

Laparoscopic Pancreaticoduodenectomy - Experiences of 40 Cases

X Wang

ABSTRACT

Background: Laparoscopic pancreaticoduodenectomy (LPD) was still one of the most challenging endoscopic surgeries by far and there were still some technical problems to be resolved. In this study, we try to investigate the difficulties and countermeasures of the LPD.

Methods: A retrospective analysis was performed for the surgical techniques of the LPD carried out for 40 patients in our hospital from December 2009 to Jul 2015 and the clinical data such as operative time, intra-operative blood loss, numbers of scavenged lymph node and postoperative complications were collected.

Results among the 40 patients, 4 cases were converted to laparotomy and the other 36 cases were successfully completed the surgery. The mean operative time was 390 ± 89 min and the mean operative blood loss was 320 ± 205 ml. the edges of all samples were tumor-negative and the average scavenged lymph nodes were 15.8 ± 6.5 pieces. postoperative complicating pulmonary infection in 1 case, while was cured after strengthened the anti-infection; incision mal-healing in 1 case and was cured by the 2nd-stage suture; seroperitoneum accompanied with infection in 1 case and was performed the re-operative drainage; bile leakage in 3 cases and were cured after drainage; pancreatic leakage in 5 cases, among which 1 case developed the secondary intra-abdominal bleeding, and was re-operated to stop the bleeding, the other case was cured after the drainage. Delayed intra-abdominal bleeding in 1 case, which was caused by the irruption of hepatic artery and was cured with re-operation.

Keywords: Laparoscopy, pancreaticoduodenectomy, pancreaticojejunostomy surgical approach

From: Department of Hepatobiliary Surgery, Yijishan Hospital, Zheshan road 92th, Wuhu city, Anhui province.

Correspondence: Dr X Wang, Department of Hepatobiliary Surgery, Yijishan Hospital Zheshan Road

92th, Wuhu City, Anhui Province, 241001, China. E-mail: xiaomingwang_123@yeah.net.

Conclusion: The application of appropriate surgical approach, improvement of the resection of UP and modification of the pancreaticojejunostomy (PJ) could make the LPD easier and safer.

INTRODUCTION

Since Gagner successfully performed the laparoscopic pancreaticoduodenectomy (LPD) for the patient with chronic pancreatitis in 1994 (1), LPD had been carried out in many hospitals, but the cases were less, the operative time was significantly prolonged and the postoperative complications were more than that in open surgery, which did not show the advantages of minimally invasive surgery (2-6), therefore, LPD was once in the controversy and developed slowly. In recent years, with the constantly improved surgical techniques and continuously updated surgical instruments, many progress had been made in LPD, the recent reports had showed the encouraging prospects (7-11). But because of the deep location, complex anatomic structure and near to many major vessels, LPD was still one of the most challenging endoscopic surgeries.

Currently, the major technical problems of LPD were as follows: the surgical approach still followed the open surgery, which could not fit the requirements of endoscopic operations. the resection of pancreatic uncinata process(UP) under the laparoscope still had some technical difficulty and the risk of bleeding. the skills demand for the reconstruction of digestive tract under the endoscope was high, especially for the PJ. Therefore, how to resolve these problems and improve the laparoscopic techniques was the key to develop LPD widely.

from December 2009 to Jul 2015, 40 cases of LPD were carried out in our hospital and the short-time outcomes were fine, which were reported as follows .

MATERIALS AND METHODS

General data

From Dec 2009 to Jul 2015, 40 patients were recruited for LPD in our department. There were 22 male and 18 female subjects with a mean age of 60 (range,35–75) years. All the patients were confirmed as the ampullary tumor or pancreatic head tumor by CT, MRI or ERCP preoperatively. The criteria of case selection: the tumor diameter was less than 4 cm, with no signs of peripheral vascular invasion, with no obvious lymph node metastasis and distant metastasis. This study was conducted in accordance with the declaration of Helsinki and with approval from the Ethics Committee of Wannan Medical College. Written informed consent was obtained from all participants.

