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Laparoscopic Pancreaticoduodenectomy - Initial Experience in a Hepatopancreatobiliary High-Volume Center

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Abbreviations:
ERCP: endoscopic retrograde cholangiopancreatography;
ALT: alanine aminotransferase;
AST: aspartate aminotransferase;
CRP: C- reactive protein;
CT: computed tomography;
MRI: magnetic resonance imaging;
EUS: endoscopic ultrasound;
RPD: robotic pancreaticoduodenectomy;
OPD: open pancreaticoduodenectomy;
LPD: laparoscopic pancreaticoduodenectomy.

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Rezumat

Duodenopancreatectomia cefalică laparoscopică - experiența inițială într-un centru high-volume de chirurgie hepatobiliopancreatică

Introducere: Duodenopancreatectomia cefalică este o intervenție chirurgicală complexă, care presupune etape minuțioase de rezecție şi reconstrucție.
Materiale şi metodă: Am analizat primele 15 duodenopancreatectomii cefalice laparoscopice efectuate pentru tumori ampulare, periampulare şi cefalo-pancreatice în cadrul Institutului Clinic Fundeni, Bucureşti, un centru cu experiență vastă în chirurgia hepato-bilio-pancreatică. Au fost evaluate datele demografice, antecedentele medicale, caracteristicile intraoperatorii, evoluția postoperatorie precoce şi rezultatele oncologice din punct de vedere al radicalității rezecției.
Rezultate: Vârsta medie a pacienților a fost de 59,4 ani, 53,33% fiind bărbați. Afecțiuni cardiovasculare au fost prezente la 60% dintre pacienți, iar 26,66% prezentau diabet zaharat tip 2 controlat. Antecedente de colecistectomie au fost identificate la 46,66%, iar 60% prezentau icter la diagnostic. Durata medie a intervenției a fost de 360 minute. Anastomoza pancreatico-gastrică a fost realizată în 66,66% din cazuri, iar pancreatico-jejunoanastomoza în 33,33%, cu 26,66% proceduri complet laparoscopice. În 13,33% dintre cazuri a apărut scurgere biochimică, iar în 6,67% dintre cazuri fistulă pancreatică grad B, tratată conservator. Fistula biliară moderată a fost prezentă în 13,3% dintre cazuri, cu remisiune sub tratament conservator. Toate rezecțiile au fost R0. Numărul mediu de ganglioni excizați a fost 15,6, iar durata medie de spitalizare 18,7 zile.
Discuții: Duodenopancreatectomia cefalică laparoscopică oferă rezultate oncologice comparabile cu abordul deschis şi poate îmbunătăți recuperarea postoperatorie în centrele cu experiență.
Concluzii: Rezultatele noastre sunt încurajatoare, cu potențial de optimizare prin selecția atentă a pacienților şi perfecționarea tehnicii chirurgicale.

Cuvinte cheie: laparoscopie, cancer pancreatic, tumori periampulare

Abstract

Introduction: Pancreaticoduodenectomy is a complex surgical procedure involving meticulous resection and reconstruction steps.

Materials and Methods: We analyzed the first 15 laparoscopic pancreaticoduodenectomies performed for ampullary, periampullary, and cephalic pancreatic tumors at the Fundeni Clinical Institute, Bucharest, a high-volume center with extensive expertise in hepatopancreatobiliary surgery. Patient demographics, medical history, intraoperative parameters, early postoperative outcomes, and oncological results regarding radical resection were evaluated.

Results: The mean patient age was 59.4 years, with 53.33% males. Cardiovascular comorbidities were present in 60% of patients, while 26.66% had controlled type 2 diabetes mellitus. Previous cholecystectomy was noted in 46.66% of cases, and 60% presented with jaundice at diagnosis. The mean operative time was 360 minutes. Pancreaticogastrostomy was performed in 66.66% of cases and pancreaticojejunostomy in 33.33%, with 26.66% of procedures being fully laparoscopic. Biochemical leakage occurred in 13.33% of cases, while grade B pancreatic fistula developed in 6.67% of cases and was managed conservatively. Moderate biliary fistula occurred in 13.3% of the patients, with remission under conservative treatment. All resections achieved negative margins (R0). The mean number of retrieved lymph nodes was 15.6, and the average hospital stay was 18.7 days.

Discussions: Laparoscopic pancreaticoduodenectomy provides oncological outcomes comparable to the open approach and may improve postoperative recovery in experienced centers.

Conclusions: Our results are encouraging, with potential for further improvement through careful patient selection and refinement of surgical technique.

Keywords: laparoscopy, pancreatic cancer, periampullary tumors

Introduction

Pancreaticoduodenectomy represents one of the most complex and challenging surgical procedures involving meticulous resection and reconstruction steps. It requires advanced expertise in hepatopancreaticobiliary surgery and dedicated surgical teams to achieve optimal results. This surgical procedure has overcome many milestones over the years, starting from the first pancreaticoduodenectomy performed in 1898 by Codivilla and evolving to the first laparoscopic pancreaticoduodenectomy (LPD) performed in 1994. It is the optimal surgical treatment for resectable ampullary tumors and periampullary tumors, which are classified in pancreatic ductal adenocarcinoma, distal cholangiocarcinoma and duodenal adenocarcinoma. It is important to distinguish the histological types of the periampullary tumors because biliary tract tumors and pancreatic cancer are associated with worse prognosis compared to ampullary carcinoma (1-3).

