

# A New Technique For Prevention of Postoperative Complications After Gastropancreaticoduodenal Resections

Resul Nusretoğlu<sup>1</sup>, Hakan Sarsılmaz<sup>2\*</sup>, Yunus Dönder<sup>3</sup>

<sup>1</sup>Batman Devlet Hastanesi Genel Cerrahi Kliniği, Batman, Turkey

<sup>2</sup>Iğdır Özel Bulut Hastanesi Genel Cerrahi Kliniği, Iğdır, Turkey

<sup>3</sup>Kayseri Şehir Eğitim ve Araştırma Hastanesi Genel Cerrahi Kliniği, Kayseri, Turkey

## ABSTRACT

Pancreaticoduodenal resection- is the only radical method of treating the tumour of the biliopancreaticoduodenal zones and chronic pseudotumour lesions of the head of the pancreas. The aim of our work is to increase good results of the gastropancreaticoduodenal resections.

From 1984-2006 in the Syzganov A.N. National scientific center of surgery, 138 pancreaticoduodenal resections were carried out due to tumors of the pancreaticoduodenal zones and chronic bulbous pseudotumourous pancreatitis. For finding out the specific complication of the gastropancreaticoduodenal resection, 103 patient's medical records of the control group were analyzed. Based on our experiences, we have the following indications before carrying out our methods of pancreatodigestive anastomosis.

Our method of the gastropancreaticoduodenal resection has reduced the post-surgical complications: acute pancreatitis of the pancreatic stump –from 49 incidence (47,5%) to only one (2,8%), pancreonecrosis -16 (15,5%) to 0, dehiscence of the pancreaticojejunal anastomosis –from 25 (24,2%) to 2 (5,7%), dehiscence of the hepaticojejunal anastomosis – from 14 (13,6%) to 1 (2,8%), dehiscence of the gastrointestinal anastomosis – from 2 (1,9%) to 0. Gastrointestinal bleeding – from 6 (5,8%) to 1 (2,8%), intestinal fistulas – from 2 (1,9%) to 0, pancreatic fistulas – from 4 (3,9%) to 0, gastro stasis – from 10 (9,7%) to 0. In the control group, the most common reason of the mortality was peritonitis in (49,9%) due to dehiscence and necrosis of the pancreas and development of retroperitoneal phlegmons and abscess, and also erosive bleeding (43,8%). In the main group within the last three years among the 35 operated patients with our methods, there was a mortality in one case (2,8%).

After all, we can conclude that, the newly developed method of invaginating pancreaticojejunal anastomosis “end to end” with adequate drainage of the anastomosis zone through microjejunostomy provides decompression of the zone of the pancreaticojejunal anastomosis through microjejunostomy, hence reduced the dehiscence of the pancreaticojejunal anastomosis.

**Keywords:** Pancreaticojejunostomy; pancreaticoduodenectomy; pancreatic fistula; external stent.

## Introduction

Among all tumor diseases, pancreatic cancer ranks 13th worldwide (1). There has also been a steady increase in the incidence of cancer of the biliopancreaticoduodenal zone (2). Pancreaticoduodenal resection is the only radical treatment for tumors of the head of pancreas and biliopancreaticoduodenal zone. Most authors indicate the leading role of the surgical method in the treatment of this patient population (2 (P.18-20), 3, 4, 5). Among typical specific complications in pancreaticoduodenal resections, there occur complications, which arise after the imposition of pancreatodigestive anastomoses, – pancreatitis of

stump, pancreonecrosis, dehiscence of pancreatic biliodigestive anastomoses, dysfunction of gastroduodenal anastomosis, erosive intraperitoneal hemorrhage, gastrointestinal hemorrhage, local suppurative complications, biliary and intestinal fistula (6, 7, 8).

Pancreatodigestive anastomosis remains the most vulnerable place of pancreaticoduodenal resection. The incidence of its dehiscence reaches 15%-30%, and in almost 50% of cases it leads to mortality (9). Another serious complication of pancreaticoduodenal resections in the early postoperative period is considered to be destructive pancreatitis of the pancreatic stump, which often lead to insufficiency of sutures of pancreaticojejunostomy (10,11). One of the

\*Corresponding Author: Hakan Sarsılmaz, Iğdır Özel Bulut Hastanesi Genel Cerrahi Kliniği, Iğdır

E-mail: hakansarsilmaz24@gmail.com, Telephone:+90 (505) 324 91 64

ORCID ID: Resul Nusretoğlu: 0000-0002-0967-2757, Hakan Sarsılmaz: 0000-0003-2268-1428, Yunus Dönder: 0000-0002-0560-1708

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reasons for the development of such complications is the reflux of intestinal contents into the duct of the pancreatic stump (12).

According to many authors (13,14,15,16), the main reason for the dehiscence of pancreaticojejunostomy is an increase in the intestinal pressure in the anastomotic zone associated with the development of postoperative intestinal paresis.

To date, methods for early diagnosis of dehiscence of pancreaticojejunostomy are not sufficiently developed. According to the literature, there is a number of different methods for diagnosing pancreaticojejunostomy dehiscence, but most of them require a long time and are quite expensive, and very often it is difficult to differentiate the picture of pancreaticojejunostomy dehiscence with symptoms of acute pancreatitis of the pancreatic stump (1 (p. 304)). The technical methods for applying pancreaticojejunostomy depending on the state of the pancreatic parenchyma and ductal system of the gland have not been fully developed, which also affects the results of pancreaticoduodenal resections.