Surgical procedure

Anesthesia and position: the patient was performed with general anesthesia and in the supine-straddle position. The laparoscopy was inserted from the small incision at the lower edge of umbilical ring (or 3-5cm below the umbilicus), then 4 incisions were made at the lower rib margin of left and right anterior axillary line and slightly above the umbilicus level of left and right clavicular middle line respectively. The surgeon stood on the left side of the patient, while the assistant stood on the right side of the patient.

Exploration: the conventional exploration was performed towards the liver, abdominal cavity and omentum to investigate whether there existed the possible metastatic lesions. The

transverse mesocolon was lifted and the inferior flexure of duodenum was exposed and mobilized from the right side of its root (Fig. 1). After entering the Toldt's space, the inferior vena cava was revealed and probed whether it was invaded by lesions. The abdominal aorta was then revealed and the para- aortic lymph nodes were obtained for the frozen section, the surgery would be gave up if there existed lymph node metastasis. The left renal vein (LRV) was revealed and the superior mesenteric artery (SMA) was exposed just above the LRV and was dissected along its trunk under the unique dorsal view of laparoscopy until to the horizontal part of duodenum, probing whether the tumor violated SMA or not. The root of celiac trunk was also revealed after mobilization cephalically and the surrounding lymph nodes were cleaned at the same time (Fig. 2). The superior mesenteric vein (SMV) was exposed at the horizontal part of duodenum, the vascular sheath was opened cephalically and the right gastroepiploic vein was dissected. The inferior edge of pancreas was then lifted and the mobilized was performed behind the pancreatic neck until to the superior edge of the pancreas to explore whether the SMV was violated or not.

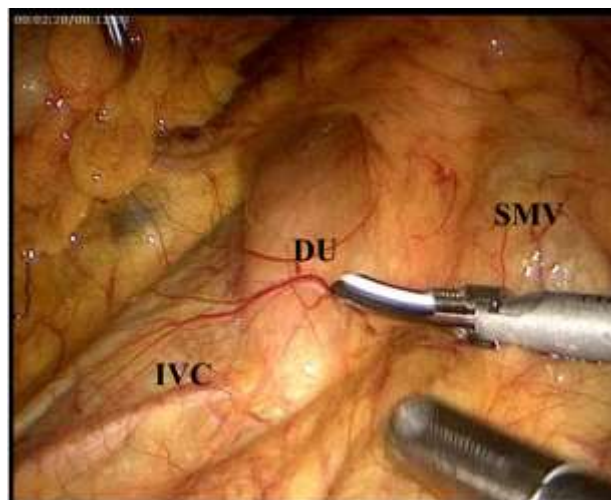


Fig. 1: The inferior flexure of the duodenum was exposed at the right of the root of the transverse mesocolon. SMV: superior mesenteric vein; IVC: inferior vena; DU: duodenum

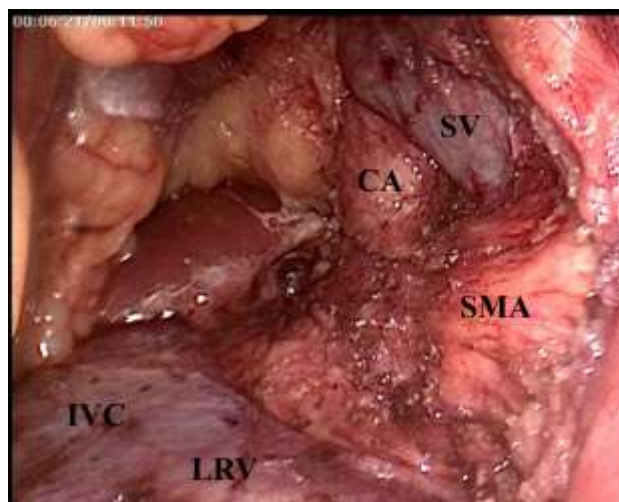


Fig. 2: The SMA and CA were exposed and the surrounding lymph nodes were cleaned .SV: spleen vein; IVC: inferior vena; LRV: left renal vein; SMA: superior mesenteric artery; CA: celiac artery

