

Laparoscopic pancreatic enucleation for tumors in close proximity to the main pancreatic duct: a high-volume center experience with selective duct stenting

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Abstract

Background

The rising incidental detection of benign and low-grade malignant pancreatic tumors has driven a shift toward parenchyma-sparing laparoscopic local pancreatectomy (LLP), however, real-world evidence on laparoscopic pancreatic enucleation (LPEn) for lesions in close proximity to the the main pancreatic duct (MPD) remains limited.

Methods

We retrospectively analyzed 64 consecutive patients undergoing LPEn for benign and low-grade malignant pancreatic tumors between January 2021 and October 2025 at a single high-volume center. Demographics, operative details, perioperative outcomes, and pathological characteristics were extracted from a prospectively maintained database.

Results

The mean patient age was 51.5 ± 14.2 years, with median tumor size 25.0 mm (IQR 15.0–36.0) and median distance to the MPD 1.7 mm (IQR 0.8–2.6); 31.3% of lesions abutted the MPD. All procedures were completed without mortality. Median operative time was 127.5 minutes (IQR 90.0–180.0) with median estimated blood loss of 20.0 mL (IQR 20.0–50.0). Clinically relevant postoperative pancreatic fistula (ISGPS Grade B/C) was reported in 56.3% of cases. No patients developed new-onset insulin-dependent diabetes or clinically significant exocrine insufficiency during 6-month follow-up.

Conclusions

LPEn is feasible for near-MPD lesions with zero mortality and preserved endocrine and exocrine function, when meticulous intraoperative ultrasound (IOUS) guidance and selective MPD stenting are employed, as demonstrated in this single-center series. These data support a selective expansion of LPEn indications, with careful patient selection balancing the inherently high fistula risk against the long-term benefits of pancreatic function preservation.

Introduction

Incidental detection of pancreatic neoplasms has surged with the advent of high-resolution cross-sectional imaging [1]. Current epidemiologic data estimate that 30%-40% of incidentally detected pancreatic lesions are histologically confirmed benign or low-grade malignant entities [2–6], most commonly non-functional pancreatic neuroendocrine tumors (NF-pNETs) and branch-duct intraductal papillary mucinous neoplasms (BD-IPMNs) [5]. Despite their indolent biology, these lesions often warrant

surgical excision to preempt life-threatening complications, including obstructive jaundice, gastrointestinal hemorrhage, or malignant transformation [7]. For decades, standard anatomic resections, namely pancreaticoduodenectomy or distal pancreatectomy, have served as the default operative approach regardless of tumor biologic behavior. However, these procedures necessitate the extirpation of substantial healthy parenchyma, invariably exposing patients to the risks of long-term endocrine and exocrine insufficiency, as well as the morbidity associated with major multivisceral resection [8–10].

In response to these overtreatment concerns, the surgical paradigm has shifted from "maximum tolerable resection" toward "minimum effective and function-preserving surgery". Laparoscopic local pancreatectomy (LLP), encompassing laparoscopic pancreatic enucleation (LPEn) and laparoscopic central pancreatectomy (LCP), has emerged as a parenchyma-sparing alternative aligned with the tenets of precision surgery [8,11,12]. Accumulating evidence from high-volume centers suggests that LLP provides comparable oncologic safety for select indications while minimizing blood loss, shortening hospital stays, and preserving pancreatic function [10,13]. Consequently, international consensus statements, including the Miami International Guidelines on Minimally Invasive Pancreas Resection (IG-MIPR) [12] and the European Guidelines on Minimally Invasive Pancreatic Surgery (EGUMIPS) [8], have acknowledged the potential benefits of LLP. Nevertheless, both guidelines refrain from recommending LPEn for lesions in immediate proximity to the main pancreatic duct (MPD), explicitly citing insufficient procedure-specific outcome data to support safe adoption.

Technically, LLP presents a formidable challenge, primarily centered on the meticulous management of the pancreatic parenchyma to prevent postoperative pancreatic fistula (POPF), one of the most vexing complications in pancreatic surgery. While LPEn minimizes parenchymal transection, it leaves behind non-anatomic raw surfaces where minor branch ducts may leak [7,14,15]. Large-scale systematic reviews indicate that POPF rates remain higher following local resection compared to standard resections. Fortunately, the majority of these events are biochemical or Grade B leaks amenable to conservative management, with low rates of reoperation or mortality [16].

Despite the growing international discourse, robust single-center datasets with mature perioperative and pathologic profiling are essential to refine patient selection and benchmark outcomes. In particular, granular real-world data linking preoperative tumor characteristics (size, minimal distance to the MPD, histologic subtype) to intraoperative decision-making and postoperative recovery are urgently needed to inform routine clinical practice. Herein, we report our single-center experience with LPEn over a contemporary cohort, analyzing demographics, operative details, perioperative outcomes, and pathologic correlates. By anchoring global trends in a concrete clinical series, we aim to provide a granular, real-world account of LPEn outcomes to refine patient selection.

Materials and Methods

Study Design and Setting

We conducted a single-center, retrospective observational cohort study including all consecutive patients who underwent LPEn between January 2021 and October 2025.

Inclusion criteria were as follows: (1) histologically confirmed benign or low-grade malignant pancreatic tumors, including NF-pNETs, BD-IPMNs, and solid pseudopapillary tumors (SPTs), without evidence of high-grade dysplasia; (2) LPEn performed as the primary and sole pancreatic procedure, with no concomitant anatomic resection (distal pancreatectomy, central pancreatectomy, or pancreaticoduodenectomy), and complete availability of baseline, operative, and 90-day postoperative clinical data extracted from our prospectively maintained institutional pancreatic surgery database. Patients were excluded if any of the following criteria were met: (1) diagnosis of high-grade malignant tumors requiring regional lymphadenectomy, such as pancreatic ductal adenocarcinoma; (2) synchronous performance of major anatomic pancreatic resections alongside enucleation, and missing key clinicopathologic variables required for outcome analysis, including tumor size, minimal distance to the MPD, or postoperative complication grading.

