken to suture the mucosa only and to avoid penetrating the muscular and serosa layer of the jejunum. The anterior or posterior lip of the pancreatic duct should be involved in the anterior or posterior row of sutures, respectively, whenever possible (Fig. 29.3).

29.2.4 Intussusceptions

The two sutures for everting the jejunum are cut before the everted jejunum is restored to its normal position, so as to wrap over the pancreatic stump. With a few stitches the cut end of the jejunum is fixed onto the pancreas. Special attention is paid to the posterior fixing point as mentioned above (Fig. 29.4).

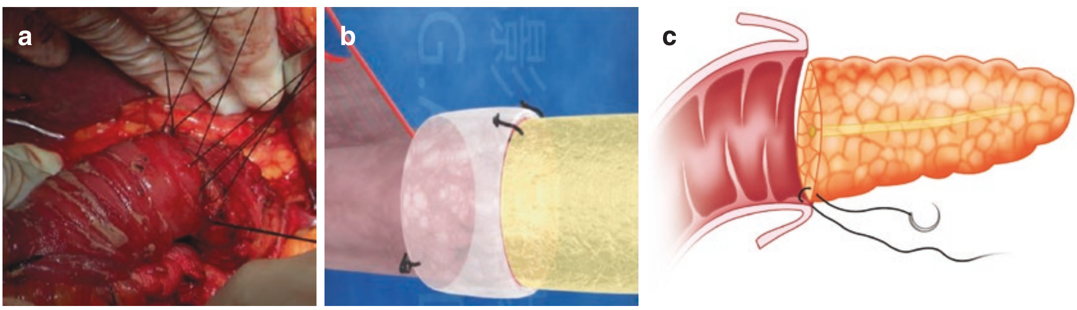

Fig. 29.3 Needle penetrates mucosa only keeping serosa muscular layer intact (Reproduced with permission from [4])

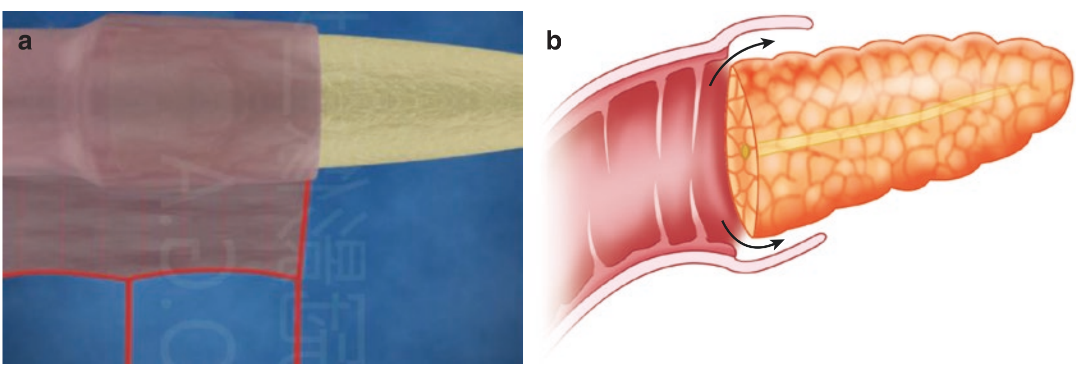

Fig. 29.4 Pancreatic remnant is intussuscepted into the jejunal lumen, the gap between them should be sealed by compression to prevent leakage (Reproduced with permission from [4])

29.2.5 Binding

At 1.5–2 cm from the cut edge of the jejunum, an absorbable tie is looped around the jejunum circumferentially together with the intussuscepted pancreas. The ligature is just tight enough to allow the tip of a hemostatic clamp to pass underneath the ligature (Fig. 29.5). Blood supply to the jejunum distal to the binding ligature is ensured by preserving a bundle of vessels for that portion of jejunum. This means that the thread for making the binding ligature is placed through a hole at the jejunal mesentery between the last two groups of vessels near the cut edge (Fig. 29.6).

