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Near total head resection of pancreas in patients with chronic pancreatitis - Outcome of a novel surgical technique

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ABSTRACT

Background: Chronic pancreatitis (CP) is characterized by debilitating pain which affects patients' quality of life. Early surgical intervention has been shown to mitigate pain and prevent a decline in quality of life. The present study evaluated the impact of bile duct and duodenum preserving pancreatic head resection (BDPPHR), an innovative technique, on pain relief, functional outcomes, postoperative morbidity, and mortality in patients with CP.

Methods: Between March 2019 and July 2022, a total of 37 patients underwent bile duct and duodenum preserving pancreatic head resection (BDPPHR) for pain relief in patients with CP. Post-operative outcomes were assessed by Izbicki pain score, exocrine insufficiency, endocrine insufficiency, and return to work. The safety of the surgical procedure was determined by evaluation of postoperative morbidity and mortality as per Clavien-Dindo scores.

Results: BDPPHR showed a significant reduction in Izbicki pain scores with 30 (81 %) patients experiencing complete or partial pain relief up to 18 months of follow up. 32(86 %) patients ceased narcotic use by the end of the 18-month follow-up period. 33 (89 %) patients were able to resume regular work at the end of 18 months. There were no significant alterations in both exocrine and endocrine statuses post-surgery. The median duration of hospital stay was 4.5 days (3-11). Major complications occurred in 2 (5 %) patients. There was no post-operative mortality.

Conclusion: BDPPHR is a novel and safe technique of near total head resection which results in very good pain relief in 81 % of patients.

1. Introduction

Traditionally, surgical intervention for chronic pancreatitis (CP) was considered as a final option due to the high postoperative morbidity of 53.3 % and mortality of 1–19 % [1,2]. However, advancements in surgical techniques, critical care, and improved postoperative management have led to a significant reduction in mortality and morbidity [3,4]. CP is primarily associated with debilitating pain, adversely affecting patients' quality of life. The concept of early surgical intervention in CP has an emerging role in preventing a decline in patients' quality of life and helps mitigate central sensitization of pain. The ESCAPE trial indicates that early surgery leads to lower pain scores [5].

The head of the pancreas has considerable significance in the onset and evolution of the disease process in chronic pancreatitis [6]. The head is considered the site of the pacemaker for pain in patients with CP [7]. Head is the dominant site of major complications associated with CP like biliary stricture, chronic pseudocyst, pseudoaneurysm and vascular thrombosis. Head is also the site of maximum stone load. In patients with CP who develops malignancy, head is the commonest site of the tumour. Hence, procedures targeting the head has the better potential in providing long term positive outcomes in patients with CP.

Various drainage, excision and hybrid procedures are described in patients with CP. On one side, radical procedures like pancreatoduodenectomy is considered as an overdo in CP which is a benign disease and on the other side, procedures like simple driange of the main pancreatic duct is considered as suboptimal in patients with CP. Hence hybrid procedures like head coring gained wider acceptance and are commonly performed. Lack of exact

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anatomical landmarks for head coring procedures results in varying extents of pancreatic tissue being excised in piecemeal thus making the operation non-uniform with varying long-term outcomes across centres. During head coring, a saucer-shaped cavity is usually left out surrounded all over by pancreatic tissue except the anterior surface of the head of the pancreas [8]. This approach has the potential to leave behind some parts of the ducts, cysts and stones in the head of the pancreas. An ideal conservative head resection in patients with CP warrants a near total head resection with complete preservation of bile duct and duodenum [9]. In this context, to remove the full extent of the pancreatic head anteroposteriorly while preserving the duodenum and bile duct, we introduced and reported the novel technique of bile duct preserving pancreatic head resection (BDPPHR) [10] in the year 2020. It is widely presumed that a thick posterior layer of pancreatic tissue should be retained to prevent postoperative pancreatic fistula (POPF), and also to avoid bilio-vascular injuries especially in cases of severe inflammation but however our experience points to the fact that the preservation of posterior pancreatic tissue is not required. The purpose of this study was to evaluate the impact of BDPPHR on postoperative morbidity, mortality and mid-term outcomes in patients with CP.