Consequently, the problem of acute postoperative pancreatitis and the dehiscence of pancreaticojejunostomy is relevant to date and requires further study. The development of a method for decompression of the pancreaticojejunostomy area, which allows to preserve the functional viability of pancreaticojejunostomy, as well as a method for the formation of pancreaticojejunostomy and early diagnosis of pancreaticojejunostomy dehiscence, are the main tasks of biliopancreaticoduodenal surgery, the solution of which will reduce the number of early complications and mortality after pancreaticoduodenal resections. It would be possible to improve the results of gastropancreaticoduodenal resections.

## Materials and Methods

The work is based on the analysis of the results of surgical treatment of 138 patients with tumors of the pancreaticoduodenal zone and chronic capitate pseudotumor pancreatitis, which underwent radical operations – gastropancreaticoduodenal resections (GPDR) in various reconstruction options for the period of 1984 - 2006. Among them, 95 men and 43 women. The age of patients ranged from 30 to 73 years.

The majority of patients had, pancreatic head cancer – 90 (65.2%), cancer of the major duodenal papilla – 35 (25.3%), and chronic cephalic pseudotumor pancreatitis – 13 (9.5%). All 138 patients underwent

GPDR surgery, where 7 patients underwent pylorus preserving resection.

Depending on the types of reconstruction, the patients were divided into two groups. The main group consisted of 35 patients with tumors of the pancreaticoduodenal zone and chronic cephalic pancreatic pseudotumor, which underwent radical surgery – GPDR with the reconstruction phase of the developed method for the period of 2004 - 2006. The control group consisted of 103 patients operated on for the period of 1984-2004.

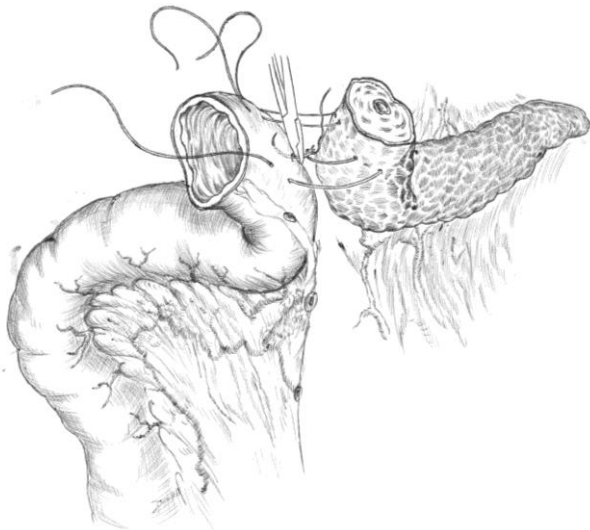
Laboratory tests, such as general blood test, determination of its rhesus group, coagulation time, prothrombin index, biochemical studies of blood serum and proteinograms, general urine test, and tumor marker CA 19-9 (for the patients with pancreaticoduodenal cancer zones) were used among all the patients. Instrumental methods of diagnosis included: ultrasound, FGDS, biopsy for tumors of the major duodenal papilla, magnetic resonance cholangiopancreatography, computer tomography, endoscopic retrograde cholangiopancreatography, laparoscopy.

Onward, the surgery continues according to our method. The stump of the gland is mobilized in 2 cm in a distal direction along the posterior semicircle. Behind the colon, 3-4 cm from the border of the intersection of the stump of the gland, an initial loop of the jejunum with stitched edges is brought up regardless of the state of the pancreatic stump parenchyma and duct diameter, the first row of the posterior lip of the anastomosis is formed with U-shaped sutures using prolene-4/0. Sutures are brought through the serous-muscular layer of the small intestine. Onward, an injection is performed on the posterior semicircle of the gland at a distance of 1.5-2 cm from the edges of the resection, capturing the capsule and parenchyma of the gland (Figure 1).

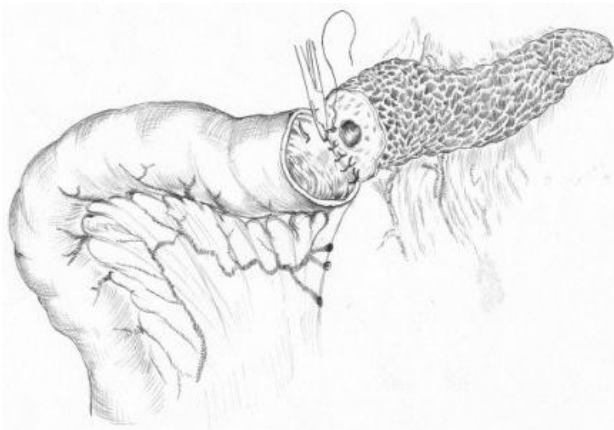
Onward, tantalum staples are removed, intestinal lumen is opened, then nodal sutures are put in onto the second row of the posterior lip of the anastomosis between the edges of the intestine and pancreas, capturing the lower wall of the pancreatic duct stump in the suture (Figure 2).

The front lip is formed in the same manner, like the second row of the rear lip (Figure 3).

In order to keep the tightness and reliability of the anastomosis, the pancreatic stump is invaginated into the small intestine. The second row of U-shaped sutures is put in along the anterior semicircle of the serous-muscular layer of the jejunum at a distance of 1.5 cm from the anastomosis with underrunning the capsule and parenchyma of the pancreas at a distance of 1.5-2 cm from the anastomosis line. When



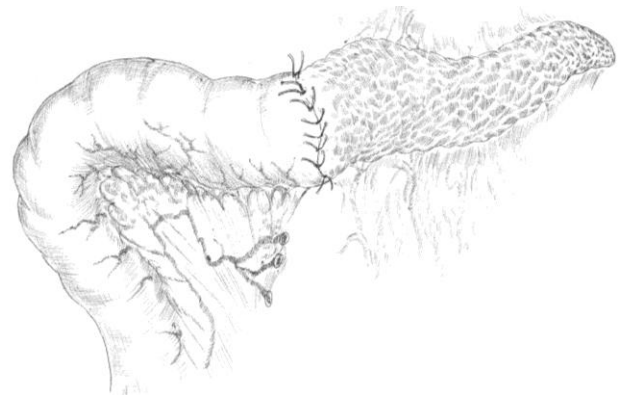
**Fig. 1:** Putting in of U-shaped sutures on the posterior semicircle of the anastomosis