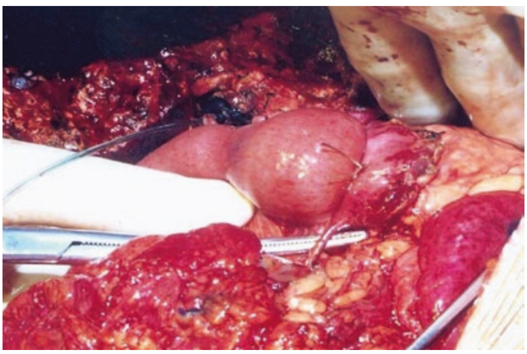

Fig. 29.5 A hemostatic clamp passed underneath the ligature

29.3 Comment

Potential mechanisms of occurrence of pancreatic leakage mainly include leakage from the needle hole and from the seam at the adjacent stitch, anastomotic blood supply, tension at the anastomosis, poor anastomotic healing, etc. [5]. BPJ is a safe and effective technique that avoids the primary complication of pancreatic anastomosis leakage.

In this technique, the cut edge of the pancreas is sutured only to the mucosa of the jejunum. Thus, if there is a leakage, the pancreatic juice goes into the gut lumen. The jejunum, with its mucosa destroyed, is wrapped over the pancreatic remnant. The gap between these two structures is sealed by compressing from the outside with a binding ligature. Healing between the jejunum and the pancreas is promoted by destroying the jejunal mucosa with carbolic acid. The real anastomotic site is at the binding ligature where no sutures are applied. The blood supply to the jejunal cut end is kept by preserving a branch of the vessels (Fig. 29.5). The mobilization of the pancreatic stump for more than 3 cm from the cut edge could possibly compromise the blood supply to the cut end to a certain extent [2–4].

Thus, BPJ is a worthwhile procedure to decrease the rate of pancreatic fistula, especially in case of soft texture of the pancreas and normal

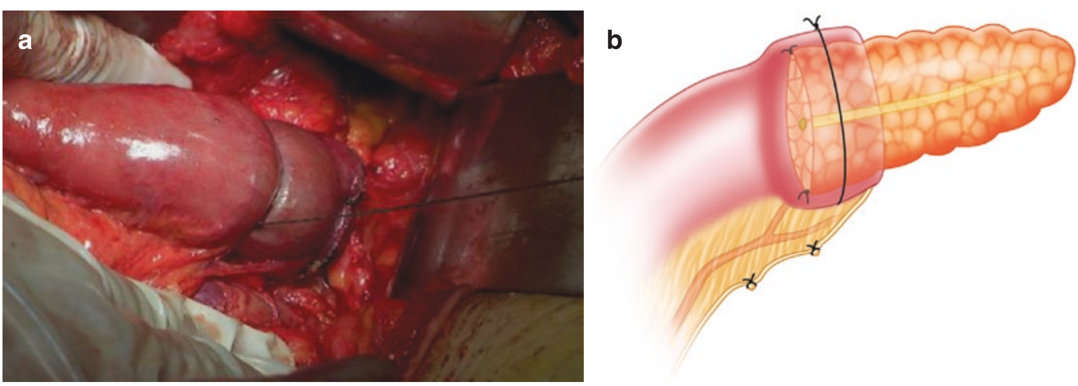

Fig. 29.6 Circumferential ligature can surely prevent leakage

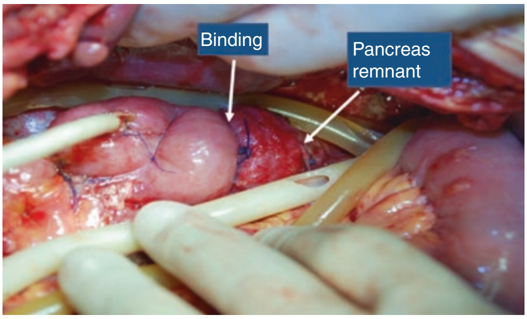

Fig. 29.7 BPJ was used in the second operation caused by pancreatic fistula or postoperative hemorrhage

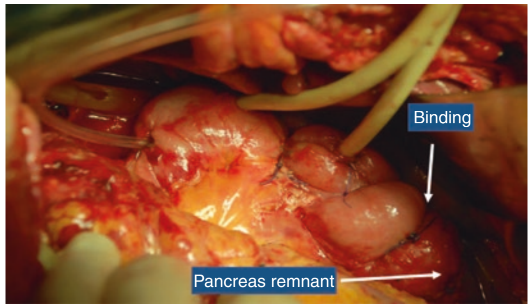

Fig. 29.8 BPJ was used in the second operation caused by pancreatic fistula or postoperative hemorrhage