The first results obtained in 10 patients treated with laparoscopic pancreaticoduodenectomy were discouraging: a 40% conversion rate, a surgical duration of 8.5 hours, and led to the conclusion that this approach is not beneficial compared with the open approach. Although the procedure was not abandoned and has improved over the years, it is now routine in high-volume, experienced centers. Many studies have shown that laparoscopic pancreaticoduodenectomy provides short-term benefits, including faster recovery, lower postoperative pain, reduced need for postoperative analgesia, shorter hospital stay and comparable oncological outcomes to the open approach. Even if the operation duration is longer and the surgical procedure costs are higher, these costs are offset by reduced hospitalization expenses (4-7).

Objectives

The primary objective of this study is to describe the surgical technique employed and the initiation of the learning curve in the transition from the open pancreaticoduodenectomy to the laparoscopic approach. The secondary objectives are to describe the characteristics of patients eligible for this approach and to evaluate short-term outcomes following its introduction.

Material and Method

We collected data between July 2025 and February 2026, covering the first 15 LPDs performed by a single

surgeon team, in the General Surgery and Liver Transplantation Department and the Oncological Surgery Department at the Fundeni Clinical Institute, Bucharest, Romania, a high-volume center with extensive expertise in hepatopancreaticobiliary surgery. The patients were prospectively followed and the following data were recorded promptly: patients' demographics, medical history, preoperative imaging and biochemical evaluation, preoperative interventions, intraoperative information such as operation duration and surgical technique, postoperative evolution and oncological results, including only those identified in the histopathological results. Patient selection criteria included resectable ampullary or periampullary tumors without preoperative imaging evidence of vascular involvement or local invasion, good preoperative performance status, and the absence of severe cardiovascular or pulmonary conditions that would have contraindicated a prolonged pneumoperitoneum. Exclusion criteria were represented by high imagistic suspicion of ampullary or periampullary tumor with vascular involvement, high imagistic suspicion of local invasion, preoperative poor performance status and severe cardiovascular and pulmonary conditions. Even though multiple prior abdominal surgical interventions might have been considered a milestone and contraindicated the laparoscopic approach, we did not consider it an exclusion criterion. The operating theatre was equipped with high-performance laparoscopic equipment, enabling the procedure to be performed to high standards.

In addition to presenting the patient's characteristics, postoperative course and outcomes, we also detailed our surgical technique.

The study has a descriptive purpose and highlights our initial experience, technique and short-term outcomes. We did not include a comparative open cohort because our group is too small at this time to have statistical relevance and the pathology is too heterogeneous.

In the present study, we used the updated definitions for postoperative pancreatic fistula grading published by Bassi C. in 2016 (8).

Grade A pancreatic fistula was redefined as biochemical leak and no longer considered a true pancreatic fistula or an actual complication. It is characterized by an amylase level in the drain fluid >3 times the upper limit of normal institutional serum amylase, measured on or after postoperative day 3.

Grade B pancreatic fistula was defined as: a properly defined fistula involving increased amylase activity in the fluid from any drain in association with a clinically relevant condition or persistent drainage over 3 weeks.

Grade C pancreatic fistula was considered whenever a grade B pancreatic fistula led to organ failure or to clinical instability such that a reoperation was needed.

Amylase and lipase levels were systematically measured from peripancreatic drain outputs on postoperative days 1 and 3, regardless of the patient's clinical presentation.

Results

Patient Characteristics

The study included 15 patients: 7 women (46.6%) and 8 men (53.33%), with a mean age of 59.4 years and a median age of 62 years. Patient's comorbidities were represented by type 2 diabetes mellitus, 4 patients (26.66%) with one patient under insulin treatment and 3 patients under oral antidiabetic therapy, 9 patients (60%) presented cardiovascular diseases (9 patients-arterial hypertension, 3 patients-congestive heart failure and one patient-history of acute myocardial infarction). None of these comorbidities was severely affecting the patient's performance status and the patient did not have a contraindication to laparoscopy from the anesthesiologists. Seven patients (46.66%) presented with a history of cholecystectomy (in one case by laparoscopic approach and in 6 cases by open approach).

Table 1 summarizes the patient's comorbidities.

The most common symptom at diagnosis was represented by abdominal pain in 9 patients (60%). Two patients (13.33%) presented with a history of chronic pancreatitis. Three patients (20%) had pre-

Table 1. Comorbidities summary

Comorbity	Number of patients	Percentage	Comments
Diabetes mellitus	4 patients	26.66%	1 patient - insulin 3 patients - oral antidiabetics
Arterial hypertension	9 patients	60%	Standard anti-hypertensive treatment
Congestive heart failure	3 patients	20%	Standard treatment
History of acute myocardial infarction	1 patient	6.66%	Antiagregant therapy
History of cholecystectomy	7 patients	46.66%	One case-laparoscopic approach and 6 cases-open approach

operative anemic syndrome with a minimum hemoglobin value of 9.3 g/dL and a mean value of 12.62 g/dL. 20% of the patients had a hemoglobin value below 12 g/dL. One patient required a preoperative blood transfusion because of a long-standing uncorrected secondary anemic syndrome.

The minimum preoperative albumin level was 3.8 g/dL, with a mean value of 4.59 g/dL.