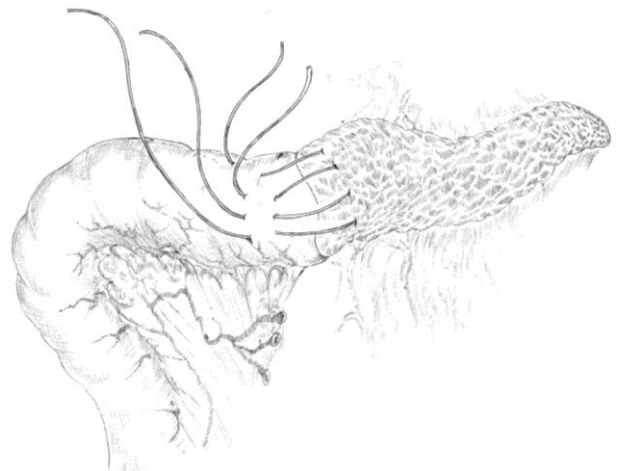
**Fig. 2:** The formation of the second row of the posterior lip of the anastomosis with the capture of the lower wall of the stump of the pancreatic duct with interrupted sutures

tightening the sutures, the intestine is screwed onto the stump of the pancreas without tension and eruption, even with an extremely juicy parenchyma of the gland (Figure 4).

In order to decompress and prevent PJS dehiscence, this zone is being drained – a silicone tube is installed in the intestinal lumen with multiple holes made on the lateral surfaces. Below the PJS zone at 20 cm-30 cm, a purse suture with catgut is put in onto the serous surface of the anterior jejunum wall. A hole is formed in the center of the purse suture by coagulation, where it is introduced to the PJS zone. Microjejunostomy is fixed with a purse suture. Onward, at the end of the surgery, the microjejunostomy is sutured on the right to the lateral surface of the anterior abdominal wall and is brought out through the counterpuncture, where it is fixed to the skin (Figure 5).



**Fig. 3:** The formation of the anterior lip of the anastomosis with interrupted sutures

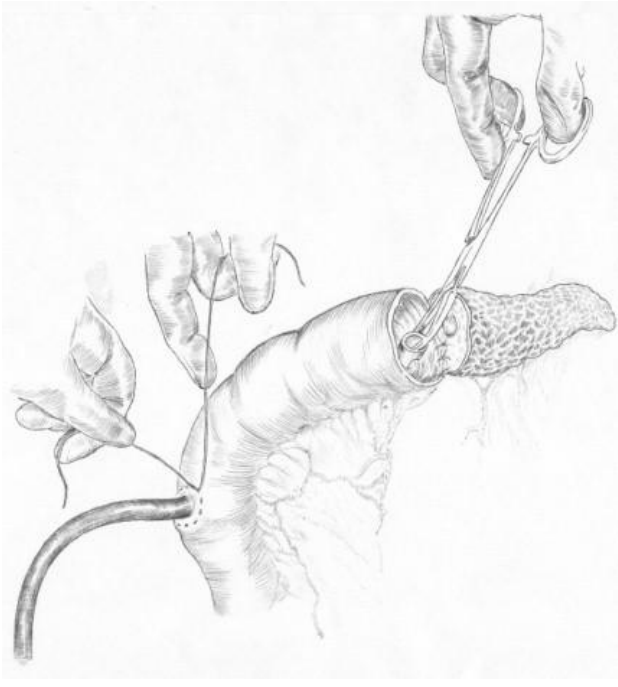


**Fig. 4:** Invagination of the pancreatic stump into the small intestine

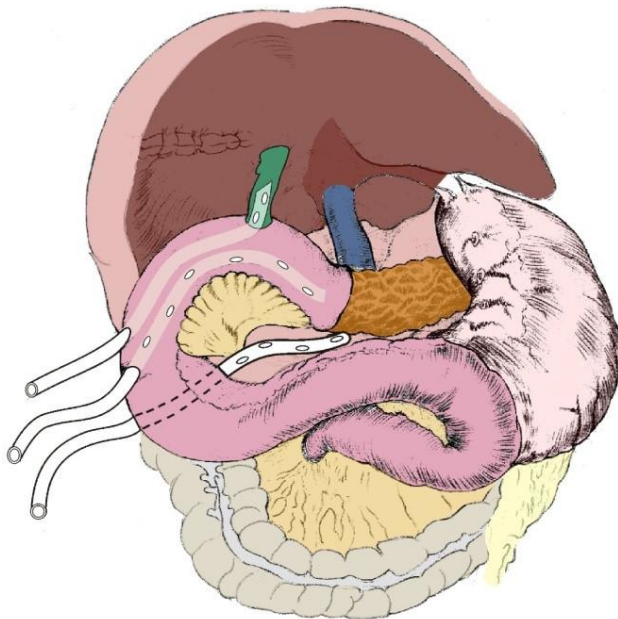
Dehiscence of a biliodigestive anastomosis is the next most dangerous complication of GPDR. It is closely connected with a number of complications, in particular with the development of pancreonecrosis and local purulent processes in the abdominal cavity. HJS is formed below the PJS at 10-15 cm, using "end-to-side" method with single-row interrupted outside sutures with Vicryl 4/0 suture material that resolves after about 40 days, which prevents the formation of ligative lithiasis. In order to decompress the hepatic ducts, we conducted the drainage according to Felker through the microjejunostomy, in case of preservation of the cystic duct, we conducted the drainage according to Pikovsky (Figure 6).