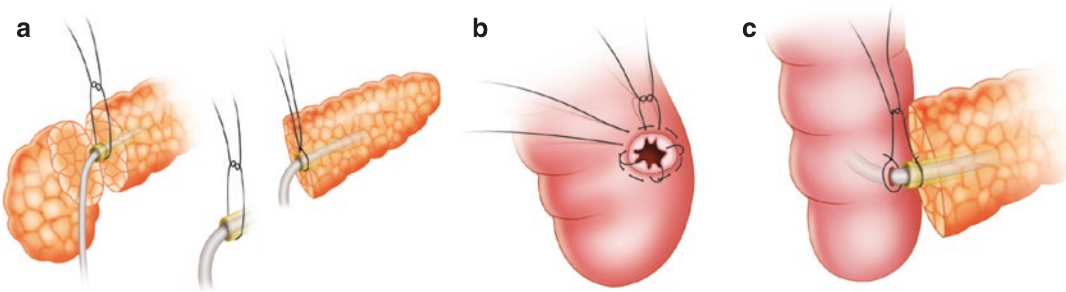

Fig. 29.9 Binding pancreatic duct to mucosa anastomosis (**a**, binding seam of pancreatic duct. **b**, binding seam of jejunum mucosa. **c**, ligation of the two binding sutures)

MPD. It can be used in the second operation caused by pancreatic fistula or postoperative hemorrhage (Figs. 29.7 and 29.8). But there are two problems with BPJ [4]: a high discrepancy in the size of pancreas stump and the jejunal lumen; sutures on to the pancreas for fixation might cause exudation of pancreatic juice into the abdominal cavity. In order to avoid these two problems, binding pancreatic duct to mucosa anastomosis (BDM) (Fig. 29.9) and binding pancreaticogastrostomy (BPG) were designed and successfully performed clinically with encouraging results. BPG is good for accommodating a large pancreas stump, and the binding technique is very helpful in minimizing the leak rate as well, we will describe the details of BPG in the next chapter.

Acknowledgment Some of the figures and contexts were reused with permission from our previous papers.

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30 Binding Pancreaticogastrostomy

Xu-An Wang, Ying-Bin Liu, and Shu-You Peng

30.1 Introduction

Binding pancreaticojejunostomy (BPJ) has been widely used in China; however, when the stump of the pancreas remnant is too large, it might be difficult to insert it into the lumen of the jejunum [1, 2]. In order to solve this problem, a new procedure called binding pancreaticogastrostomy (BPG) has been designed by the author and classified it into four types [1, 2] (Fig. 30.1).

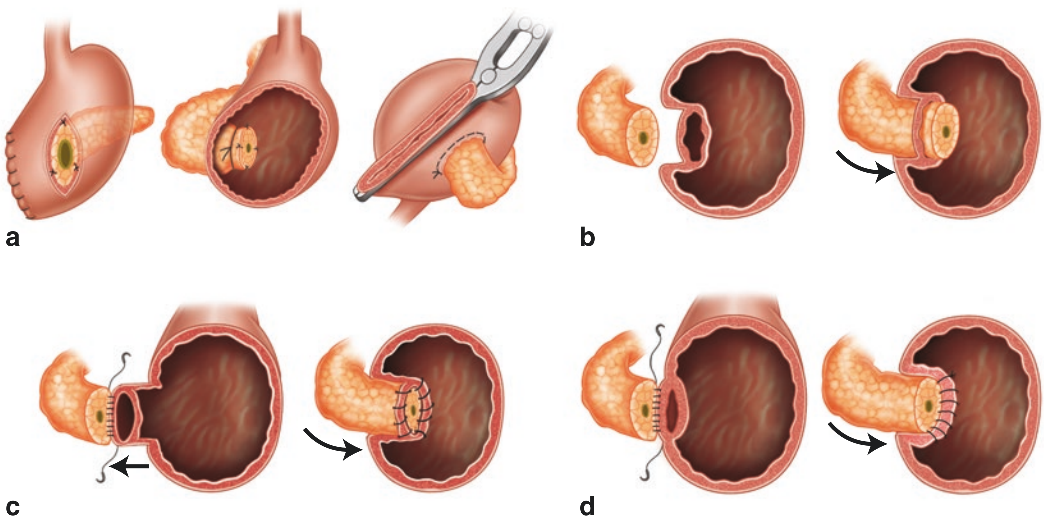

Fig. 30.1 Binding pancreaticogastrostomy (**a**, type I BPG. **b**, type II BPG. **c**, type III BPG. **d**, type IV BPG.) (Reproduced with permission from [1])