Nine patients (60%) presented with jaundice at diagnosis and 4 of them benefited from endoscopic retrograde cholangiopancreatography (ERCP) with stent placement before surgery. Five patients (33.33% from the total number of patients) had jaundice at the time of resection. The maximum value of preoperative total bilirubin in these cases was 24.4 mg/dL and the mean value was 3.75 mg/dL. Also, in these 5 cases, elevated liver enzyme levels were observed, with maximum alanine aminotransferase (ALT) of 570 U/L and aspartate aminotransferase (AST) of 389 U/L.

Preoperative serum amylase and lipase levels were within normal limits in all patients.

All patients had normal preoperative leukocyte counts, including those presenting with jaundice at the time of resection, as they had received antibiotic therapy prior to transfer to our clinic for surgical intervention.

The maximum preoperative C-reactive protein (CRP) level was 117 mg/l, observed in one patient with jaundice at the time of resection, but not associated with other elevated markers suggestive of an inflammatory syndrome.

The maximum preoperative CA 19-9 level was 700 U/ml. Two patients (13.33%) had CA 19-9 values exceeding 200 U/ml. We did not consider an elevated CA19-9 level with no imagistic evidence of vascular invasion or metastatic disease a contraindication for laparoscopic resection.

The diagnostic imaging methods used were computed tomography (CT) in 13 patients (86.6%), magnetic resonance imaging (MRI) in 6 patients (40%), and endoscopic ultrasound (EUS) in 2 patients (13.3%), with biopsies performed in these cases but yielding inconclusive results. There was no suspicion of vascular involvement on preoperative imaging.

Prior to surgery, all patients were discussed at a multidisciplinary meeting where the surgical approach was approved. None of the patients required neoadjuvant treatment.

Surgical Technique

A total of five laparoscopic trocars were used: two metallic trocars of 10 mm, two plastic trocars of 12 mm and one metallic trocar of 5 mm. The patient was positioned on the operating table in the French Position, with the laparoscopic trolley appropriately placed at the upper right shoulder. The optical port was placed infraumbilically (metallic, 10 mm), two 12 mm plastic working trocars were placed on the left and right pararectal lines, one 10 mm metallic trocar in the right subcostal area and one 5 mm metallic trocar in the epigastric area. The trocar placement is illustrated in *Fig. 1*. The primary surgeon was stationed between the patient's legs, while the camera assistant was located on the left side and the second assistant surgeon was situated on the right side of the patient. A third assistant contributed to the instrumentation and optimisation of the surgical devices.

We began by opening the omental bursa and exposing the anterior surface and the inferior border of the pancreas. After identifying the tumoral mass, which is more feasible in pancreatic head cancer, we opened the lesser omentum and dissected the superior border of the pancreas, thereby identifying the common hepatic artery arising from the celiac trunk. The Kocher maneuver was performed and the origin of the superior mesenteric artery from the aorta was identified to ensure that it was not invaded by the tumor – the artery-first approach. Lymphatic tissue was meticulously removed from the right border of the superior mesenteric artery to ensure accurate staging. In 3 cases (20%), a right hepatic artery arising from the superior mesenteric artery was confirmed, consistent with preoperative imaging findings.

Following the course of the common hepatic artery, the dissection was carried out up to the origin of the gastroduodenal artery and the right gastric artery, which were dissected and ligated. The stomach was

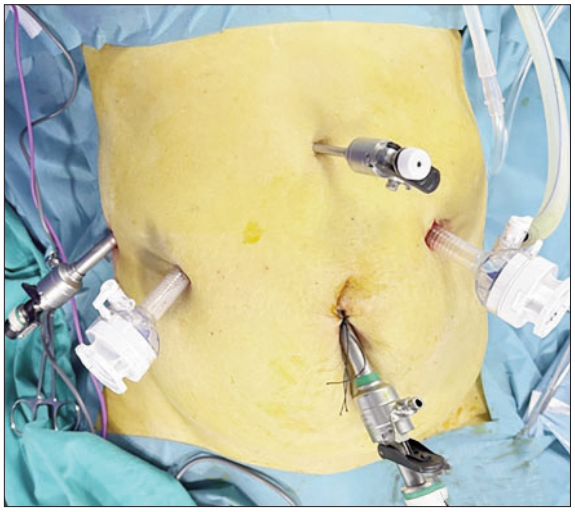


Figure 1. Trocar placement

transected using a 60-mm Endo GIA stapler with a purple cartridge. Next, a cholecystectomy was performed, with dissection of the hepatic pedicle to identify the common hepatic duct, the proper hepatic artery, and the portal vein, followed by transection of the hepatic duct above the insertion of the cystic duct. A complex lymph node excision was carried out along the common hepatic artery, celiac trunk, and hepatic pedicle to ensure an adequate quantity of lymph nodes for subsequent histopathological evaluation.

Dissection was continued along the inferior border of the pancreas, and a retropancreatic tunnel was created, exposing the anterior surface of the portal vein. To facilitate accurate identification of the superior mesenteric vein, we used the Henle trunk as a reference point, thereby minimizing the risk of venous injury to the superior mesenteric vein or the spleno-portal junction. The duodenojejunal flexure was mobilized, and the jejunum was transected using a 60-mm Endo GIA stapler with a yellow cartridge.

The pancreas was transected at the level of the created tunnel using cold scissors in order to clearly see the Wirsung duct and the resection of the specimen from the portal vein was continued using plastic clips for the portal branches supplying the pancreatic uncinate process and the head of the pancreas. Prior to pancreatic transection, 4-0 Prolene sutures were utilized to ligate the superior and inferior vascular arcades of the pancreas, effectively minimizing the risk of hemorrhage.