At the beginning, a small curvature of the stomach stump is formed by double-row sutures. Departing from the GEA by 40-50 cm, the "end to side" GEA is put in with double-row sutures. The probe is brought behind the GEA.

Having analyzed the incidence of dehiscence in various types of pancreaticojejunostomy, we found that it typically evolved during its formation with drainage of the pancreatic duct. We believe that it is connected with the deficiencies of drainage systems,

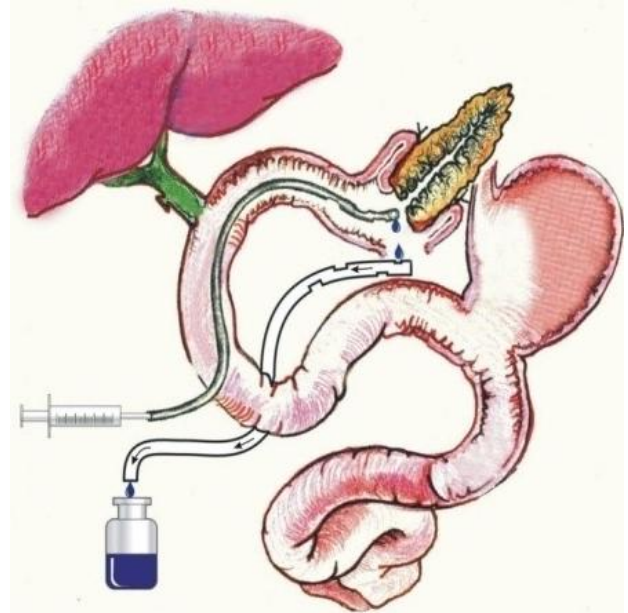


**Fig. 5:** Drainage of the pancreaticojejunostomy zone through microjejunostomy



**Fig. 6:** Schematic illustration of the surgery of the reconstructive phase in its final form

which cover the outflow of pancreatic juice from subsegmental ducts of the pancreatic stump with wall sections, especially with loose gland with unchanged ducts. It was established that 14,2% of patients had the dehiscence of PJS with drainage of the pancreatic duct; 10.1% of patients had PJS dehiscence without drainage of the pancreatic duct. Based on our experience, we have determined the following indications for choosing the PJS method. When treating a pancreatic stump, regardless of the size of the duct of Wirsung and pancreatic parenchyma, we



**Fig. 7:** Schematic illustration of the method for early diagnosis of pancreaticojejunostomy dehiscence after gastropancreaticoduodenal resection

have developed an end-to-end invaginated PJS with drainage of the anastomotic zone through microjejunostomy.

Over the past three years, we have preferred the formation of all anastomoses on one loop of the jejunum. 35 patients of the main group were operated on using this method. The imposition of anastomoses is performed in the following order: PJS, HJS, GEA.

We have developed a method for the prevention of pancreaticojejunostomy dehiscence with GPDR. The essence of the invention is that decompression of the PJS zone outward through the microjejunostomy ensures the removal of pancreatic secretion, bile, intestinal contents from the wound surface of the pancreatic stump, and also the intestinal pressure on the sutures of the anastomosis is eliminated, since an increase of pressure in the small intestine can lead to the eruption of sutures, especially with prolonged, postoperative intestinal paresis.

The formation of PJS causes a decrease in tone and violation of peristaltic activity of the intestine. As a result, the intestinal pressure increases, which leads to overstretching of the intestinal walls, and due to overstretching, ischemic disorders and the development of suture dehiscence can occur in the anastomotic area. Also, intestinal contents are thrown into the pancreatic duct of the pancreatic stump, which is especially important for prolonged postoperative intestinal paresis. In order to avoid this complication, we conducted the drainage of the PJS zone through the microjejunostomy. Outward PJS drainage allows controlling the intestinal pressure and thereby facilitates decompression of the anastomotic

area, preventing the development of pancreatitis and PJS dehiscence.

Pressure measuring in the small intestine was daily performed for all patients of the main group. On the first day after the surgery, the patient was injected with warm degassed mineral water into the microjejunostomy in a volume of 400 ml. The speed of fluid injection was 60-70 drops per minute. The solution perfusion was performed from a height of 300 mm in a horizontal position of the patient's body, on his back. The level of the midaxillary line was taken as the zero mark. Naturally, the pressure in the small intestine is 80-90 mm w.c.

In our survey, the pressure in the intestinal lumen on the first day was ( $226.9 \pm 8.4$ ) mm w.c. On the second day, the intestinal pressure decreased to ( $210.6 \pm 8.0$ ) mm w.c. On the third day, the intestinal pressure was ( $193.2 \pm 7.0$ ) mm w.c. On the fourth day, the intestinal pressure decreased to ( $170.9 \pm 6.8$ ) mm w.c. On the fifth day, the intestinal pressure decreased to ( $145.5 \pm 5.1$ ) mm w.c. On the sixth day, the intestinal pressure was up to ( $121.5 \pm 3.3$ ) mm w.c. On the seventh day, the intestinal pressure decreased to the upper normal level ( $101.6 \pm 2.0$ ) mm w.c., on the eighth day, the intestinal pressure decreased to the normal level and was ( $86.9 \pm 1.1$ ) mm w.c.

Statistically processed data prove the reliability of the intestinal pressure increase up to high values, in the first 7 days after GPDR. This method proves the need for drainage of the PJS zone through the microjejunostomy, since the intestinal pressure decreases in dynamics to the normal level ( $86.9 \pm 1.1$ ) mm w.c. for eight days.