The study protocol was approved by the Institutional Review Board (No. 20262191), and the requirement for informed consent was waived owing to the retrospective nature of the study. All procedures were performed in accordance with the Declaration of Helsinki, and data were anonymized prior to analysis.

Preoperative Assessment and Patient Preparation

All patients underwent standardized preoperative evaluation including contrast-enhanced computed tomography (CT) of the abdomen. The necessity of performing magnetic resonance imaging with magnetic resonance cholangiopancreatography (MRI/MRCP) (Fig. 1), and endoscopic ultrasound with or without fine-needle aspiration (EUS ± FNA) was determined on patients' specific condition. We systematically documented tumor characteristics, including size, location (head/neck, body, or tail), and proximity to the MPD. Preoperative MPD stent placement via endoscopic retrograde cholangiopancreatography (ERCP) was selectively performed at the discretion of the attending surgeon, primarily for lesions located within 3 mm of the MPD or with imaging suspicion of MPD compression. Tumor-to-MPD distance was measured independently by two radiologists on axial arterial-phase CT images, with discrepancies resolved by consensus review; intraoperative IOUS measurements were used for final confirmation. We prospectively recorded demographic and comorbidity data, including American Society of Anesthesiologists (ASA) physical status classification, body mass index (BMI), diabetes mellitus, and hypertension.

Surgical procedure

All procedures were performed by 3 surgeons who had each completed > 150 minimally invasive pancreatic cases prior to 2021, with dedicated ERCP and pancreatic anesthesia teams providing perioperative support. For patients requiring MPD stenting, the procedure was performed via ERCP on

the day prior to surgery under CO₂ insufflation (Fig. 2). Under general anesthesia, patients were placed in a supine or reverse Trendelenburg position. Pneumoperitoneum was established, and five trocars were arranged in a "V" configuration.

For lesions in the pancreatic head and uncinate process, we always obtained supracolic access following exploration of the abdominal cavity. We divided the gastrocolic ligament to enter the lesser sac and adequately exposed the pancreas, Kocherizing the duodenum when necessary to facilitate posterior pancreatic exposure (Fig. 3). When necessary, intraoperative laparoscopic ultrasonography can be employed to confirm tumor location, define the relationship with the MPD, and guide the plane of dissection. We then carefully enucleated the tumor using a combination of ultrasonic dissection devices and monopolar electrocautery, maintaining a close margin around the lesion while preserving MPD integrity whenever technically feasible. Upon completion of tumor removal, the integrity of the MPD was verified by inspecting the resection bed for clear fluid leakage. In cases where a minor ductal orifice was identified, it was carefully sutured using fine absorbable sutures (such as 5 – 0 or 6 – 0 Prolene). A closed suction drain was routinely placed in close proximity to the surgical bed. Abdominal enhanced CT scans are routinely performed on the postoperative day two, with a follow-up examination scheduled at six months after the surgery.

In cases of inadvertent MPD injury or confirmed ductal defect encountered during enucleation, a "stent-and-sew" salvage technique was employed [17]. The preplaced pancreatic duct stent (5 Fr or 7 Fr) was retained as an internal scaffold; the MPD defect was sutured over the stent using 6-0 absorbable monofilament, and the resection bed was reinforced with fibrin glue or a small pedicled omental buttress. Conversion to formal pancreatectomy was undertaken if MPD injury was deemed irreparable. This approach was intended to convert a potential major duct leak into a controlled fistula amenable to conservative management.

We converted to open surgery or formal anatomic resection whenever oncologic or technical circumstances mandated a change in the operative plan. Conversion criteria included inability to safely expose the lesion, uncontrolled hemorrhage, unexpected malignant features requiring wider resection margins, or significant MPD injury necessitating formal pancreatic resection and reconstruction.

Definitions and Variables

Baseline demographic and clinical characteristics included age, sex, BMI, presenting symptoms, comorbidities, and preoperative interventions such as pancreatic stenting. Operative details comprised surgical duration (minutes), estimated blood loss (milliliters).

Postoperative outcomes were defined according to international consensus criteria. POPF was graded using the 2016 International Study Group on Pancreatic Surgery (ISGPS) grading system [18]. Clinically relevant POPF (CR-POPF) was defined as Grade B or C. Secondary endpoints included abdominal

infection, postoperative hemorrhage (PPH), delayed gastric emptying (DGE), length of postoperative hospital stay, total hospitalization costs, and readmission within 90 days.

Pathologic diagnoses were reviewed by two independent senior pathologists. Tumor size (millimeters) and the minimal distance between the tumor and the MPD (millimeters) were measured based on preoperative imaging and confirmed intraoperatively using intraoperative ultrasound.

Statistical Analysis

Continuous variables were tested for normality using the Shapiro-Wilk test. Normally distributed variables were expressed as mean $\pm$ standard deviation (SD). Non-normally distributed variables were summarized as medians with interquartile ranges (IQR: 25th-75th percentiles). Categorical variables were presented as frequencies and percentages.

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 29.0 (IBM Corp., Armonk, NY, USA).

Results

Patient Cohort and Baseline Characteristics

Between January 2021 and October 2025, 64 consecutive patients undergoing LPEn were included. All 64 enrolled patients had complete baseline, operative, and 90-day postoperative data available for analysis. Of the 64 patients, 59.4% were female, with a median tumor-to-MPD distance of 1.7 mm (IQR 0.8–2.6 mm) and 31.3% of tumors directly abutted the MPD. Preoperative MPD stenting was performed in 33 patients (51.6%). Only 12 patients were admitted to the hospital with symptoms of upper abdominal discomfort, and two presented with manifestations of hypoglycemia. The remaining patients were discovered incidentally during routine physical examinations and reported no clinical symptoms. The median age was 51.50 ± 14.21 years, with a median BMI of 24.98 ± 5.61 kg/m². Detailed demographic and preoperative characteristics are summarized in Table 1.