Specimen dissection: after the exploration, if the tumor was resectable, the surgical field was shifted to the left of transverse mesocolon root. The jejunum was transected 15cm away from the Treitz ligament and the proximal jejunum was pulled to the upright behind the mesenteric vessels. The gastric body was transected with a linear stapler. The pancreatic neck was transected using ultrasonic shears and the common hepatic artery was revealed at its superior edge, the gastroduodenal artery and the right gastric artery was divided. Then a tape was placed under the pancreatic head and was pulled rightwards (Fig. 3), meanwhile the SMV was pushed leftwards to reveal the right lateral aspect of the SMA. The UP was then dissected off along the right lateral aspect of the SMA using ultrasonic shears caudal-to-cephalically and the surrounding lymph nodes was cleaned. Entered the hepatoduodenal ligament, the PV, hepatic artery and bile duct were isolated and skeletonized respectively, the surrounding lymph nodes were cleaned fully. Finally, dissected gallbladder

and transected the common bile duct and removed the specimen from a small incision on the middle abdomen.

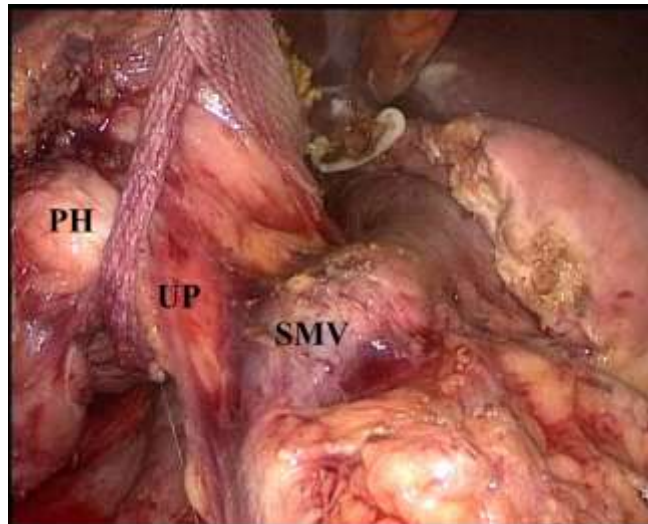


Fig 3: A tape was placed under the pancreatic head and was pulled rightwards. PH: pancreatic head; UP: uncinus process; SMV: superior mesenteric vein

Reconstruction: The digestive tract was reconstructed with the Child procedure under endoscope or small incision assistance. For the PJ, the first 10 cases were performed with the traditional duct-mucosal anastomosis, and the latter 30 cases were performed with the self-designed single-layer penetrative end-to-side anastomosis, the procedure was as follows (Fig. 4): Firstly, two sutures were placed above and below the pancreatic duct respectively with about 1 cm from the transected edge of pancreas, each suture was inserted from the anterior aspect of pancreatic stump and withdrew from the posterior aspect. Seromuscular sutures were then placed in the anti-mesenteric wall of the jejunum from the back to the front, Tension was not applied to the suture temporarily. Secondly, anastomosis of pancreatic duct and jejunal mucous was carried out interruptedly with 0/5 absorbable suture, a stent was then

inserted into the pancreatic duct and fixed. Thirdly, the detained suture was tied while paid attention to make the jejunum wall cover the pancreatic stump. Finally, another two sutures were placed on the anterior and posterior wall of pancreatic stump respectively just at the site of pancreatic duct.