Pancreatic secretion through the anastomosis with the further formation of a purulent leak in the free abdominal cavity above the PJS zone. In the second case, a complete destruction of the suture line evolved. We have developed an early and quick way to diagnose PJS dehiscence. The method is implemented as follows. 4.5% indigo carmine in a volume of 100 ml is injected in the microjejunostomy located in the PJS zone with a help of a medical syringe. Moreover, if there is a dehiscence of the PJS, the indigo carmine solution will pour out from this zone into the abdominal cavity and then will be allocated according to the control drainage, which is located in the abdominal cavity in the PJS area. Effusing of the solution from the control drainage confirms the dehiscence of the PJS anastomosis (Figure.7)

## Results

In order to identify specific complications of GPDR, an analysis was conducted through the case histories of 103 patients from the control group who underwent GPDR using various reconstructive methods: with preservation of the pylorus – 7 (6.8%) patients, standard GPDR – 96 (93.2%) patients. Among the typical specific complications of GPDR, we distinguish: postoperative pancreatitis, pancreonecrosis, dehiscence of pancreaticjejunostomy and hepaticojejunostomy, intraperitoneal arrosive and gastrointestinal hemorrhages, peritoneal abscesses, biliary, pancreatic and intestinal fistulas, dysfunction of gastroenterostomic anastomosis.

In the immediate postoperative period 7 patients (20%) in the main group had complications. In the control group in the immediate postoperative period after the GPDR for the period of 1984-2006 49 patients had the complications (47.5%), and the majority had two or more complications. The most frequent and dangerous complication after GPDR was the dehiscence of pancreaticojejunostomy, which was found in 25 patients (24.2%). 14 (13.6%) patients had hepaticojejunostomy failure (HJS).

In 64 cases (62.1%), pancreaticjejunostomy and hepaticojejunostomy were formed on the loop switched off according to Roux-en-Y, gastroenteroanastomosis on the efferent intestinal loop of the small intestine. In 27 cases (26.2%), pancreatoenteroanastomosis and hepaticojejunostomy were bypassed on an isolated loop of the small intestine according to Roux-en-Y with an antireflux cuff, and gastroenteroanastomosis was applied on the efferent intestinal loop. In 12 cases (11.6%), only two anastomoses, pancreaticojejunostomy and gastroenteroanastomosis were bypassed. This method of reconstruction was performed for those patients who had previously been operated on for the purpose of decompression of the biliary tract, with the formation of cholecystjejunostomy with interintestinal anastomosis according to Brown. In 7 cases, PDR was made with the preservation of the pylorus – no mortality occurred. However, immediately after surgery, 5 patients had gastrostasis and troubles with stomach evacuation processes, and therefore a feeding process had to be conducted through a nasogastric tube.

In the control group, 49 patients (47,5%) had acute stump pancreatitis. In most cases, its appearance occurred when there was a soft, loose consistency of the stump of the gland. In the control group, 16 patients (15.5%) had pancreonecrosis. According to the control group, 25 patients (24.2%) had PJS dehiscence. Analyzing the data of these patients, it



was found that before insolvency, all patients had persistent intestinal paresis, which was the main reason for the dehiscence of PJS. 14 patients (13.6%) in the control group had HJS dehiscence. In the first two days after the GPDR surgery, the HJS dehiscence caused biliary peritonitis among 4 patients (28.6%). Among 5 patients (35.7%) over 5 days or more, the HJS dehiscence did not lead to general peritonitis. Taking into account the insolvency of HJS in the main group, recently, we have been performing drainage of hepaticojejunostomy with narrow thin-walled hepatic choledochus according to Felker or Pikovsky. 2 (1.9%) patients in the control group had gastroenteroanastomosis dehiscence (GEA).

We believe that this complication in one case was connected with the absence of a nasogastric tube, and in another case, with a technical defect within the formation of GEA, when gastric material began to effuse through the control drain on the third day.

According to the control group, 3 patients (2.9%) had abdominal abscess. So, two patients had purulent parapancreatitis, which caused destructive pancreatitis in the postoperative period. In the third case, an abscess and phlegmon of retroperitoneal tissue were formed due to the dehiscence of the PJS. 3 patients (2.9%) in the control group had arrosive intraperitoneal hemorrhage. 6 patients (5.8%) in the control group had gastrointestinal hemorrhage. 10 patients (9.7%) in the control group had gastrostasis; this complication is connected with the preservation of the pyloric stomach and its sphincter apparatus, which has contractility failures in this area, with a high degree of surgical trauma and extensive vagal denervation.

## Discussion

Pancreas surgery is performed frequently for many reasons like malignant tumors of pancreatic head, ampulla, distal bile duct, and may be performed for benign tumors, and trauma of pancreatic head and duodenum, while rarely perform for chronic pancreatitis, all around the world. Pancreaticoduodenectomy (PD) is accepted as a basic treatment option in pancreatic cancer (17).

The mortality rate after pancreaticoduodenectomy (PD) has decreased to less than 5% in high-volume centers (18). Postoperative complications prevalence is still high, although, morbidity and mortality have improved recently and after an improvement in intensive care management and surgical techniques (19).

The main complications of gastropancreatoduodenal resection are: acute

pancreatitis of the pancreatic stump in 47.5%, pancreonecrosis in 15.5%, dehiscence of pancreaticojejunostomy in 24.2%, dehiscence of hepaticojejunostomy in 13.6% of cases (20).

For Example, Postoperative pancreatic fistula (POPF) rates remain higher than 10% in most previous prospective studies (21). It is clear that pancreatic anastomotic leakage is still one of the most important complications after the Gastropancreaticoduodenal Resections (22).

POPF is believed to be consequence of pancreatic exocrine secretion seepage across a compromised anastomotic site, with the most likely mechanism being autodigestion

and destruction of the tissue surrounding the PJ anastomotic site leading to dehiscence and seepage into the abdominal cavity. The release of these activated pancreatic juices then cause peripancreatic collections, intra-abdominal abscesses, hemorrhage, and POPF (23).