In cases where invasion of the portal vein by the tumoral mass was observed, after transection of the pancreas, the laparoscopic phase was stopped, and a small epigastric incision was made to continue the venous resection and reconstruction (2 cases-13.33%). We did not consider these cases conversions to open surgery because we used just a small epigastric incision for the venous resection and reconstruction, similar to the incision we used only for the reconstruction phase in the cases where when a gastro-pancreatic anastomosis was performed. An intracorporeal gastro-pancreatic reconstruction has not been attempted yet.

In the initial cases, we chose to perform only the hepaticojejunal anastomosis intracorporeally, while the gastro-pancreatic (10 patients-66.66%) or pancreatico-jejunal (1 patient) anastomoses were constructed extracorporeally through a small epigastric incision (11 cases-73.33%). 4 cases (26.6%) benefited from a full laparoscopic reconstruction phase with hand-sewn pancreatico-jejunal (4 patients-26.6%) anastomosis and mechanical gastro-jejunal anastomosis using a 60-mm Endo GIA stapler with a purple cartridge. The Wirsung duct was stented in 14 cases (93.33%). All hepatico-jejunal anastomoses were performed using continuous sutures with a self-locking thread. In all cases where the reconstruction was performed intracorporeally, the surgical specimen was extracted through a small Pfannenstiel incision. A standard number of four intraperitoneal drainage tubes were placed, with an optional single subcutaneous drain.

Intraoperative aspect of the portal anastomosis is illustrated in *Fig. 2*.

The postoperative aspect is illustrated in *Figs. 2, 3, 4, 5* and *6*. The intraoperative data is illustrated in *Table 2*.

Figure 2. Superior mesenteric vein to portal vein anastomosis

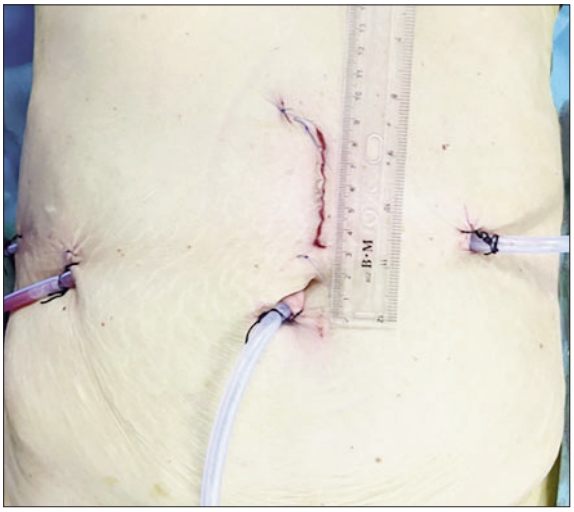


Figure 3. Epigastric incision patient 1

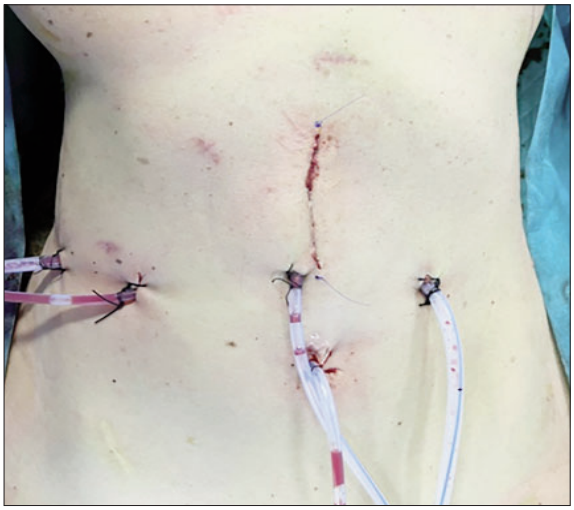


Figure 4. Epigastric incision patient 2 with mesenterico-portal resection and anastomosis

Figure 5. Epigastric incision patient 3

Intraoperative Course

The maximum operation duration was 8 hours – 480 minutes, with a mean value of 6.07 hours – 360 minutes. The maximum intraoperative blood loss was 200 ml and one patient required intraoperative transfusion of one packed red blood cells.

Postoperative Evolution

The mean value for intensive care unit stay was 12 hours (standard postoperative stay) with a maximum of 72 hours stay, except for 1 case with a 47-day stay for non-surgical reasons. The average hospital stay was 18.2 days, reflecting our careful approach during this early phase.

Regarding biological status after surgery, the postoperative day 1 amylasemia had a maximum value of 507 U/L and a mean value of 292.33 U/L. On postoperative day 1, lipase had a maximum value of 984 U/L and a mean of 203 U/L. These values were encountered in the 3 patients who presented biochemical leak and grade B postoperative pancreatic fistula, but were not associated with any clinical impact. The remaining patients had persistently normal values starting on postoperative day 1.