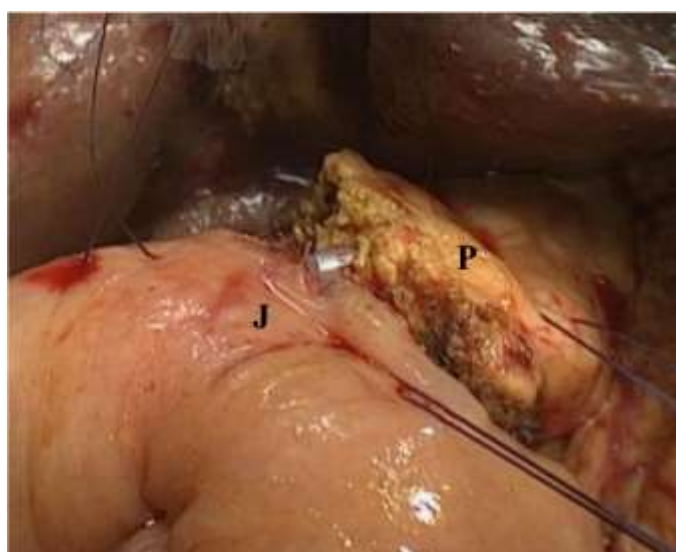


Fig. 4: Single-layer penetrative end-to-side anastomosis: two sutures were placed above and below the pancreatic duct respectively with about 1 cm from the transected edge of pancreas. J: jejunum; P: pancreas

RESULTS

Surgical results

Among the 40 patients, 4 cases were converted to laparotomy and the other 36 cases were successfully completed the surgery. Conversion reasons were as follows: the lesion was closely related with vessels and was difficult for the endoscopic separation in 3 cases, chronic pancreatitis exhibited heavier adhesion with the surrounding tissues which would easily cause

bleeding during separation in 1 case. The mean operative time was 390 ± 89 min, and the mean intra-operative blood loss was 320 ± 205 ml

Pathologic results

Adenocarcinoma of lower common bile duct in 4 cases, duodenal papilla cancer in 8 cases, duodenal stromal tumor in 1 case, Vater ampulla carcinoma in 6 cases, carcinoma of pancreatic head in 14 cases, chronic calcific pancreatitis accompanied with cyst formation or duct dilatation in 4 cases, mucinous cystic neoplasm of pancreatic head in 2 cases, pancreatic solid pseudo-papilloma in 1 case. The edges of all samples were tumor-negative and the mean scavenged lymph nodes were 15.8 ± 6.5 pieces.

Postoperative complications

postoperative complicating pulmonary infection in 1 case, which was cured after strengthened the anti-infection; incision mal-healing in 1 case and was cured by the 2nd-stage suture; seroperitoneum accompanied with infection in 1 case and was performed the re-operative drainage; bile leakage in 3 cases and were cured after drainage; pancreatic leakage in 5 cases, among which, 1 case (which were performed with the conventional anastomosis) occurred the secondary intra-abdominal bleeding, and was re-operated to stop the bleeding, the other case was cured after the drainage. delayed intra-abdominal bleeding in 1 case, which was caused by the irruption of hepatic artery and was cured with re-operation.

DISCUSSION

Currently, the surgical approach of LPD also followed the open surgery which started with Kocher maneuver, but the part of duodenum here was deep into the retroperitoneum with

transverse colon and its mesentery covered before. On the other hand, the operation was also limited by the site of trocar, so it would be difficult to copy the open surgical approach to the laparoscopic surgery. Therefore, how to improve the laparoscopic approach was important for the completion of the surgery. In the past practice, we found the inferior flexure of duodenum was relatively superficial with only one layer of peritoneum covered, this segment was located on the right of transverse mesocolon root and could be exposed when the transverse mesocolon was lifted. The anterior aspect of this segment was the SMV and the posterior aspect was the inferior vena cava, so this part was the “hub” of the surgery. We started the operation from this part and developed a new approach so called “inferoposterior approach” for LPD.