2. Materials and methods

A retrospective analysis was conducted in a prospectively maintained database comprising patients who underwent BDPPHR for chronic pancreatitis from March 2019 onwards. The study received approval from the institute's scientific advisory and ethics committees. Inclusion criteria comprised patients aged 18 and above with chronic pancreatitis who underwent surgical management. Patients exclusively presenting with stones and strictures in the tail of the pancreas, with a relatively normal pancreatic head and body, were excluded from the study. The sample size for analysis was determined, based on the expected long-term outcome, as 37, based on the ESCAPE trial's finding that 58 % of patients experienced complete or partial pain relief with early surgical intervention, with a precision of 14 % [5]. Demographic information, medical history, and physical examination findings were documented for each patient. Preoperative imaging results from transabdominal ultrasonogram (USG) and contrast-enhanced computerized tomography (CECT) of the abdomen were recorded.

2.1. Surgical technique

The surgical technique of BDPPHR was previously described by the first author [10]. A bilateral subcostal incision provided access to the abdomen. Subsequently, entry into the lesser sac was achieved dividing the gastro-colic omentum, followed by the ligation of the right gastroepiploic vessels and the right colic veins. Pancreatic exposure extended from the head to the tail till the splenic hilum. Defining the inferior border of the pancreas involved releasing the mesocolic peritoneal reflection on the pancreas from the neck to the tail after identifying the superior mesenteric vein (SMV) and inferior mesenteric vein (IMV). Mobilization of the hepatic flexure of the colon and Kocherization of the duodenum were performed. Posterior pancreatic capsule which is also termed fascia of Treitz was found to be thick in all patients due to chronic inflammation. The surgical procedure involved excising the head of the pancreas in bulk starting from the inferior border of the pancreatic head near the third part of the duodenum leaving behind the thick capsule. In the pancreatic head, the main pancreatic duct (MPD) is not opened but is excised along with the head. Less than 5 mm rim of pancreatic tissue in the duodenal groove was preserved to maintain the vascular arcade to the duodenum (Figs. 1 and 2). Careful preservation of the bile duct was ensured throughout the procedure, with a small segment of pancreatic tissue retained between the bile duct and the duodenum next to the D1-D2 junction. The entire pancreatic ductal complex was excised along with the specimen. The pancreatic sphincter was divided just near the terminal bile duct over a probe negotiated to the duodenum (Fig. 3). In the event of difficulty in identifying the bile duct by inspection, a long right-angled forceps was introduced through the cut edge of the pancreatic sphincter which was negotiated into the bile duct. The entire posterior capsule of the pancreas is bared. A rim of uncinate tissue was preserved to facilitate suturing it with the jejunal limb. A sharp division of the neck of the pancreas was performed just to the right of the SMV. The main pancreatic duct was cut opened longitudinally in the body and till the terminal part of the tail. A lateral pancreatojejunostomy was carried out with a single Roux loop of jejunum prepared approximately 40 cm from the duodenojejunal (DJ) flexure. The loup of jejunum was sutured to the edge of the pancreatic duct and parenchyma in the body and tail and continued to the duodenal serosa in the head region avoiding bites to the rim of the pancreatic tissue to preserve the vascular arcade.

2.2. Outcome measures

The intensity of pain was evaluated using the Izbicki pain score, a validated measure for pain specifically designed for chronic pancreatitis [11]. This score encompassed two subjective elements (Visual Analogue Scale and frequency of pain attacks) and two objective components (use of analgesics and disease-related inability to work). Each item was assigned a score ranging from 0 to 100, and the sum of these values, divided by four, yielded the final pain score. The pain score was initially assessed preoperatively, within three days before the surgery. Subsequent postoperative evaluations were conducted at 6 months, 12 months, and 18 months. Complete pain relief was defined as an Izbicki score of $\leq$10 points, while partial pain relief was indicated by a reduction of more than 50 % from the baseline (with a final score exceeding 10).