Table 1
Demographic and Preoperative Characteristics

Variable	Total (N = 64)
Age (years), mean $\pm$ SD	51.50 $\pm$ 14.21
Sex, n (%)	Male: 26 (40.6%) Female: 38 (59.4%)
BMI (kg/m ²), mean $\pm$ SD	24.98 $\pm$ 5.61
Comorbidities, n (%)	Hypertension: 12 (18.8%) Diabetes mellitus/ hypoglycemia: 1/1 (1.6%) Chronic pancreatitis: 1 (1.6%) Others (cardiovascular, thyroid disease, etc.): 12 (18.8%)
Tumor size (mm), median (IQR: 25th–75th)	25 (15, 36)
Location	Head/neck 5 Body 50 Tail 9
ASA	$\leq$ II
Distance to MPD (mm), median (IQR: 25th–75th)	1.7 (0.83–2.6)
Preoperative pancreatic stent placement, n (%)	33 (51.6%)
BMI Body Mass Index, IQR interquartile ranges, ASA American Society of Anesthesiologists, MPD main pancreatic duct	

Two cases of MPD injury during enucleation were salvaged using a "stent-and-sew" technique, converting a potential catastrophe into a controlled fistula. Both cases developed only ISGPS Grade B POPF postoperatively, which resolved with prolonged closed-suction drainage and conservative management, with no need for completion pancreatectomy or reoperation.

All 64 patients successfully completed the surgery without mortality. Intraoperative and postoperative outcomes, as well as comprehensive pathologic and tumor characteristics, are presented in Table 2. In two cases, due to the considerable technical difficulty encountered during the procedure which precluded effective exposure of the pancreatic tumors, the operations were converted to an open surgical approach. The median surgical duration was 127.5 minutes (IQR: 90.0-180.0). Hemorrhage during operation is small, with a median of 20.0 mL (IQR: 20.0–50.0). The mean total hospitalization

costs was \$ 8547.42 ± 3510.6. Among the 16 cases of encapsulated abdominal fluid collection, 11 achieved resolution following puncture drainage and the remaining patients were successfully managed with conservative therapy. And two cases of Postoperative hemorrhage (PPH) were cured through Digital Subtraction Angiography (DSA).

Table 2
Intraoperative and Postoperative Outcomes

Variable	Total (N = 64)
Operative time (min), median (IQR: 25th–75th)	127.5 (90, 180)
Estimated blood loss (mL), median (IQR: 25th–75th)	20 (20,50)
POPF (ISGPF grade), n (%)	No fistula: 9 (14.1%) Biochemical Leak (BL): 19 (29.7%) CR-POPF 36 (56.3%) Grade B: 35 (54.7%) Grade C: 1 (1.6%)
Encapsulated abdominal fluid collection, n (%)	16 (25.0%)
DGE, n (%)	3 (4.7%)
PPH, n (%)	2 (3.1%)
Intra-abdominal infection, n (%)	9 (14.1%)
Postoperative hospital stay (days), median (IQR: 25th–75th)	9 (7, 14)
Readmission within 90 days, n (%)	5 (7.8%)
Pathology, n (%)	Serous cystic adenoma: 11 (17.2%) Mucinous cystic neoplasm: 11(17.2%) IPMN 5 (7.8%) Neuroendocrine tumor (G1/G2): 22 (34.4%) Solid pseudopapillary tumor: 5 (7.8%) Other (pseudocyst, schwannoma, ectopic spleen, etc.): 10 (15.6%)

Follow-up was performed via phone calls or outpatient visits. None of the 64 patients developed new-onset insulin-dependent diabetes or clinically significant exocrine insufficiency during the index

hospitalization or within the 6-month postoperative follow-up period. The CT imaging was obtained on postoperative day 2, and the follow-up CT scan at six months postoperatively is presented in Fig. 4.

Discussion

The traditional dogma of radical resection has long prioritized oncologic clearance at the expense of functional parenchyma. While effective against malignancy, these procedures require removing significant healthy tissue, which can lead to lifelong metabolic complications such as brittle diabetes from loss of endocrine function and severe malabsorption due to exocrine insufficiency. The pendulum has swung toward parenchyma-sparing approaches for benign and low-grade malignant pancreatic tumors, and LPEn stands at the vanguard of this shift. LPEn removes only the tumor, leaving the main pancreatic duct and surrounding parenchyma intact. This balances oncologic safety with long-term functional preservation, addressing the key limitation of standard resection. In this high-volume series, we demonstrate that even for tumors lying perilously close to the MPD, with a median distance of just 1.7 mm, LPEn can be performed with zero mortality. Crucially, this technical feat did not come at the cost of metabolic trade-offs. No patient developed new-onset insulin-dependent diabetes or clinically significant exocrine insufficiency at 6-month follow-up, validating the procedure's role in preserving long-term pancreatic function. Placed within the contemporary body of evidence, the present single-center experience reinforces several well-established principles of LPEn, while providing granular, procedure-level insights that refine its safe application.

Operative Performance and Postoperative Course

Our operative times of 127.5 min and estimated blood loss aligns with benchmark series, reflecting the intrinsic advantages of parenchyma-sparing surgery, which circumvents extensive vascular control and retroperitoneal dissection [19,20]. The median postoperative stay of 9 days, longer than the 4–6 days reported under fast-track protocols in Europe and North America, largely reflects institutional drain-management policies rather than biological differences [21]. Drains were retained until amylase-normalized output persisted for 48 hours, a strategy that likely contributed to our low readmission rate (7.8%) and infrequent need for re-intervention.

CR-POPF remains the main complication following LPEn, a reality reflected in our cohort. While our observed CR-POPF rate of 56.3% is higher than the 31.6% reported by Aussilhou et al. for lesions in close proximity to the MPD [22], the notably lower incidence of Grade C fistula in our series (1.6% vs. 4.1%) suggests a critical nuance. It is that although prophylactic or intraoperative MPD stenting does not eliminate the overall risk of POPF, it effectively mitigates fistula severity and curtails the need for completion pancreatectomy or reoperation. This observation is further bolstered by the management of our cohort, where even the most severe cases were effectively controlled using conservative measures including prolonged suction drainage, short-course somatostatin analogues, or percutaneous interventions, and no patient required completion pancreatectomy. Such outcomes reinforce the prevailing understanding that fistulas after enucleation are typically low-pressure exudates from non-

anatomic raw surfaces, favoring a strategy of clinical patience over early re-operative intervention. Ultimately, the consistent application of intraoperative ultrasound (IOUS) coupled with selective MPD stenting expands the technical envelope of LPEn, challenging rigid distance-based exclusion criteria and supporting a selective, expertise-driven extension of this organ-preserving approach to tumors previously considered unsuitable [23–26].