This new approach had the following advantages: Firstly, the biopsy of para- aortic lymph node could be completed earlier in this approach. Pancreatic cancer had a high rate of lymph node metastasis, 54-86% of patients were found lymph node metastasis when receiving the surgery (12-13). The involvement of para-abdominal aortic lymph nodes was seen as distant metastasis (M1), which often implied a poor prognosis (14-15). In viewing this, the intra-operative biopsy of the para- aortic lymph node was very important, which could help surgeon to evaluate patient’s prognosis further and determine the surgical methods. In the traditional approach, it would be more difficult to get the lymph nodes in this region, which must dissect the hepatic flexure of colon, make the Kocher maneuver and fully freed pancreatic head and duodenum. While this new approach could directly enter the region just after freed the inferior flexure of duodenum, so it could obtain the lymph node with the shortest distance and the fastest speed for earlier assessment of lymph node metastasis. When

the intra-operative biopsy showed the lymph node metastasis in this region, the surgery would be gave up to avoid further trauma. Secondly, the SMA could be explored earlier in this new approach. In the PD, the resection and reconstruction of the SMV were safe and feasible (16),but the invasion to the SMA was the surgical contra-indication, because the resection and reconstruction of SMA would cause high mortality and complications after surgery and it could not prolong the survival rate of patients . In the traditional approach, the SMA was often found being invaded in the last stage of resection and the surgeon would have no way out at this time. Pessaux (17) proposed the “artery-first” approach in 2006, which would allow the surgeon to find the invasions to the SMA in early stage thus abandoned the further resection. After that, some similar reports was published and different “artery-first” approaches were proposed (18-21). In this study, the “artery-first” exploration could be performed easily through the new approach using the unique dorsal view of laparoscopy. Finally, the exploration of the SMV became safer in this new approach. In the traditional approach, the exploration of the SMV started from the lower edge of the pancreas (22-23). However, there were many branches flew into the SMV at this site from different spaces and would often cause uncontrollable bleeding during the isolation. In this study, we started the exploration of the SMV from the anterior aspect of the "hub". At this site, the SMV was longer and located entirely within the small bowel mesentery and had no branches to flow in, so it would be convenient and safe for the exposure. Opening the vascular sheath from this site and freeing upwards could quickly locate and deal with the vessel branches, which could reduce the risk of bleeding.

Another debate in LPD was whether the full resection of the UP could be achieved.

Anatomically, some part of the UP often connected to the SMA through the post of the SMV and there were many vessel branches between them, so the resection of the UP would be difficult and often suffered from uncontrollable bleeding, thus the resection of the UP fully was challenging. It was once reported that the UP was resected with the endoscopic stappler, which was simple but there might exist the residue of pancreatic tissues, and the lymph node around the UP could not be cleaned fully. In this study, “hanging maneuver” was used to complete the resection of the UP (24-25), this maneuver had the following advantages: Firstly, the tape could be safely pulled by the assistant surgeon to lift up the specimen during the resection, which could increase the distance between the UP and SMA so that allow for safe and early recognition of the right lateral aspect of the SMA, it would significantly reduce the risk of injuring the major vessels. Secondly, this technique could make the planned isolation line visible with a sufficient laparoscopic view, which would make the resection be carried out under the correct direction and surgical space. Thirdly, it simplified the manipulation just with a single tape instead of grasping the pancreatic parenchyma directly with laparoscopic instruments and was effective in decreasing the bleeding caused by the disruption of the pancreatic parenchyma. Meanwhile, the tightening of the pancreas head with the tape could prevent the venous bleeding from the pancreatic head, although it remained congested.

The laparoscopic technique had been widely used in abdominal surgeries, but LPD was still in the exploratory stage. One of the very important reasons was that there was no ideal method for the endoscopic PJ, although there were many different methods for the anastomosis (26-29). In the traditional methods, the pancreas was treated as a hollow organ, and the stump of the pancreas was divided into the anterior wall and posterior wall for a

circular anastomosis with the jejunum. So, it would inevitably lead to more suture layers and time-consuming. Moreover, the parenchyma of the pancreatic edge was prone to be cut because of less tissues being bitted in each suture. In fact, the pancreas was a solid organ and the key element to ensure the success of PJ was that the pancreatic edge were anastomosed firmly to the jejunal wall and allowed the pancreatic juice inside the main pancreatic duct to enter the intestine. According to this conception, we modified the traditional end-to-side anastomosis and designed a new method – single-layer penetrative PJ. In this method, the transected surface of the pancreatic remnant need not be mobilized excessively and the posterior wall of the pancreas need not to be sutured separately, which dramatically reduced the technical demands on the surgeon. Moreover, the intestinal wall would attach to the pancreatic edge closely when the suture tied, which reduced the dead space between them and made the anastomosis more firm. So, this method reduced the technical complexity and shorted the operative time while producing acceptably comparable outcomes.