X.-A. Wang (✉) · Y.-B. Liu
Xinhua Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, China

S.-Y. Peng
The Second Affiliated Hospital of Zhejiang University School of Medicine, Shanghai, China

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And a number of randomized controlled trials and meta-analyses have demonstrated that PG can reduce overall occurrences of postoperative pancreatic fistula (POPF) (biochemical or clinical) compared with PJ [3, 4]. However, the invagination method, with the pancreatic stump inserted into the stomach lumen, has a risk for pancreatic stump bleeding caused by acid corrosion. Thus, we developed a modification technique—the single purse-string duct-to-mucosa PG [5].

30.2 Details of Surgical Procedures (Invagination Method)

The detailed processes were described as our previous paper [2], we divided the processes into five main steps: preparation of the pancreas stump, excising partial seromuscular of stomach posterior wall, excising the gastric anterior wall, opening the mucosa layer of excised partial seromuscular of stomach posterior wall, and binding anastomosis.

30.2.1 Preparation of the Pancreas Stump

The remnant of the pancreas was mobilized for 2–3 cm. The section of the pancreas remnant is interrupted sutured (avoiding pancreatic duct sutured).

30.2.2 Excising Partial Seromuscular of Stomach Posterior Wall

Excising a piece of seromuscular layer at the gastric posterior wall, the size being equivalent and the location being opposite to the pancreas stump, a seromuscular depth purse-suturing with 4-0 Prolene suture is pre-placed around the incision for later use (Fig. 30.2).

30.2.3 Excising the Gastric Anterior Wall

Excising the gastric anterior wall or opening the part of sealed distal gastric stump. To facilitate

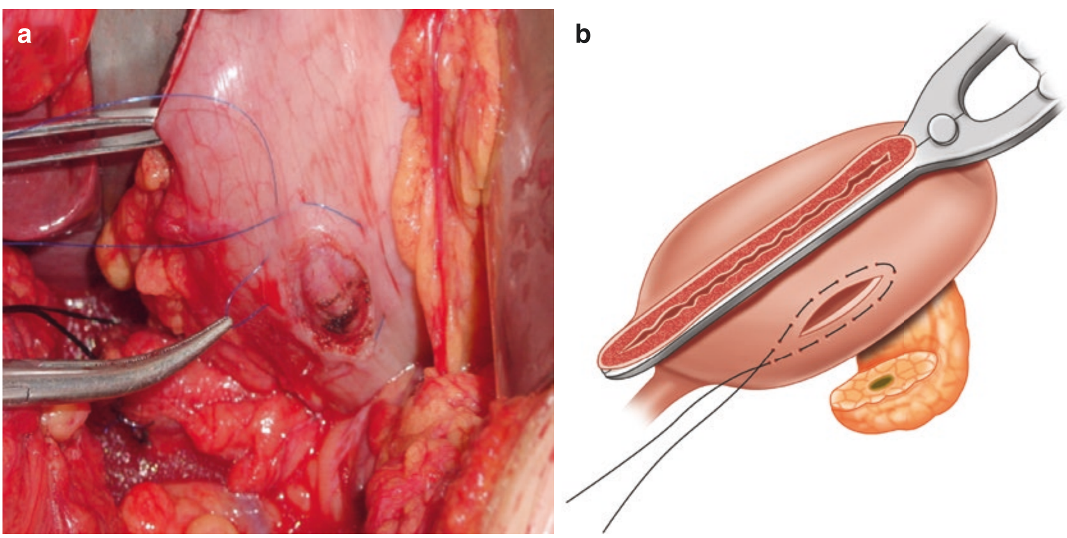

Fig. 30.2 Excising partial seromuscular of stomach posterior wall and pre-placed of suture for purse-string suture (Reproduced with permission from [2])

anastomosis in gastric lumen, either method can be performed by excising the gastric anterior wall or opening the part of sealed distal gastric stump: (1) excise 5 cm anterior gastric wall (for later gastrointestinal anastomosis or later closed for resection of middle-segment of pancreas); (2) opening 5 cm in the middle of the gastric stump which cut by linear stapler. And gastric lumen was then sterilized with povidone iodine through gastric anterior incision or distal incision.