Reappraising “Deep Enucleation”

Our data contribute meaningfully to the ongoing debate regarding enucleation of lesions in close proximity to the MPD. In this cohort, the median tumor diameter was 25.0 mm (IQR 15.0–36.0), and the median tumor-to-MPD distance of 1.7 mm in our series demonstrates that “deep enucleation” is technically achievable. However, this requires meticulous intraoperative judgment to avoid catastrophic ductal injury. Nearly one-third of lesions lay within 1 mm of the MPD, underscoring that, in experienced hands, LPEn can safely address tumors traditionally considered “borderline deep.”

It supports moving beyond fixed 2-mm distance thresholds: in 20 cases where the tumor-to-MPD distance was < 1 mm, careful IOUS-defined dissection planes allowed enucleation without MPD injury, provided stenting was available as backup [27–28]. Intraoperative recognition of a thinned but intact ductal wall, together with prophylactic or reactive ductal stenting, enables a judicious expansion of the enucleation envelope without proportionally increasing the risk of severe POPF [24,29,30].

Pancreatic Duct Stenting: Technique and Rationale

A cornerstone of our approach is the standardized use of MPD stenting, ideally performed on the day of surgery via ERCP using CO₂ insufflation, accompanied by aspiration of gastric and duodenal gas to optimize exposure. Stent length is individualized so that the distal tip extends beyond the tumor–MPD interface, serving both as an intraoperative palpable landmark and a postoperative internal drain. In cases of inadvertent MPD injury, we employed a “stent-and-sew” technique [17]. No severe pancreatic fistula was observed, with favorable postoperative outcomes. This approach effectively converts a potential surgical catastrophe into a controlled, healing fistula. In our study, it is worth mentioning that even patients with amylase-rich output on postoperative day 3 frequently stabilized by the second postoperative week, further supporting conservative management in stented patients.

Comparative Context and Patient Selection

Our median operative time of 127.5 minutes falls between the 90–110 minutes reported by ultra-high-volume minimally invasive centers and the 180–220 minutes typical of early learning-curve series, reflecting deliberate IOUS-guided dissection rather than case complexity. This interval reflects deliberate, IOUS-guided dissection near the MPD rather than case complexity arising from additional procedures [22].

From a selection standpoint, we included tumors up to 80 mm, with a median size of 25 mm. Larger lesions were exophytic, encapsulated, and lacked mural nodules or solid components concerning for high-grade IPMN. This judicious expansion beyond the traditional ≤ 3 cm enucleation threshold is

increasingly reported and, in our series, was not associated with higher fistula or recurrence rates, although longer-term surveillance remains necessary [31,32].

Organ Preservation and Functional Outcomes

Consistent with prior large-cohort data showing a < 2% rate of new-onset insulin-requiring diabetes mellitus and a low incidence of long-term exocrine insufficiency following pancreatic enucleation [33], none of the 64 patients in our series developed new-onset insulin-dependent diabetes or clinically significant exocrine insufficiency during the index admission. By preserving 70%–90% of pancreatic parenchyma, enucleation mitigates the metabolic sequelae of standard resections, an advantage of particular relevance to younger patients with decades of life expectancy.

Study Limitations

The present study has several limitations that should be acknowledged. First, the modest sample size (n = 64) precluded robust multivariable adjustment and meaningful subgroup analyses, such as stratifying postoperative pancreatic fistula risk by precise main pancreatic duct distance, tumor location, or stenting status, thus limiting our findings to descriptive, hypothesis-generating observations. Second, the single-center, retrospective design inherently restricts generalizability; outcomes reflect the accumulated expertise, refined protocols, and mature learning curve of a high-volume tertiary center, and may not be readily replicable in low-volume settings with less procedural experience. Last, the relatively short follow-up, confined to the perioperative period and six months postoperatively, is insufficient to capture late recurrence, long-term endocrine or exocrine functional changes, or durable quality-of-life outcomes, which typically require three to five years of surveillance. We acknowledge these constraints and are conducting extended longitudinal follow-up to address them in future reports.

Conclusion

LPEn for near-MPD lesions requires equivalent preoperative planning and intraoperative expertise to anatomic resection, and should not be perceived as a low-complexity procedure. For select near-MPD lesions, it achieves excellent short-term safety and functional preservation when supported by IOUS and selective stenting. Surgeons should weigh the high fistula risk against the benefits of parenchyma preservation. Until higher-level evidence matures, this single-center experience reinforces that, in expert hands, LPEn remains a cornerstone of organ-preserving pancreatic surgery, balancing oncologic prudence with functional preservation and quality of life.

Declarations

Human Ethics and Consent to Participate declarations: This study was reviewed and approved by the Institutional Review Board (IRB) of Sir Run Run Shaw Hospital, Zhejiang University School of Medicine (Approval No.: 2026.2191). The requirement for informed consent was waived by this IRB because the study involved retrospective analysis of anonymized existing data, in line with the Ethical Review Measures for Biomedical Research Involving Humans (National Health Commission of China).

Consent for publication

Not applicable. No identifying images, personal information, or clinical details that could compromise participant anonymity are included in this manuscript.

Clinical trial number: Not applicable.

Data Availability Statement The raw data supporting the conclusions of this article will be made available by the corresponding author upon reasonable request.

Contribution Statement Defei Hong and Jiandong Zhang conceived and designed the study. Xiaolong Liu collected data. Bo Zhuang analyzed the data. Jiandong Zhang drafted the manuscript. All authors reviewed, revised and approved the final version of the manuscript.

Conflict of Interest Statement: Jiandong Zhang, Xiaolong Liu, Bo Zhuang, and Defei Hong declare that they have no conflicts of interest.