In conclusion, the application of appropriate surgical approach, improvement of the resection of UP and modification of the PJ could make the LPD easier and safer.

AUTHORS' NOTE

All of the authors declare that they have no conflicts of interest regarding this paper

REFERENCES

1. Gagner M, Pomp A. Laparoscopic pylorus-preserving pancreatoduodenectomy. *Surg Endosc.* 1994; 8 (5):408-10
2. Zheng MH, Feng B, Lu AG, Li JW, Hu WG, Wang ML. et al. Laparoscopic pancreaticoduodenectomy for ductal adenocarcinoma of common bile duct: a case report and literature review. *Med Sci Monit.* 2006; 12 (6): CS 57-60
3. Cai X, Wang Y, Yu H, Liang X, Xu B, Peng S. Completed laparoscopic pancreaticoduodenectomy. *Surg Laparosc Endosc Percutan Tech.* 2008; 18 (4):404-6
4. Dulucq JL, Wintringer P, Mahajna A. Laparoscopic pancreaticoduodenectomy for benign and malignant diseases. *Surg Endosc.* 2006; 20(7):1045-50
5. Kendrick ML, Cusati D. Total laparoscopic pancreaticoduodenectomy: feasibility and outcome in an early experience. *Arch Surg.* 2010; 145 (1):19-23
6. Gumbs AA, Rodriguez Rivera AM, Milone L, Milone L, Hoffman JP. Laparoscopic pancreatoduodenectomy: a review of 285 published cases. *Ann Surg Oncol.* 2011; 18 (5):1335-41
7. Kim SC, Song KB, Jung YS, Kim YH, Park do H, Lee SS. et al. Short-term clinical outcomes for 100 consecutive cases of laparoscopic pylorus-preserving pancreatoduodenectomy: improvement with surgical experience. *Surg Endosc.* 2013; 27(1):95-103
8. Nakamura M, Nakashima H. Laparoscopic distal pancreatectomy and : is it worthwhile? A meta-analysis of laparoscopic pancreatectomy. *J Hepatobiliary Pancreat Sci.* 2013;20 (4):421-8.

9. Corcione F, Pirozzi F, Cuccurullo D, Piccolboni D, Caracino V, Galante F. et al. Laparoscopic pancreaticoduodenectomy: experience of 22 cases. *Surg Endosc.* 2013; 27 (6):2131-6.
10. Correa-Gallego C, Dinkelspiel HE, Sulimanoff I, Fisher S, Viñuela EF, Kingham TP. et al. Minimally-invasive vs open pancreaticoduodenectomy: systematic review and meta-analysis. *J Am Coll Surg.* 2014; 218(1):129-39
11. Subar D, Gobardhan PD, Gayet B. Laparoscopic pancreatic surgery: An overview of the literature and experiences of a single center. *Best Pract Res Clin Gastroenterol.* 2014; 28(1):123-32
12. Massucco P, Ribero D, Sgotto E, Mellano A, Muratore A, Capussotti L. Prognostic significance of lymph node metastases in pancreatic head cancer treated with extended lymphadenectomy: not just a matter of numbers. *Ann Surg Oncol.* 2009; 16(12): 3323–32.
13. Kanda M, Fujii T, Nagai S, Kodera Y, Kanzaki A, Sahin TT et al. Pattern of lymph node metastasis spread in pancreatic cancer. *Pancreas.* 2011; 40 (6): 951-55.
14. Schwarz L, Lupinacci RM, Svrcek M, Lesurtel M, Bubenheim M, Vuarnesson H. et al. Para-aortic lymph node sampling in pancreatic head adenocarcinoma. *BJS* 2014; 101(5): 530–8
15. Loehrer PJ , Feng Y, Cardenes H, Wagner L, Brell JM, Cella D. et al. Gemcitabine alone versus gemcitabine plus radiotherapy in patients with locally advanced pancreatic cancer: an Eastern Cooperative Oncology Group trial. *J Clin Oncol.* 2011; 29(31): 4105–12.