30.2.4 Opening the Mucosa Layer of Stomach Posterior Wall

Opening the mucosa layer of the stomach posterior wall where the partial seromuscular was excised afore and pre-placed of suture for purse-string suture. In the gastric lumen, a small incision is made at the mucosa layer of excised partial seromuscular of stomach posterior wall afore. A mucosa depth purse-suturing with 4-0 Prolene suture is pre-placed around the posterior gastric mucosal incision for later use (Fig. 30.3).

30.2.5 Binding Anastomosis

Through the two pre-placed purse-strings, using the hemostatic forceps to grasp the sutures which was sutured in the pancreas remnant and pulled the pancreas remnant into the gastric lumen (Fig. 30.3b). Posterior gastric wall is then pushed backward to keep the isolation of pancreatic stump in the gastric lumen and keep the posterior gastric wall in close contact with the pancreas. Thereafter, the seromuscular depth purse-string pre-placed is tied (outer binding) (Fig. 30.4) and then the mucosa depth purse-string pre-placed is also tied (inner binding) (Fig. 30.5).

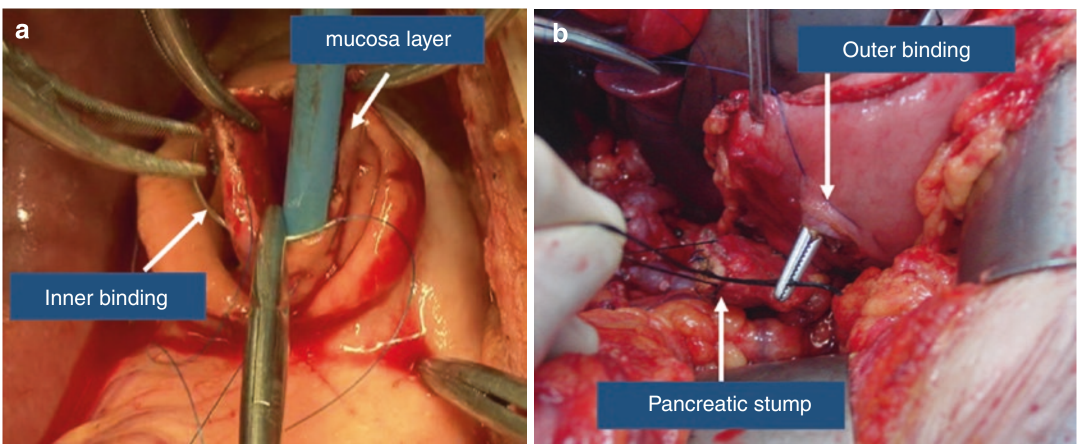

Fig. 30.3 Opening the mucosa layer of excised partial seromuscular of stomach posterior wall afore and pre-placed of suture for purse-string suture (Reproduced with permission from [2])