The two major risk factors for developing POPF are soft texture of the pancreatic remnant and diameter of the pancreatic duct stump (24). In order to reduce postoperative complications, especially PJ( pancreaticojejunostomy) anastomosis techniques were evaluated comparatively (25,26,27).

There have been many attempts to reduce the incidence of POPF by, amongst others, technical variations of the reconstruction after PD, somatostatin analogues, pancreatic stenting and pancreatic drainage.

To prevent the pancreatic anastomotic leak and clinically relevant POPF, there are four important points concerning PJ technique should be considered, based on previous evidence. 1- Pancreatic juice should be completely drained, 2- blood flow should be maintained in the pancreatic stump, 3-laceration of pancreatic parenchyma should be prevented, 4- the jejunum wall should be in close contact to the pancreatic cut surface (28). Invagination and duct-to-mucosa anastomosis techniques were compared in many studies, and the long-term results of the invagination technique were found to be more satisfactory for soft pancreas(25,26).

To protect the integrity of the anastomotic site by diverting the potentially caustic exocrine secretions of the pancreatic remnant away, Stent placement across the PJ anastomosis has been proposed. In addition, such stents have been theorized to promote precise placement of anastomotic sutures, facilitate decompression of the pancreatic remnant, and maintain patency of the pancreatic duct postoperatively (29,30). Two

types of pancreatic ductal stent are used widely by surgeons for the pancreaticojejunal anastomosis: external or internal (31).

The internal stent technique is generally performed by inserting a 6 cm stent into the pancreatic duct such that one-half of its length remains within the duct itself, bridges across the anastomotic site, and empties into the jejunal lumen. On the other hand, the external stent

utilizes a longer stent placed similarly within the pancreatic duct stump, bridges across the anastomotic site into the jejunal lumen, but the tail of which is exited through a small enterotomy site in the free end of the jejunal loop. This is then closed with a purse-string

suture, externalized via a stab incision in the anterior abdominal wall, and closed by suturing the serosa of the jejunum to the peritoneum of the abdominal wall (32,33).

The outcomes of trials comparing external and internal stenting are discordant, and definitive evidence regarding the optimal surgical technique to reduce POPF rates is still lacking. It has been stated that new surgical approaches are needed to reduce pancreatic anastomotic leakage and related complications(34,35).

External stents have a low risk of proximal migration, but stent removal is potentially

hazardous and can cause pancreatitis or late-onset stenosis(32). In contrast, internal stents have no risks associated with accidental removal or kinking of the stent, but proximal migration is a possibility and can cause pancreatitis or pancreatolithiasis.

One meta-analysis reported that an external stent for PJ decreased the rates of POPFs(36), however, another recent comprehensive systematic review with a meta-analysis reported that there was no significant difference in the rates of POPFs, in-hospital mortality, reoperation, delayed gastric emptying, wound infection, and intra-abdominal abscesses between the stent and no-stent groups. They only found that the postoperative overall morbidity was lower and the total hospital stay was shorter in the external stent group compared to the no-stent group(37). In a 2012 randomized control trial, Matoi et al. found that the incidence of clinically significant POPF was decreased in the presence of an externalized pancreatic duct stent (6.4% stented vs. 21.7% non-stented,  $P = 0.04$ ) (33). Howard reported no pancreatic fistulas in 56 consecutive cases using the external drainage tube, and a prospective study found that pancreatic fistula decreased from 29% to 7% using an external drainage tube (38). In a randomized

controlled trial (RCT), Poon et al found that patients with an external drainage tube had a significantly lower pancreatic fistula rate compared with a nonstented group, and pancreatic texture did not affect the incidence of pancreatic fistula(32).

For external stents, several RCTs, observational case series and meta-analyses have shown reductions in the incidence of POPF when compared with no stenting. Internal stents have also been reported as effective in reducing POPF rates in some retrospective studies. In contrast, discordant results reporting no utility of external or internal stents can be found in the literature(39). An RCT conducted by Kamoda et al. compared external and internal stents, and showed similar POPF rates(40). In another RCT comparing external and internal stents after PD, postoperative hospital stay was shorter in the internal stent group, but there was no impact on complication rates, including POPF(30).

Our method of GDPR allowed us to reduce the number of postoperative complications: acute pancreatitis of the pancreatic stump – from 49 cases (47.5%) to one (2.8%), pancreonecrosis – 16 (15.5%) to 0, dehiscence of pancreaticojejunostomy – from 25 (24.2%) to 2 (5.7%), dehiscence of hepaticojejunostomy – from 14 (13.6%) to 1 (2.8%), dehiscence of gastroenteroanastomosis – from 2 (1.9%) to 0, gastrointestinal hemorrhage – from 6 (5.8%) to 1 (2.8%), intestinal fistula – from 2 (1.9%) to 0, pancreatic fistula – from 4 (3.9%) to 0, gastrostasis – from 10 (9.7%) to 0.

For the period of 1984-1991 the mortality rate was 28%. For the period of 1992-1997 the mortality rate was 14.2%. For the period of 1998-2003 the mortality rate was 8.8%.

For the period of 2004-2006 when our method of gastropancreatoduodenal resection was applied, the mortality rate decreased by 2.8%.

The obtained scientific and practical results of the application of the developed method of gastropancreatoduodenal resection for the treatment of tumors of the pancreatoduodenal zone and chronic cephalic pseudotumor pancreatitis made it possible to formulate the following scientific conclusions and practical recommendations.