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References

1. Oakes, S, Mahmood, S, Lekharaju, V, et al. HPB S006 - An advanced clinical practitioner (ACP) led pancreatic cyst surveillance programme BRIT J SURG. 2024; 111 (Supple9): doi: 10.1093/bjs/znae271.239.
2. Rodriguez, JR, Salvia, R, Crippa, S, et al. Branch-duct intraductal papillary mucinous neoplasms: observations in 145 patients who underwent resection. GASTROENTEROLOGY. 2007; 133 (1): 72-9; quiz 309-10. doi: 10.1053/j.gastro.2007.05.010.
3. Lahat, G, Ben Haim, M, Nachmany, I, et al. Pancreatic incidentalomas: high rate of potentially malignant tumors. J AM COLL SURGEONS. 2009; 209 (3): 313-9. doi: 10.1016/j.jamcollsurg.2009.05.009.
4. Winter, JM, Cameron, JL, Lillemoe, KD, et al. Periapillary and pancreatic incidentaloma: a single institution's experience with an increasingly common diagnosis. ANN SURG. 2006; 243 (5): 673-80; discussion 680-3. doi: 10.1097/01.sla.0000216763.27673.97.
5. Kent, TS, Vollmer, CM, Callery, MP. Intraductal papillary mucinous neoplasm and the pancreatic incidentaloma. World J Gastrointest Surg. 2010; 2 (10): 319-23. doi: 10.4240/wjgs.v2.i10.319.
6. Bruzoni, M, Johnston, E, Sasson, AR. Pancreatic incidentalomas: clinical and pathologic spectrum. AM J SURG. 2008; 195 (3): 329-32; discussion 332. doi: 10.1016/j.amjsurg.2007.12.027.
7. Tanaka, M, Fernández-Del Castillo, C, Kamisawa, T, et al. Revisions of international consensus Fukuoka guidelines for the management of IPMN of the pancreas. PANCREATOLOGY. 2017; 17 (5): 738-753. doi: 10.1016/j.pan.2017.07.007.

8. Abu Hilal, M, van Ramshorst, TME, Boggi, U, et al. The Brescia Internationally Validated European Guidelines on Minimally Invasive Pancreatic Surgery (EGUMIPS). *Ann Surg.* 2024; 279 (1): 45-57. doi: 10.1097/SLA.000000000000600.
9. Ohtsuka, T, Fernandez-Del Castillo, C, Furukawa, T, et al. International evidence-based Kyoto guidelines for the management of intraductal papillary mucinous neoplasm of the pancreas. *PANCREATOLOGY.* 2024; 24 (2): 255-270. doi: 10.1016/j.pan.2023.12.009.
10. Farrarons, SS, van Bodegraven, EA, Sauvanet, A, et al. Minimally invasive versus open central pancreatectomy: Systematic review and meta-analysis. *Surgery.* 2022; 172 (5): 1490-1501. doi: 10.1016/j.surg.2022.06.024.
11. Tustumi, F, Calthorpe, L, Fotoohi, N, et al. The São Paulo International Consensus on Minimally Invasive Pancreatic Surgery for Cancer. *HPB.* 2026; 28 (2): 105-118. doi: 10.1016/j.hpb.2025.11.012.
12. Asbun, HJ, Moekotte, AL, Vissers, FL, et al. The Miami International Evidence-based Guidelines on Minimally Invasive Pancreas Resection. *ANN SURG.* 2020; 271 (1): 1-14. doi: 10.1097/SLA.0000000000003590.
13. Anecchiarico, M, Loiacono, G, Cirillo, C, et al. Minimally Invasive Pancreas-Preserving Duodenal Resections: Indications, Technical Strategies, and Outcomes *GASTROINTEST DISORD.* 2026; 8 (2): 25. doi: 10.3390/gidisord8020025.
14. Hüttner, FJ, Koessler-Ebs, J, Hackert, T, et al. Meta-analysis of surgical outcome after enucleation versus standard resection for pancreatic neoplasms. *BRIT J SURG.* 2015; 102 (9): 1026-36. doi: 10.1002/bjs.9819.
15. Nebbia, M, Capretti, G, Nappo, G, et al. Updates in the management of postoperative pancreatic fistula. *Int J Surg.* 2024; 110 (10): 6135-6144. doi: 10.1097/JS9.0000000000001395.
16. Shen, X, Yang, X. Comparison of Outcomes of Enucleation vs. Standard Surgical Resection for Pancreatic Neoplasms: A Systematic Review and Meta-Analysis. *Front Surg.* 2021; 8 744316. doi: 10.3389/fsurg.2021.744316.
17. Li, Z, Shi, Y, Zhuo, Q, et al. Main pancreatic duct exposure, repair, or reconstruction during minimally invasive pancreatic enucleation: a long-term metabolic outcome from a prospective cohort study (CSPAC-MIEN-1). *INT J SURG.* 2025; 111 (11): 8001-8014. doi: 10.1097/JS9.0000000000003016.
18. 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(3):584-591. doi:10.1016/j.surg.2016.11.014.
19. Bartolini, I, Bencini, L, Risaliti, M, et al. Current Management of Pancreatic Neuroendocrine Tumors: From Demolitive Surgery to Observation. *GASTROENT RES PRACT.* 2018; 2018 9647247. doi: 10.1155/2018/9647247.
20. Bolm, L, Nebbia, M, Wei, AC, et al. Long-term Outcomes of Parenchyma-sparing and Oncologic Resections in Patients With Nonfunctional Pancreatic Neuroendocrine Tumors <3 cm in a Large Multicenter Cohort. *ANN SURG.* 2022; 276 (3): 522-531. doi: 10.1097/SLA.0000000000005559.