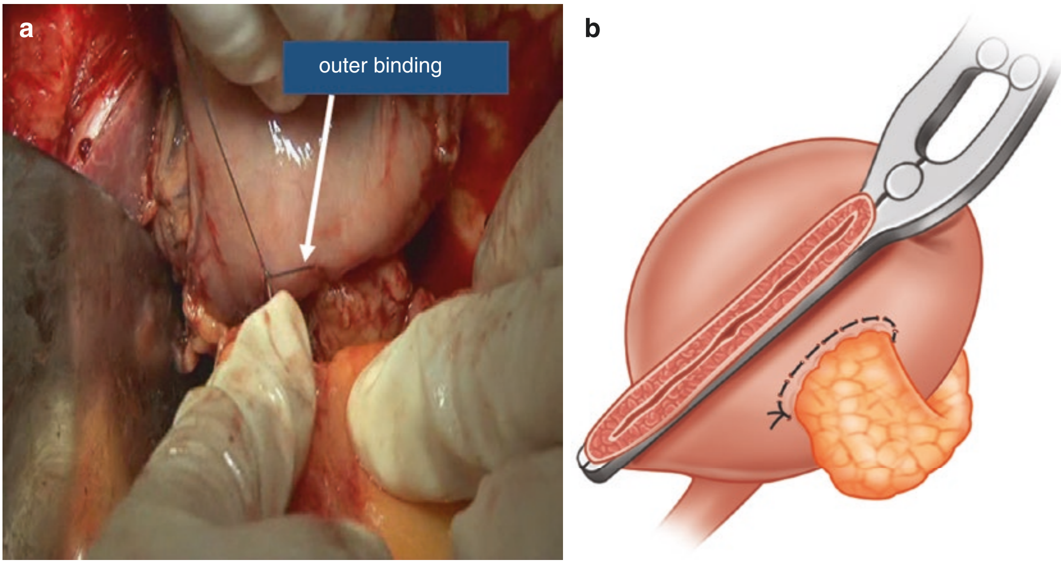

Fig. 30.4 The seromuscular depth purse-string pre-placed is tied

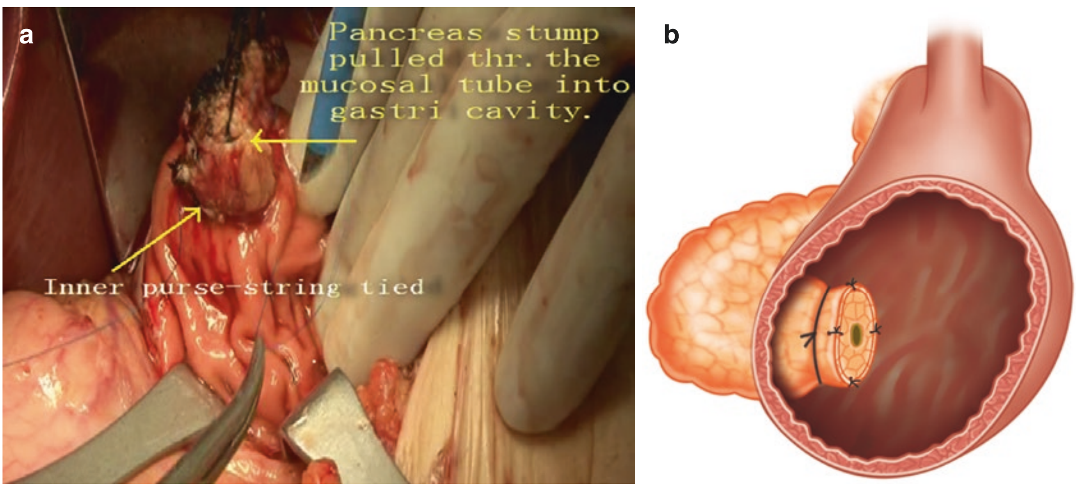

Fig. 30.5 The mucosa depth purse-string pre-placed is also tied (Reproduced with permission from [2])

30.3 Details of Surgical Procedures (Duct-to-Mucosa Method)

The detailed processes were described as our previous paper [5], we divided the processes into four steps.

30.3.1 Preparation of the Pancreas Stump

The pancreatic distal stump was then separated from the splenic vein and artery about 3 cm to facilitate the PG anastomosis. The size of the main pancreatic duct (MPD) and texture of the remnant pancreatic stump were assessed during the procedure. A silicone tube equal in diameter to the MPD was then inserted into the MPD as a stent to prevent occlusion of the pancreatic duct, and the pancreatic parenchyma beside the MPD was transfixed with 3-0 Vicryl stay sutures, one needle on each side without cutting. The sutures were used to pull the pancreatic duct and silicone stent into the stomach.

30.3.2 Excising the Seromuscular Layer of the Posterior Gastric Wall

At an appropriate place on the posterior wall of the stomach opposite the pancreatic stump, a 2- to 3-cm diameter seromuscular layer was excised, around which a single purse-string suture of 2-0 polydioxanone was placed (Fig. 30.6). The size of this excision was equal to the size of the pancreatic stump, if the excision was too large, then the purse-string would be difficult to tie, if it was too small, then the pancreatic stump would not be easy to insert.