The presence of clinical exocrine pancreatic insufficiency (EPI) was ascertained through the identification of steatorrhea and the responsiveness to pancreatic enzyme replacement therapy [12,13]. The evaluation of EPI was conducted both preoperatively and postoperatively. The presence of pancreatic endocrine insufficiency was established through criteria such as fasting plasma glucose exceeding 126 mg/dl, HbA1c levels surpassing 6.5 %, or the use of antidiabetic medication [14]. Other outcomes measured were disease progression (such as pseudocyst formation, bile duct stricture etc.), weight gain, resumption of work, post-operative hospital admissions, short-term and long-term morbidities, postoperative interventions, and mortality.

2.3. Data collection & stastistical analysis

Preoperative data, operative details, and short-term outcomes were extracted from the chronic pancreatitis registry maintained by the Department of Surgical Gastroenterology. Long-term follow-up assessments were conducted at the outpatient department of Surgical Gastroenterology every six months, with a minimum follow-up duration of 18 months. For patients who were unable to attend in person, telephonic interviews were carried out. Data was checked for normality using the Shapiro-Wilkes test. Both Descriptive and Inferential statistics were used for analysis. Quantitative variables were expressed as mean (SD) or, if skewed, as median and range. Categorical data were expressed as proportions. Appropriate statistical tests were used to compare continuous

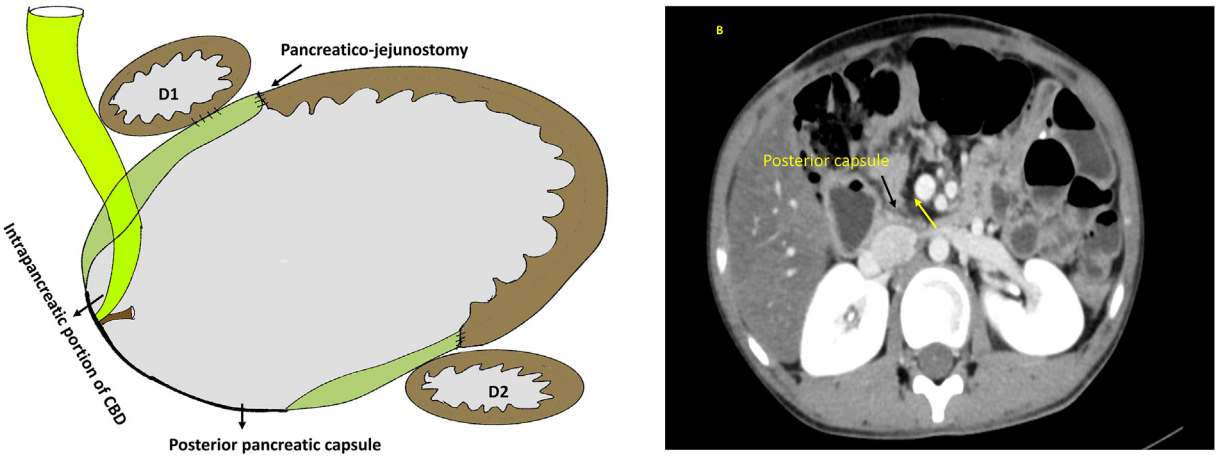

Fig. 1. A) Schematic representation showing perpendicular plane of transection, in bile duct preserving pancreatic head resection (BDPPHR) technique. B) Post bile duct preserving pancreatic head resection (BDPPHR), Contrast enhanced computed tomography (CECT) of the abdomen showing posterior pancreatic capsule and no pancreatic tissue noted over the right edge of the superior mesenteric vein (SMV) (yellow arrow) or posteriorly.