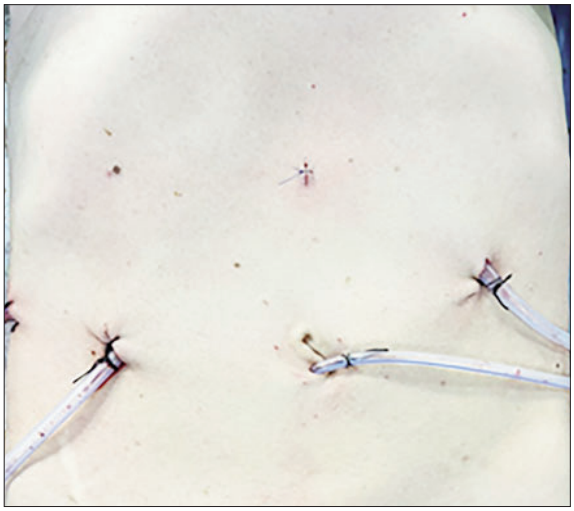


Figure 6. Pfannenstiel incision

On day 1, amylase levels from the drain tube had a maximum of 4640 U/L and a mean of 1692.5 U/L. On day 1, lipase levels from the drain tube had a maximum

Table 2. Intraoperative data

Full laparoscopic reconstruction	4 patients	26,66%	hand-sewn pancreatico-jejunal anastomosis and mechanical gastro-jejunal anastomosis
Gastro-pancreatic anastomosis	10 patients	66,66%	Using a small epigastric incision
Pancreatico-jejunal anastomosis	5 patients	33,33%	4 laparoscopic and one using a small epigastric incision
Portal vein segmental resection and reconstruction	2 patients	13,33%	Using a small epigastric incision

of 3500 U/L and a mean of 2249 U/L.

On day 3, amylase levels from the drain tube had a maximum of 1600 U/L and a mean of 316 U/L. On day 3, lipase levels from the drain tube had a maximum of 1100 U/L and a mean of 209.3 U/L.

Initially, given the non-standardized definitions of grade A pancreatic fistula, we included cases in this category in which amylase levels exceeded three times the upper limit of normal, even when measured only on postoperative day 1. Subsequently, we revised the manuscript and aligned our analysis with the standardized 2016 definition of pancreatic fistula proposed by Claudio Bassi. Accordingly, postoperative day 1 values were interpreted as predictive, while postoperative day 3 values - newly incorporated into the analysis - were considered diagnostic of a biochemical fistula when they met the criteria described in that study (8).

The initial association between elevated amylase levels and postoperative pancreatic fistula may be explained by their use as an early marker in the existing literature (9-12). Indeed, our data indicate that elevated values on postoperative day 1 predicted the occurrence of fistula in 73.33% of cases (11 patients). However, this association does not persist when standardized definitions are applied, with only 20% of cases (3 patients) meeting the criteria for a fistula on postoperative day 3 assessment.

In 2 cases (13.33%), a biochemical leak was encountered, and, according to the updated definitions of pancreatic postoperative fistula mentioned earlier, it is no longer considered a complication. The drains were removed once the output was minimal and the imagistic evaluation confirmed the absence of any intra-abdominal collection.

A single patient (6.67%) exhibited a grade B pancreatic fistula, which was clinically insignificant but required extended drainage for 22 days. This case was managed conservatively, by monitoring the clinical, biochemical parameters and the volume and characteristics of the drain output. The drain was removed once the output had decreased to a minimal volume and after imaging evaluation confirmed the absence of any intra-abdominal collection.

The postoperative day 1 and 3 amylase levels in patients with biochemical leak and grade B pancreatic fistula are illustrated in *Table 3*.

Table 3. Postoperative day 1 and 3 amylase levels in patients with biochemical leak and grade B pancreatic fistula

Patient	Day 1 drain tube amylase	Day 3 drain tube amylase
1-biochemical leak	2423 U/L	1200 U/L
2-biochemical leak	4500 U/L	1000 U/L
3- grade B postoperative pancreatic fistula	4640 U/L	1600 U/L

Two patients (13.33%) presented postoperative acute pancreatitis with optimal response under conservative treatment.

A patient developed delayed gastric emptying two weeks following surgery. Gastric tolerance improved significantly after the administration of a prokinetic agent.

Two patients (13.33%) experienced biliary fistulas, which resolved within about one week following conservative management.

The postoperative complications are illustrated in *Table 4*.

It is significant that no severe morbidity or postoperative mortality was observed within our group during this initial experience, indicating patient safety and providing confidence to proceed with a broader series.

14 patients (93.33%) received postoperative antibiotherapy prescribed by the infectious diseases department, based on the postoperative bioumoral inflammatory syndrome, but only 2 (13.33%) patients had confirmation of infection in the biliary culture. The maximal value of postoperative leukocytosis was 19.7* 10^3/ul. Five patients (33.33%) had leukocytosis > 15*10^3/ul. The maximum CRP value was 250 mg/L in patients with confirmed infection on biliary culture.

The minimum postoperative hemoglobin level was 7.5 g/dl, with a mean of 8.67 g/dl. Five patients (33.33%) had a hemoglobin level below 8 g/dl and required a postoperative blood transfusion.

Histopathological Result

The histopathological results are available for 13 of the patients at the time this paper is written.

The following histopathologies were encountered: 3

Table 4. Postoperative complications

Complication	Number of patients	Percentage	Comments	Treatment
Grade B pancreatic postoperative fistula	1 patient	6,67%	-	Conservative treatment
Postoperative acute pancreatitis	2 patients	13,33%	-	Conservative treatment
Biliary fistula	2 patients	13,33%	-	Conservative treatment

patients - ductal pancreatic adenocarcinoma, 4 patients - ampullary adenocarcinoma, 2 patients - duodenal adenocarcinoma, 1 case - intrapancreatic biliary duct cholangiocarcinoma associated with uncinate process intraductal papillary mucinous neoplasm, 1 case of chronic pseudotumoral pancreatitis, 1 case of neuroendocrine G1 tumor and 1 case of a rare hydatid cyst of the pancreatic head. The mean number of harvested lymph nodes was 15.6. All oncological resections achieved R0 status.