16. Fukuda S, Oussoultzoglou E, Bachellier P, Rosso E, Nakano H, Audet M. et al. Significance of the depth of portal vein wall invasion after curative resection for pancreatic resection for pancreatic adenocarcinoma. *Arch Surg.* 2007; 142 (2):172–9
17. Pessaux P, Varma D, Amaud JP. Pancreaticoduodenectomy: superior mesenteric artery first approach. *J Gastrointest Surg.* 2006; 10 (4):607–11.
18. Weitz J, Rahbari N, Koch M, Büchler MW. The “artery first” approach for resection of pancreatic head cancer. *J Am Coll Surg.* 2010; 210 (2):e1–4.
19. Shrikhande SV, Barreto SG, Bodhankar YD, Suradkar K, Shetty G, Hawaldar R, et al. Superior mesenteric artery first combined with uncinate process approach versus uncinate process first approach in pancreatoduodenectomy: a comparative study evaluating perioperative outcomes. *Langenbecks Arch Surg.* 2011; 396 (8):1205–12.
20. Kurosaki I, Minagawa M, Takano K, Takizawa K, Hatakeyama K. Left posterior approach to the superior mesenteric vascular pedicle in pancreaticoduodenectomy for cancer of the pancreatic head. *JOP.* 2011; 12 (3):220–9.
21. Sanjay P, Takaori K, Govil S, Shrikhande SV, Windsor JA. 'Artery-first' approaches to pancreatoduodenectomy. *Br J Surg.* 2012; 99 (8):1027-35.
22. Palanivelu C, Rajan PS, Rangarajan M, Rangarajan M, Vaithiswaran V, Senthilnathan P. et al. Evolution in techniques of laparoscopic pancreaticoduodenectomy: a decade long experience from a tertiary center. *J Hepatobiliary Pancreat Surg.* 2009; 16(6):731–40
23. Zureikat AH, Breaux JA, Steel JL, Hughes SJ. Can Laparoscopic Pancreaticoduodenectomy Be Safely Implemented? *J Gastrointest Surg.* 2011;

15(7):1151–7

24. Kuroki T, Tajima Y, Kitasato A, Adachi T, Kanematsu T. Pancreas-hanging maneuver in laparoscopic pancreaticoduodenectomy: a new technique for the safe resection of the pancreas head. *Surg Endosc.* 2010; 24 (7):1781-3
25. Addeo P, Marzano E, Rosso E, Pessaux P. Hanging maneuver during pancreaticoduodenectomy: a technique to improve R0 resection. *Surg Endosc.* 2011; 25 (5):1697-8
26. Nakamura Y, Matsumoto S, Matsushita A, Yoshioka M, Shimizu T, Yamahatsu K. Pancreaticojejunostomy with closure of the pancreatic stump by endoscopic linear stapler in laparoscopic pancreaticoduodenectomy: a reliable technique and benefits for pancreatic resection. *Asian J Endosc Surg.* 2012; 5 (4):191-4.
27. Lei Z, Zhifei W, Jun X, Chang L, Lishan X, Yinghui G. et al. Pancreaticojejunostomy sleeve reconstruction after pancreaticoduodenectomy in laparoscopic and open surgery. *JSLs.* 2013; 17(1):68-73
28. Cho A, Yamamoto H, Kainuma O, Muto Y, Park S, Arimitsu H. et al. Performing simple and safe dunking pancreaticojejunostomy using mattress sutures in pure laparoscopic pancreaticoduodenectomy. *Surg Endosc.* 2014; 28 (1):315-8.
29. Hughes SJ, Neichoy B, Behrns KE. Laparoscopic intussuscepting pancreaticojejunostomy. *J Gastrointest Surg.* 2014; 18 (1):208-12.