30.3.3 Duct-to-Mucosa Anastomosis

An incision about 3–5 cm was made in the anterior gastric wall, and the gastric lumen was washed using 0.5% povidone-iodine diluted with physiological saline. After that a small hole (2–5 mm) was made in the mucosa of the posterior gastric wall adjacent to the position of the pancreatic duct, through which the pancreatic duct with silicone stent was pulled into the gastric lumen by gently pulling the sutures (Fig. 30.7). The gastric mucosa and pancreatic parenchyma beside the pancreatic duct were transfixed (about 1.5 cm distant to the pancreatic cut surface) with interrupted absorbable 3-0 Vicryl stay sutures, 4 needles on each side (Fig. 30.8). If the MPD diameter is >3 mm, it was sutured continuously with the gastric mucosa by 5-0 Prolene (Ethicon); otherwise, the MPD

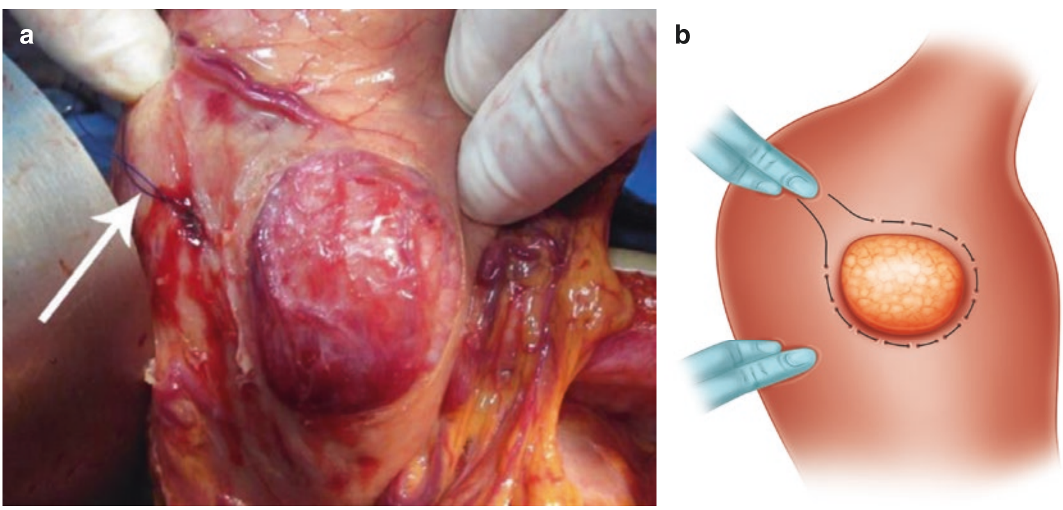

Fig. 30.6 A 2- to 3-cm diameter seromuscular layer was excised, around which a single purse-string suture (arrow) of 2-0 polydioxanone was placed (Reproduced with permission from [5])

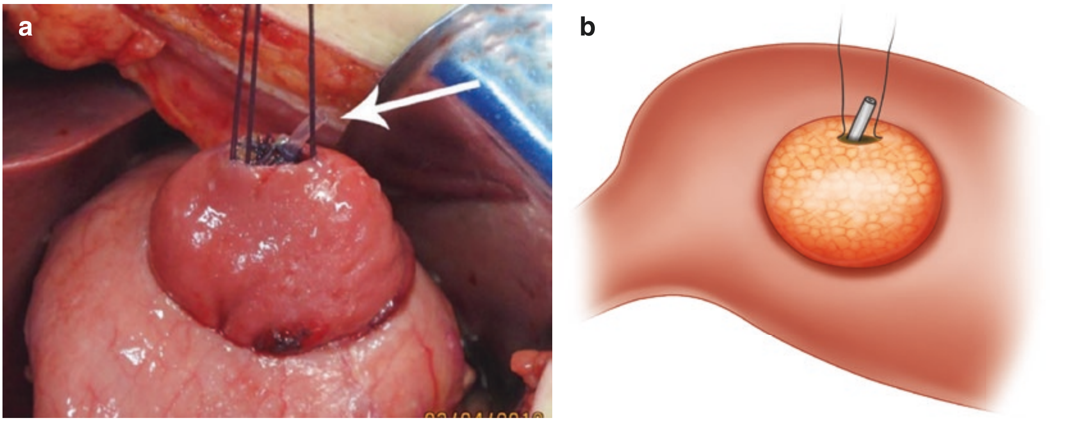

Fig. 30.7 A small hole (2–5 mm) was made in the mucosa of the posterior gastric wall, through which the pancreatic duct with silicone stent was pulled into the gastric lumen. Arrow, silicone stent in the pancreatic duct (Reproduced with permission from [5])