21. de Rooij, T, van Hilst, J, van Santvoort, H, et al. Minimally Invasive Versus Open Distal Pancreatectomy (LEOPARD): A Multicenter Patient-blinded Randomized Controlled Trial. *ANN SURG.* 2019; 269 (1): 2-9. doi: 10.1097/SLA.0000000000002979.
22. Aussilhou, B, Ftéliche, FS, Bouquot, M, et al. Laparoscopic pancreatic enucleation: cystic lesions and proximity to the Wirsung duct increase postoperative pancreatic fistula. *SURG ENDOSC.* 2023; 37 (1): 544-555. doi: 10.1007/s00464-022-09527-w.
23. Caringi, S, Delvecchio, A, Casella, A, et al. Parenchyma-Sparing Pancreatic Surgery: Current Indications, Results, and Future Prospects. *CANCERS.* 2026; 18 (10): doi: 10.3390/cancers18101550.
24. Moekotte AL, Rawashdeh A, Asbun HJ, et al. Safe implementation of minimally invasive pancreas resection: a systematic review. *HPB (Oxford).* 2020;22(5):637-648. doi:10.1016/j.hpb.2019.11.005.
25. Matti, J, Theivendrampillai, T, Soonawalla, Z, et al. 54 Does Preoperative Prophylactic Pancreatic Duct Stenting Prior to Enucleation Mitigate the Risk of Postoperative Fistula: A Meta-Analysis *BJS-BRIT J SURG.* 2025; 112 (Supple17): doi: 10.1093/bjs/znaf270.037.
26. Hackert T, Hinz U, Hartwig W, et al. Internal pancreatic duct stenting in enucleation: technique and outcomes. *HPB (Oxford).* 2022;24(3):312-319. doi:10.1016/j.hpb.2021.08.012.
27. Li C, Yu Y, Guo W, et al. Laparoscopic enucleation: a safe and feasible treatment option for large (≥ 4 cm) benign or low-grade malignant pancreatic tumors. *Front Med (Lausanne).* 2025;12:1666758. doi:10.3389/fmed.2025.1666758.
28. Cienfuegos JA, Salguero J, Núñez-Córdoba JM, et al. Short- and long-term outcomes of laparoscopic organ-sparing resection in pancreatic neuroendocrine tumors: a single-center experience. *Surg Endosc.* 2017;31(10):3847-3857.
29. Roesel, R, Bernardi, L, Bonino, MA, et al. Minimally-invasive versus open pancreatic enucleation: systematic review and metanalysis of short-term outcomes. *HPB (Oxford).* 2023; 25 (6): 603-613. doi: 10.1016/j.hpb.2023.02.014.
30. Xu, Q, Xie, Q, Ge, C, et al. Risk factors and prevention of postoperative pancreatic fistula after insulinoma enucleation: a retrospective study from a high-volume center. *Pancreatology.* 2021; 21 (6): 1208-1215. doi: 10.1016/j.pan.2021.06.001.
31. Heidsma, CM, Tsilimigras, DI, van Dieren, S, et al. Indications and outcomes of enucleation versus formal pancreatectomy for pancreatic neuroendocrine tumors. *HPB.* 2021; 23 (3): 413-421. doi: 10.1016/j.hpb.2020.06.015.
32. Zhou, D, Tan, F, Wang, Z, et al. Safety and Efficiency of Various Pancreatic Enucleation Procedures: A Systematic Review and Meta-Analysis. *J CLIN MED.* 2026; 15 (9): doi: 10.3390/jcm15093543.
33. Giuliani, T, De Pastena, M, Paiella, S, et al. Pancreatic Enucleation Patients Share the Same Quality of Life as the General Population at Long-Term Follow-Up: A Propensity Score-Matched Analysis. *ANN SURG.* 2023; 277 (3): e609-e616. doi: 10.1097/SLA.0000000000004911.