Fig. 7 illustrates the aspect of a duodenal tumor and *Fig. 8* illustrates the aspect of the pancreatic head adenocarcinoma with portal invasion.

Laparoscopic-Assisted Pancreaticoduodenectomy for a Hydatid Cyst of the Pancreatic Head

We report the case of a 32-year-old female patient with a history of acute pancreatitis, evaluated for dyspeptic symptoms. Abdominal ultrasound and computed tomography revealed a well-defined, multiloculated cystic lesion in the pancreatic head, with imaging features suggestive of a hydatid cyst, including internal detached membranes. Serological testing for Echinococcus granulosus was positive. Preoperative management included two courses of Albendazole.

Surgical intervention was initiated via a laparoscopic approach, allowing mobilization and partial dissection of the lesion from the mesenterico-portal axis. Due to significant vascular involvement, including intimate adherence to the superior mesenteric vein, an epigastric incision was required (but smaller than in classic open surgery for pancreaticoduodenectomy). Intraoperative findings confirmed a hydatid cyst of the pancreatic head with communication to the Wirsung duct and extension into the mesenteric root. A pancreaticoduodenectomy was performed, including segmental resection of the superior mesenteric vein with end-to-end reconstruction to the spleno-portal confluence.

Digestive reconstruction consisted of a pancreaticogastrostomy with Wirsung duct stenting (lost stent technique), termino-lateral hepatico-jejunostomy, and termino-lateral gastroenterostomy, along with anterior gastrotomy and subsequent gastrorrhaphy.

The postoperative course was favorable, with early recovery of enteral feeding, followed by oral feeding, and no evidence of pancreatic or biliary fistula. A single, self-limited episode of upper gastrointestinal bleeding was noted and managed conservatively, with negative endoscopic findings - *Fig. 9*. The patient was discharged on postoperative day 16.

Figs. 10 and *11* illustrate the aspect of the surgical specimen.

Discussions

The first LPD was performed in 1994. In subsequent years, Gagner and Pomp reported results from 10 patients treated with laparoscopic pancreaticoduodenectomy, with a 40% conversion rate and a surgical duration of 8.5 hours, and concluded that this approach is not superior to the open approach (1).

The first discouraging results after LPD did not diminish the interest in this surgical approach. Larger patient cohorts were studied, and the outcomes began to show that the laparoscopic approach is not only as safe as the open approach in oncological terms, but may also offer some short-term benefits. Data extracted from the National Cancer Database between 2010-2011

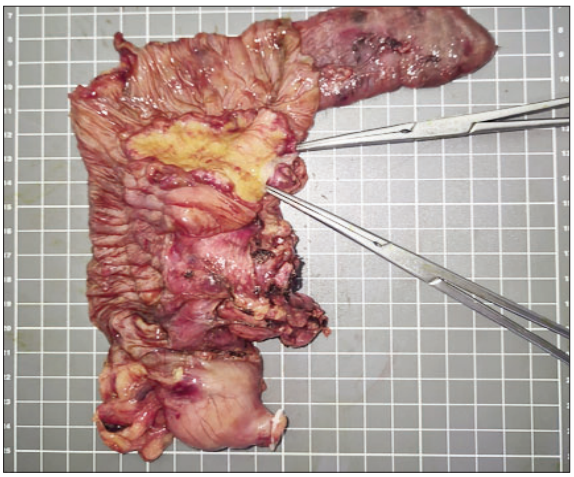


Figure 7. Surgical specimen- duodenal tumor

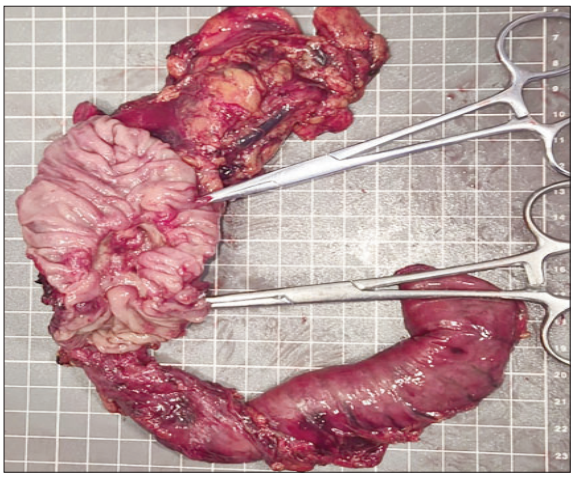


Figure 8. Surgical specimen: pancreatic head adenocarcinoma with portal vein invasion