The developed "end-to-end" invaginative pancreaticojejunostomy pancreatitis with drainage of the pancreaticojejunostomy zone through microjejunostomy reduces the incidence of acute pancreatitis from 47.5% to 2.8%, pancreatic necrosis – from 15.5% to 0%, pancreaticojejunostomy dehiscence – from 24.2% to 5.7%,

hepaticojejunostomy dehiscence – from 13.6% to 2.8%, mortality rate – from 17% to 2.8%.

The developed method for drainage of the pancreaticojejunostomy zone through the microjejunostomy and the introduction of indigo carmine through it allows an early diagnosis of pancreaticojejunostomy dehiscence. Detection of anastomotic leakage in the early period is important. High suspicion and early detection of the postoperative complication is the critical factor in the care of the patient (22).

The formation of invaginative pancreaticjejunostomy on a single loop of the jejunum provides an adequate exogenous and endogenous function of the pancreatic stump in the shortest time after surgery, which allows to achieve good immediate treatment results with 88% of patients.

Recent studies using a technique similar to ours are not available in the database. As a result, our study; offers a new and effective method to reduce pancreatic leak and related complications. The newly developed method of invaginating pancreaticojejunal anastomosis “end to end” with adequate drainage of the anastomosis zone through microjejunostomy provides decompression of the zone of the pancreaticojejunal anastomosis through microjejunostomy, hence reduced the indehiscence of the pancreaticojejunal anastomosis.

1-The developed drainage of the pancreaticojejunostomy zone through microjejunostomy reduces the incidence of acute pancreatitis, pancreatic necrosis, pancreaticojejunostomy dehiscence and hepaticojejunostomy dehiscence via decompression of anastomosis.

2- By the use of microjejunostomy and the introduction of indigo carmine through it allows an early diagnosis of pancreaticojejunostomy dehiscence.

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## References

1. Kubyshkin V.A., Vishnevsky V.A. Rak podzheludochnoj zhelezy. 2003 P.-30, P.-232-241.P.318.P.322, P.304. P.305-306.P. 308-309 (in Russian)
2. Demin D.I., Kralish V.V., Minaev I.I. Propp A.R., Karpenko A.D. Problemy radikal'nogo hirurgicheskogo lecheniya bol'nyh

- pankreatoduodenal'nym rakom. Rossijskij onkologicheskij zhurnal 1997; 2: 18-20. (in Russian)
3. Karmilov V.A., Tishkin N.S. Kliniko-anatomicheskie sopostavleniya pri rake podzheludochnoj zhelezy. Klin. hir. 1988. Vol.11. P. 58-59. (in Russian)
4. Samoilenko V. M. Rak organov pankreatoduodenal'noj zony. PhD Dissertation (Medicine). Moscow 1990; 256: (in Russian)
5. Miény M. Carcinoma of the pancreas: role of radical surgery // S. Afr. Cancer Bull. 1985. Vol. 29. № 1-2. P. 70-73.
6. Danilov M.V., Pomelov BC, Vishnevsky V., A., Buriev I.M., Vikhorev A.V., Kazanchyan P.O., Savvina T.V. Metodika pankreatoduodenal'noj rezekcii i total'noj duodenopankreatektomii. Hirurgiya. 1990. Vol. 10 P.94-108. (in Russian)
7. Veronovsky G.I. Shtofin S.G., Ivanov G.V., Popov A.I., i soavt. Hirurgicheskoe lechenie zlokachestvennyh opuholej golovki podzheludochnoj zhelezy i periampulyarnoj oblasti. Vestnik hirurgii, 1992. Vol. 6. P.288-292. (in Russian)
8. Miedema B. W., Sarr M. G., van Heerden J. A. et al. Complications Following Pancreaticoduodenectomy // Arch. Surg. 1992. Vol. 127: Aug. P. 945-950.
9. Kubyshkin V.A., Vishnevsky V.A., Danilov M.V., Buriev I.M., Vukolov A. V. Ocenka metodov zaversheniya pankreatoduodenal'noj rezekcii. Hirurgiya. 2001. Vol.1. P. 46-50.P. 80 (in Russian)
10. Buyanov V.M., Egiev V. B, Rudakova M.N., Rusanov V.P. Tekhnika pankreatoduodenal'noj rezekcii i intraoperacionnaya profilaktika ostrogo pankreatita. Hirurgiya. 1996. Vol.2. P. 5-7 (in Russian)
11. Kuzin M.I., Danilov M.V., Blagovidov D.F. Hronicheskij pankreatit. Moscow: Medicina, 1985. 368 p. (in Russian)
12. Lapkin K.V., Bazilevich F.V., Malyarchuk V.I., Udotov O.A., Rusanov V.P., Antonov V.V. Precizionnaya tekhnika pankreatoduodenal'noj rezekcii. Hirurgiya. 1991. Vol.2. P. 104. (in Russian)
13. Reding R. Versorgung des Pankreasrests nach kephalen Resektion // M.Trede, H.D.Saeger. Aktuelle Pankreas-Chirurgie. Berlin: Springer, 1990. S.213-218.
14. Patyutko Yu.I., Klimenkov A.A., Itin A.B., Samoilenko V.M. Spособ gastropankreatoduodenal'noj rezekcii. Hirurgiya. 1990.Vol. 2.P.133-135. (in Russian)
15. Seidov V.D., Abdullaev I.K. Naruzhnoe drenirovaniepankreaticheskogo protoka posle