Figures

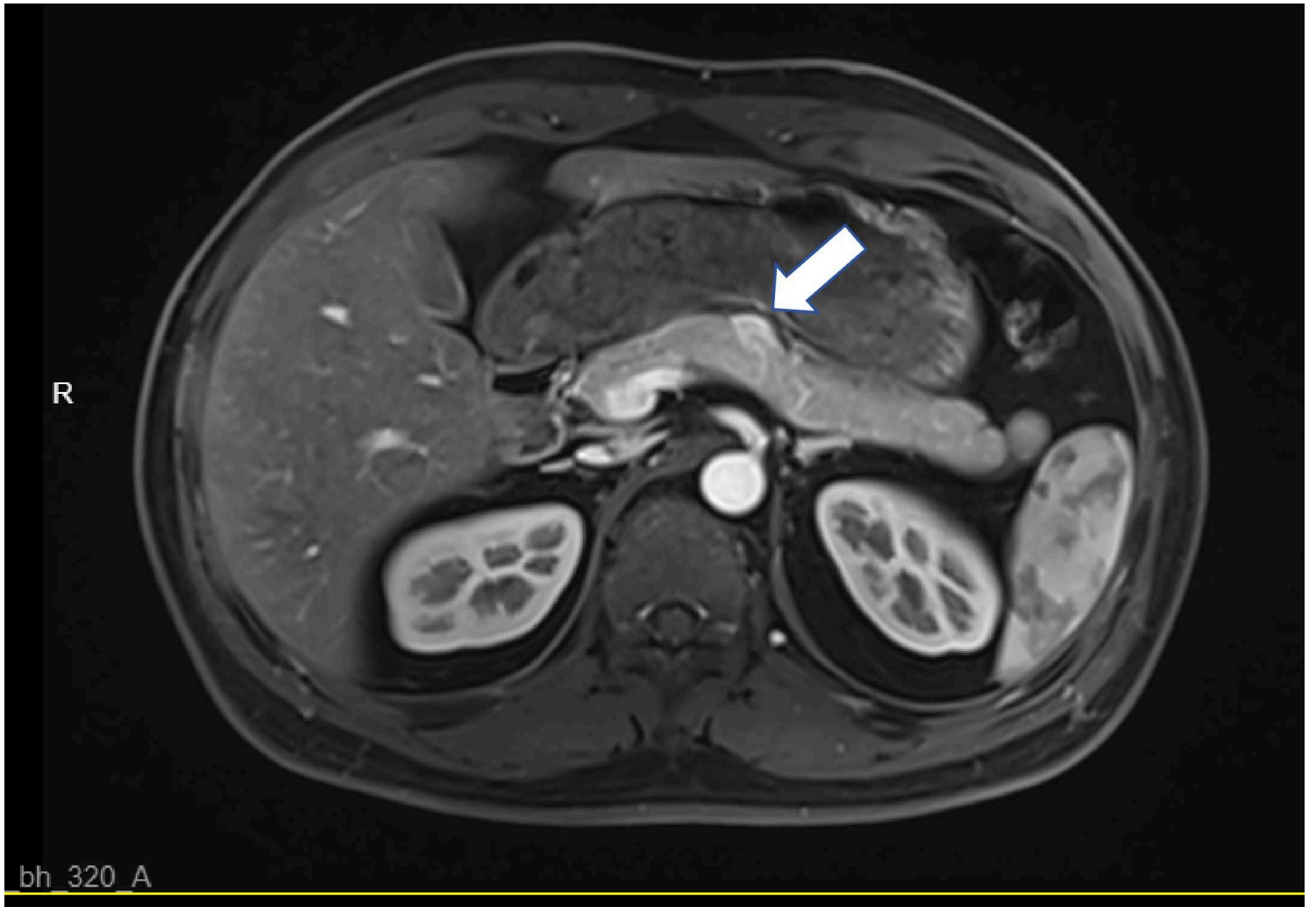


Figure 1

Preoperative MRCP demonstrating the pancreatic tumor and its relation to the MPD.

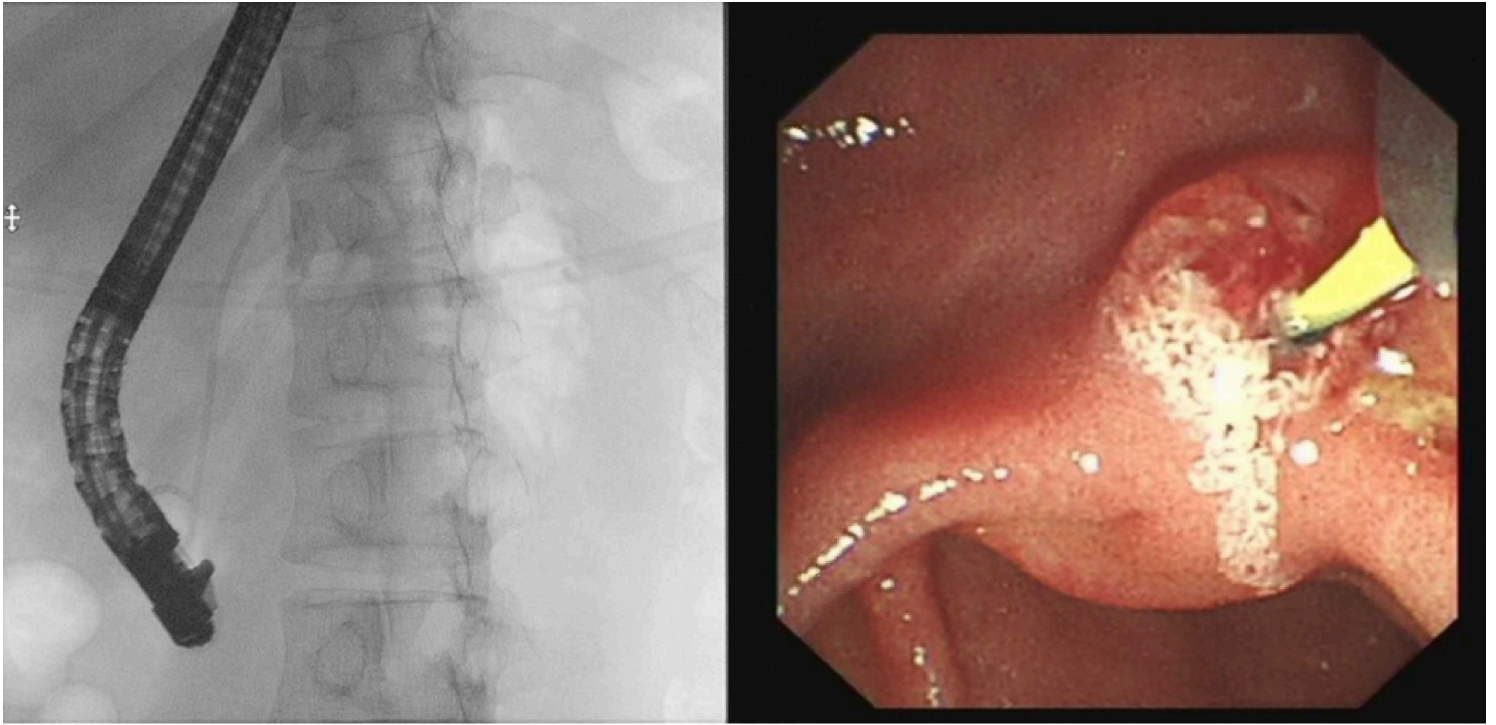


Figure 2

ERCP guided MPD stent placement performed on the day prior to surgery.