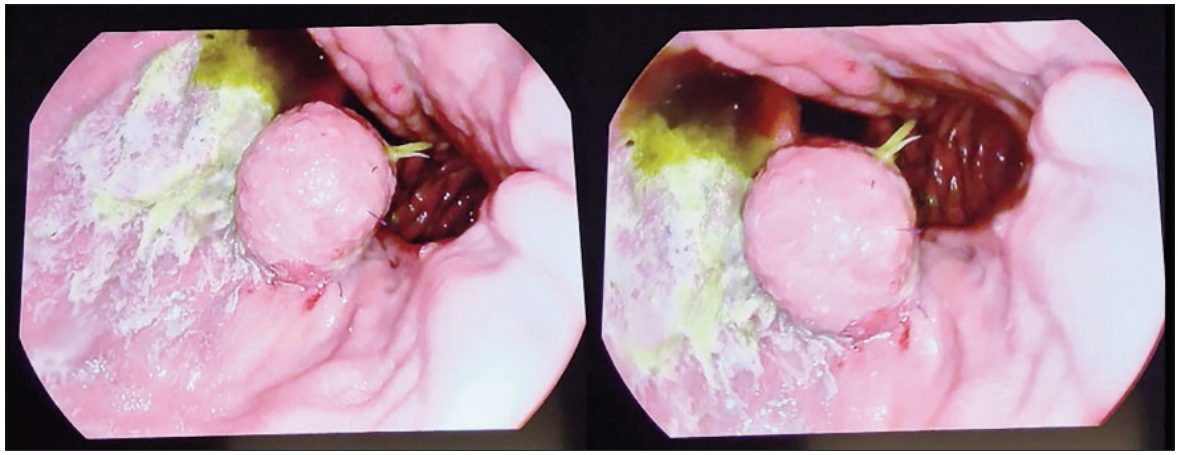
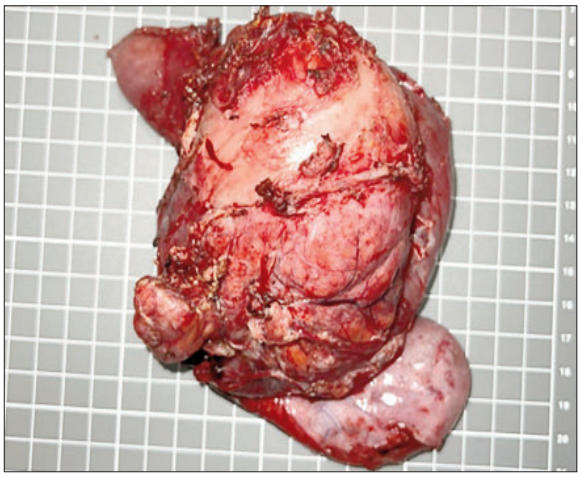


Figure 9. Upper GI endoscopy – pancreatico-gastrostomy with pancreatic stump without signs of bleeding, ulcers and stent in the Wirsung duct



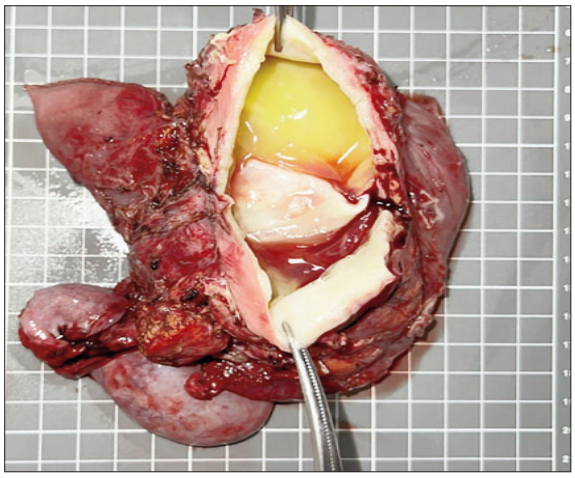


Figure 10 and 11. Surgical specimen: Pancreatic head hydatid cyst

on 4037 (91%) patients treated for pancreatic cancer by OPD and 384 (9%) patients treated by LPD showed that: for the laparoscopic group, the length of hospital stay was shorter (8 versus 10 days), the postoperative morbidity was lower, but the the 30-day mortality was higher comparing to the open approach in low volume centers. There were no significant differences in lymph node count (at least 12 lymph nodes were retrieved) or in the rates of positive margins between the two groups (4,5).

The short-term benefits of the LPD were underscored in another study comparing 137 patients treated with laparoscopic pylorus-preserving pancreaticoduodenectomy with 2055 patients treated with open pylorus-preserving pancreaticoduodenectomy. Even though the operation duration was longer in the laparoscopic approach (482.5 minutes versus 347.9 minutes in the open approach), postoperative pain and the need for postoperative analgesia were lower, with faster recovery and discharge (4,6).

An important moment in the evaluation of minimally invasive pancreaticoduodenectomy was the LEOPARD-2 trial. This multicenter, patient-blinded, randomized controlled trial, conducted by the Dutch Pancreatic Cancer Group, directly compared LPD with open pancreaticoduodenectomy. The trial was stopped early because of safety concerns, as patients in the laparoscopic group had a higher 90-day mortality rate than those in the open group. Before termination, no clear advantage in functional recovery, the primary endpoint, had been demonstrated, and the overall complication rates were similar between groups (13).

These findings shifted attention from the potential perioperative benefits of LPD to issues of safety,

training and patient selection. The study also emphasized the importance of the learning curve and institutional experience, suggesting that minimally invasive pancreaticoduodenectomy should be introduced cautiously, within structured training pathways and preferably in high-volume centers (13–15).

The impact of LEOPARD-2 was substantial and led to the development of further randomized studies, including DIPLOMA-2, with improved design and stricter safety standards (16).

In this context, minimally invasive pancreaticoduodenectomy is now viewed less as a broadly applicable alternative to open surgery and more as a procedure that requires appropriate expertise, case selection and ongoing evaluation.