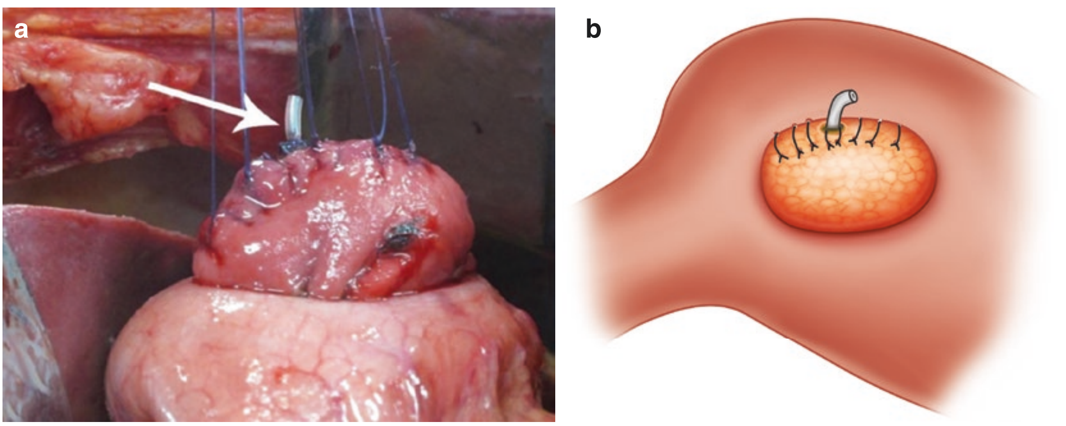

Fig. 30.8 The gastric mucosa and pancreatic parenchyma beside the pancreatic duct were transfixed with 4 needles on each side (Reproduced with permission from [5])

would not be sutured with the gastric mucosa, they will grow together along the silicone stent.

30.3.4 Binding

Subsequently, the purse-string suture was tied to create a watertight closure (Fig. 30.9), but with minimal tension to avoid pancreatic duct occlusion.

30.4 Comment

BPG has been used clinically and proved to be very effective and safe in our clinical center, and even easier than BPJ to perform. Numerous technical and theoretical advantages of PG have been summarized [5], including the proximity of the gastric wall to the pancreas stump and the well-vascularized and thick gastric wall facilitate

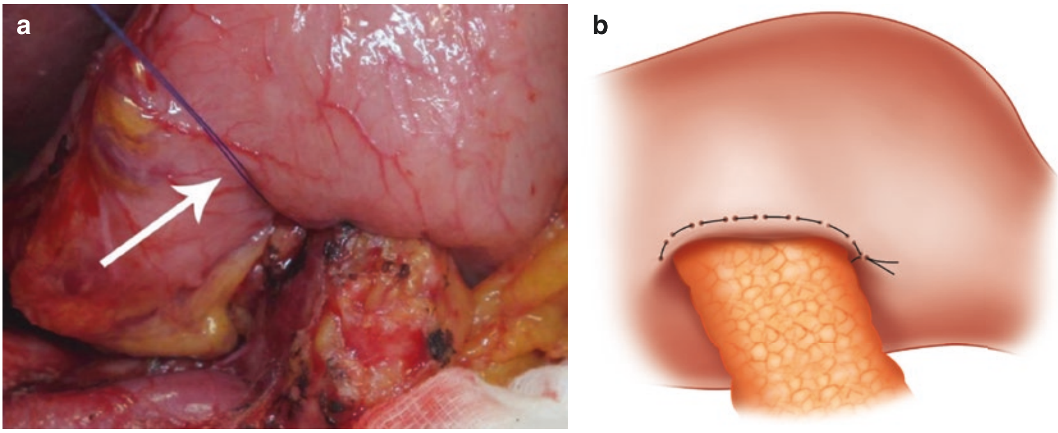

Fig. 30.9 The purse-string suture was tied (arrow) to create a watertight closure

reconstruction of a tension-free anastomosis; pancreatic enzymes will not be activated, as a lack of enterokinase and low pH in the stomach and leakage of inactivated pancreatic enzymes have less serious outcomes; a nasogastric tube, providing constant removal of gastric and pancreatic secretions, could decompress the tension of PG anastomosis; and postoperative complications, such as pancreatic stump bleeding and PG anastomosis, can be managed by gastro-endoscopy [5].

Acknowledgment Some of the figures and contexts were reused with permission from our previous papers.

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