- pankreatoduodenal'noj rezekcii. Hirurgiya. 1989. Vol. 7. P.134-135. (in Russian)
16. Danilov M.V., Pomelov BC, Vishnevsky V., A., Buriev I.M., Vikhorev A.V., Kazanchyan P.O., Savvina T.V. Metodika pankreatoduodenal'noj rezekcii i total'noj duodenopankreatektomii. Hirurgiya. 1990.
  17. Thomas E. Clancy, Stanley W. Ashley, Pancreaticoduodenectomy (Whipple operation), Surg. Oncol. Clin. N. Am. 14 (2005) 533–552.
  18. Beger HG, Gansauge F, Schwarz M, et al. Pancreatic head resection: the risk for local and systemic complications in 1315 patients a monoinstitutional experience. Am J Surg 2007;194:S16–9.)
  19. G. Conzo, C. Gambardella, E. Tartaglia, V. Sciascia, C. Mauriello, S. Napolitano, et al., Pancreatic fistula following pancreaticoduodenectomy. Evaluation of different surgical approaches in the management of pancreatic stump. Literature review, Int. J. Surg. 21 (2015) S4–S9.
  20. Karim, Sherko Abdullah Molah, et al. "The outcomes and complications of pancreaticoduodenectomy (Whipple procedure): Cross sectional study." International Journal of Surgery 52 (2018): 383-387.
  21. Bassi C, Marchegiani G, Dervenis C, et al. The 2016 update of the International Study Group (ISGPS) definition and grading of postoperative pancreatic fistula: 11 years after. Surgery 2017; 161: 584-591.
  22. D'Cruz, Jason R., Subhasis Misra, and Shafeek Shamsudeen. "Pancreaticoduodenectomy." (2020).
  23. S. Crippa, R. Salvia, M. Falconi, et al., Anastomotic leakage in pancreatic surgery, HPB Oxf. 9 (1) (2007) 8e15.
  24. Y. Yang, X. Tian, Y. Zhuang, et al., Risk factors of pancreatic leakage after pancreaticoduodenectomy, World J. Gastroenterol. 11 (16) (2005) 2456e2461.
  25. Lyu, Yunxiao, et al. "Selection of pancreaticojejunostomy technique after pancreaticoduodenectomy: duct-to-mucosa anastomosis is not better than invagination anastomosis: a meta-analysis." Medicine 97.40 (2018).
  26. Cao, Zhe, et al. "Is Invagination Anastomosis More Effective in Reducing Clinically Relevant Pancreatic Fistula for Soft Pancreas After Pancreaticoduodenectomy Under Novel Fistula Criteria: A Systematic Review and Meta-Analysis." Frontiers in Oncology 2020; 1637.
  27. Shumkovski, Aleksandar, Ljubomir Ognjenovic, and Stojan Gjoshhev. "Comparison Between Dunking (Invagination) Pancreaticojejunostomosis and Double Layer Duct to Mucosa Anastomosis After Cephalic Duodenopancreatectomy-Whipple Procedure for Pancreatic Cephalic Carcinoma." prilozi 41.3 (2020): 39-47.
  28. Hirono, Seiko, et al. "Modified Blumgart mattress suture versus conventional interrupted suture in pancreaticojejunostomy during pancreaticoduodenectomy: randomized controlled trial." Annals of surgery 269.2 (2019): 243.
  29. J. Winter, J. Cameron, K. Campbell, et al., Does pancreatic duct stenting decrease the rate of pancreatic fistula following pancreaticoduodenectomy? Results of a prospective randomized trial, J. Gastrointest. Surg. 10 (9) (2006) 1280 e1290.
  30. M. Tani, M. Kawai, S. Hirono, et al., A prospective randomized controlled trial of internal versus external drainage with pancreaticojejunostomy for pancreaticoduodenectomy, Am. J. Surg. 199 (6) (2010) 759e764.
  31. Kawai M, Tani M, Terasawa H, et al. Early removal of prophylactic drains reduces the risk of intra-abdominal infections in patients with pancreatic head resection: prospective study for 104 consecutive patients. Ann Surg 2006;244:1–7.
  32. R. Poon, S. Fan, C. Lo, et al., External drainage of pancreatic duct with a stent to reduce leakage rate of pancreaticojejunostomy after pancreaticoduodenectomy: a prospective randomized trial, Ann. Surg. 246 (3) (2007) 425e435.
  34. F. Motoi, S. Egawa, T. Rikiyama, et al., Randomized clinical trial of external stent drainage of the pancreatic duct to reduce postoperative pancreatic fistula after pancreaticojejunostomy, Br. Surg. 99 (4) (2012) 524e531.
  35. Kawaida, Hiromichi, et al. "Surgical techniques and postoperative management to prevent postoperative pancreatic fistula after pancreatic surgery." World journal of gastroenterology 25.28 (2019): 3722.
  36. Ferencz, S., et al. "Innovations in pancreatic anastomosis technique during pancreatoduodenectomies." Langenbeck's archives of surgery 405.7 (2020): 1039-1044.
  37. Patel K, Teta A, Sukharamwala P, Thoens J, Szuchmacher M, DeVito P. External pancreatic duct stent reduces pancreatic fistula: a meta-analysis and systematic review. Int J Surg 2014; 12: 827-832 PMID: 25003575 DOI: 10.1016/j.ijssu.2014.06.008
  38. Hong S, Wang H, Yang S, Yang K. External stent versus no stent for

- pancreaticojejunostomy: a metaanalysis of randomized controlled trials. *J Gastrointest Surg* 2013; 17: 1516-1525 PMID: 23568149 DOI: 10.1007/s11605-013-2187-4.
39. Howard JM. Pancreatojejunostomy: leakage is a preventable complication of the Whipple resection. *J Am Coll Surg* 1997;184:454 –7.
40. Jang, J-Y., et al. "Randomized multicentre trial comparing external and internal pancreatic stenting during pancreaticoduodenectomy." *British Journal of Surgery* 103.6 (2016): 668-675.
41. Kamoda Y, Fujino Y, Matsumoto I, Shinzeki M, Sakai T, Kuroda Y. Usefulness of performing a pancreaticojejunostomy with an internal stent after a pancreatoduodenectomy. *Surg Today* 2008; 38: 524–528.