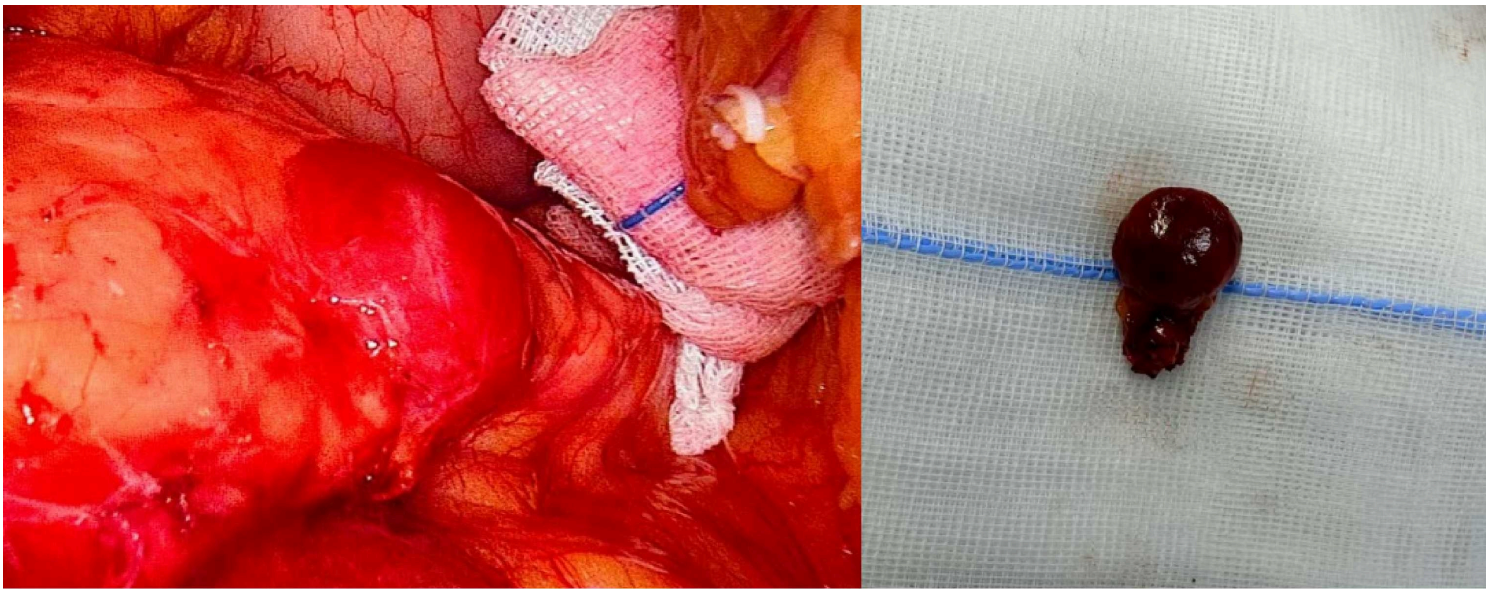


Figure 3

Intraoperative view showing the pancreas exposed via division of the gastrocolic ligament with the tumor localized by IOUS prior to enucleation.

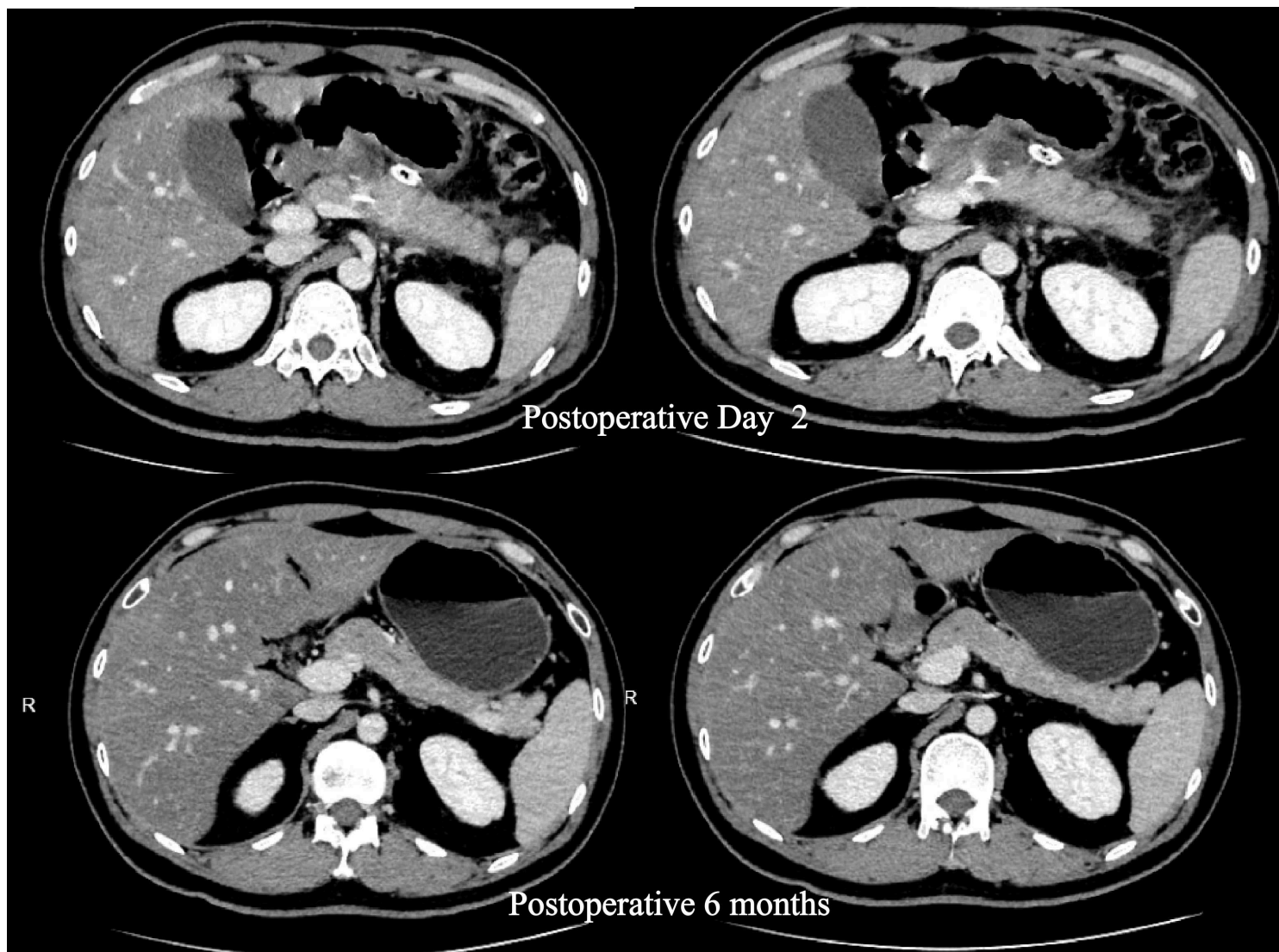


Figure 4

Follow-up contrast-enhanced CT performed at six months postoperatively showing the operative bed with no evidence of local recurrence or fluid collection.