Another relevant study, published in 2024 by van Ramshorst et al., used an international survey to evaluate current practice and attitudes regarding minimally invasive pancreatic surgery, with particular attention to laparoscopic and robotic approaches. The authors also compared these findings with a similar survey from 2016. A total of 315 pancreatic surgeons from 47 countries participated, most of them working in high-volume centers. The study showed that minimally invasive approaches have become much more common over time, especially for distal pancreatectomy. However, for pancreaticoduodenectomy, most surgeons still consider the open approach preferable. At the same time, robot-assisted surgery has become increasingly adopted for both distal pancreatectomy and pancreaticoduodenectomy, whereas laparoscopy has remained stable or declined for the more technically demanding procedures. These findings suggest increasing acceptance of minimally invasive pancreatic surgery, but also continued caution regarding minimally invasive pancreaticoduodenectomy. The authors also underlined the need for further high-quality randomized studies to better define its oncological safety and clinical value (17).

More recent literature has continued to support a role for minimally invasive approaches in selected patients, particularly in experienced centers. In a 2025 systematic review, Morales et al. reported that minimally invasive pancreaticoduodenectomy was associated with reduced intraoperative blood loss, shorter hospital stay and faster postoperative recovery, while maintaining comparable safety and feasibility relative to the open approach (18).

With regard to robotic surgery, Tang et al. evaluated short-term outcomes of robotic versus open pancreaticoduodenectomy using data from randomized controlled trials and propensity score-matched studies. Their analysis showed that robotic pancreaticoduodenectomy was associated with lower intraoperative blood loss and shorter postoperative hospitalization, without significant differences in mortality, major morbidity or oncological outcomes. These results support robotic surgery as a valid alternative to the open approach in selected settings, although the authors also noted the need for additional randomized evidence (19).

A further contribution came from Takagi et al. in 2026 through the TAKUMI-7 study, a single-center retrospective analysis comparing robotic and open pancreaticoduodenectomy in a high-volume institution. After propensity score matching, two comparable groups of 117 patients each were analyzed. Robotic pancreaticoduodenectomy was associated with lower blood loss, shorter operative time, shorter hospital stay, fewer major complications and a lower rate of clinically relevant postoperative pancreatic fistula. The proportion of patients achieving a textbook outcome was also higher in the robotic group. These findings support the potential perioperative advantages of robotic surgery when performed in centers with substantial experience, although long-term oncological validation remains necessary (20).

One of the main strengths of the robotic approach appears during the reconstruction phase of pancreaticoduodenectomy. The system offers improved dexterity, three-dimensional visualization, and better ergonomics, which may facilitate a fully minimally invasive reconstruction in selected cases (21–24).

The learning curve remains a major issue in minimally invasive pancreaticoduodenectomy. Wang et al., in a 2024 single-center study, showed that even surgeons with strong laparoscopic experience may require 30 to 50 cases to achieve proficiency in LPD. As experience increases, operative time decreases, blood loss becomes lower and postoperative outcomes improve. After the initial phase, results may approach those reported by established high-volume centers (25).

Similarly, Kim and colleagues found that operative efficiency improved after approximately 33 cases, while more stable outcomes, including lower complication rates and better overall performance, were achieved after about 44 cases. Their findings again underline that LPD requires time, case volume, and sustained institutional support before consistent results can be expected (26).

Taken together, the available evidence shows that minimally invasive pancreaticoduodenectomy has progressed considerably over the past decades. Early concerns about safety and technical feasibility were justified, but more recent data suggest that, in experienced centers, minimally invasive approaches can provide meaningful short-term benefits without compromising oncological quality. At the same time,

the LEOPARD-2 results remain an important reminder that this technique should not be adopted without appropriate training, careful implementation, and strict patient selection. For now, minimally invasive pancreaticoduodenectomy is best regarded as a specialized procedure, suitable for high-volume centers with the expertise required to perform it safely.

Robotic surgery may address some of the technical limitations associated with laparoscopy - such as restricted instrument movement - while also improving patients' postoperative recovery. Nevertheless, existing research has largely concentrated on short-term results. There remains a need for more robust, high-quality randomized studies to determine whether these minimally invasive approaches are equally safe and effective over the long term and to define their precise role within pancreatic surgery.

Importantly, the steep and prolonged learning curve - typically requiring approximately 30–50 cases to achieve procedural proficiency - remains a key limiting factor for the widespread adoption of minimally invasive pancreatoduodenectomy.

Conclusions

Based on our results, we may conclude that LPD is technically feasible and has acceptable short-term postoperative and oncological outcomes, including resection radicality.

Given that this is our initial experience, we have chosen to take cautious steps towards discharge, which might have resulted in a prolonged hospital stay, but the time has decreased as we have gained experience with each case.

The postoperative complications encountered in our study were managed conservatively and did not significantly affect the hospital stay.

We believe we have briefly described our surgical technique and supported the feasibility of the approach.

The study lacks a control group, so we could not make clear comparisons with the open approach. However, we considered our results encouraging compared with the literature. Another weak point of the study was the heterogeneity of the pathology we included, which prevented us from drawing separate conclusions about the adequacy of the approach for each type.

By consensus in our clinic, we set the target of 50 cases to achieve procedural proficiency. Once this number is reached, we will refine our study by adding a control group, separating the different pathologies that require pancreaticoduodenectomy and publishing our results. Also, we aim to improve the patient selection process. We estimate that the number will be achieved by the end of 2026.

We consider that reporting the initial experience of a high-volume center specializing in hepatopancreatobiliary surgery is highly relevant and encouraging for young surgeons or those intending to begin their experience with this procedure. Although the present study has certain limitations, these are expected to be overcome as experience accumulates over time, thereby more clearly highlighting the true value of the procedure.

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Conflicts of Interest

The authors declare no conflicts of interest.

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