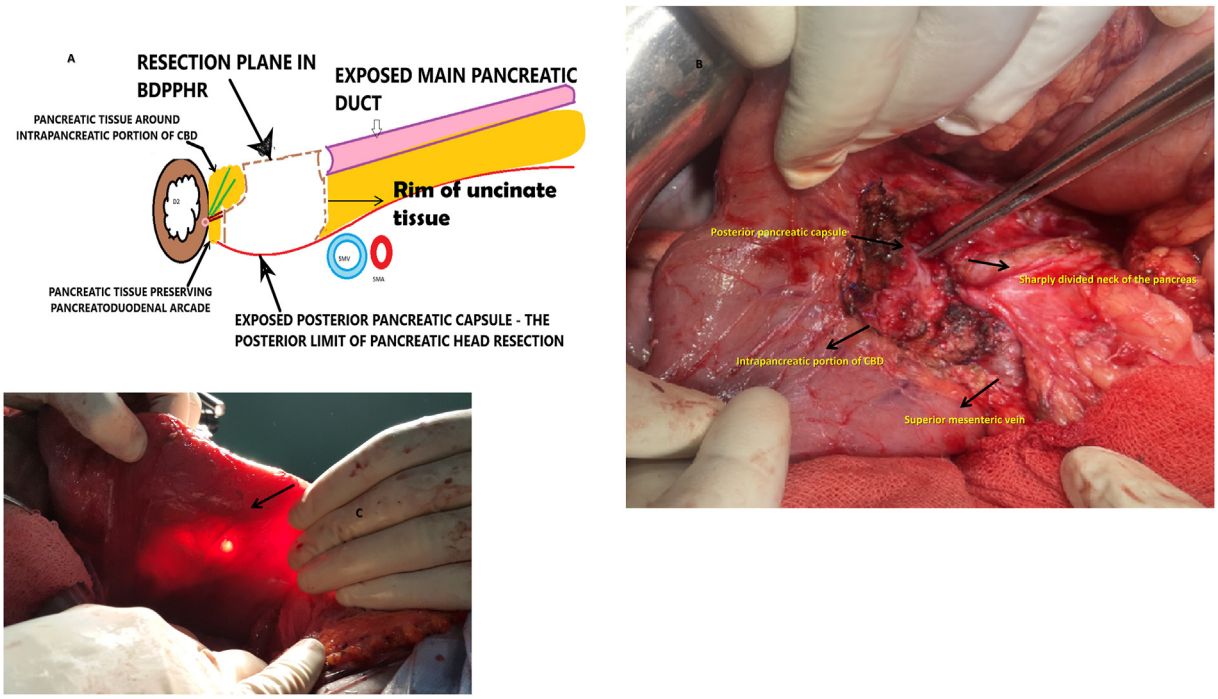

Fig. 2. View from the inferior aspect of pancreas with posterior pancreatic capsule as the posterior limit of bile duct preserving pancreatic head resection (BDPPHR). A) Diagrammatic representation of the resection plane in bile duct preserving pancreatic head resection(BDPPHR) procedure. B) Intraoperative picture after bile duct preserving pancreatic head resection (BDPPHR) depicting posterior pancreatic capsule, intra-pancreatic portion of common bile duct (CBD) & sharply divided neck of the pancreas. C) Intraoperative picture showing illuminated posterior pancreatic capsule (black arrow) after excision of pancreatic head.

variables. Related continuous variables were analyzed using repeated measures ANOVA and categorical variables by McNemar test. The differences in the treatments across multiple test attempts were analyzed by Friedman's test. All analyses were done at a 95 % confidence interval using SPSS version 21. Statistical significance was defined as $p < 0.05$.

3. Results

A total of 37 patients were enrolled. Median age of the study population was 34 years (22–56 years) with a median duration of symptoms due to CP was 3 years (1–15 years) prior to inclusion into the study. The mean BMI of the study populations was 21 kg/m^2 (17–24 kg/m^2). There were 22 (59 %) males and 15 (41 %) females included in our study and the most common aetiology for chronic pancreatitis was alcohol abuse in 14 (37.8 %) patients. Other aetiologies for CP were tropical pancreatitis in 12 (32.4 %) patients, hereditary pancreatitis in 6 (16.2 %) patients and due to obstructive aetiology (pancreatic divisum and sphincter of oddi dysfuction) in 3 (8 %) patients. The aetiology for CP is not identified in 2 (5.4 %) patients and 31 patients (83.7 %) were receiving opoids for pain management before surgery. The CP was complicated with biliary stricture in 6 patients, pseudocyst in 4 patients, inflammatory head mass in 4 patients and splenic vein thrombosis in 3 patients. On

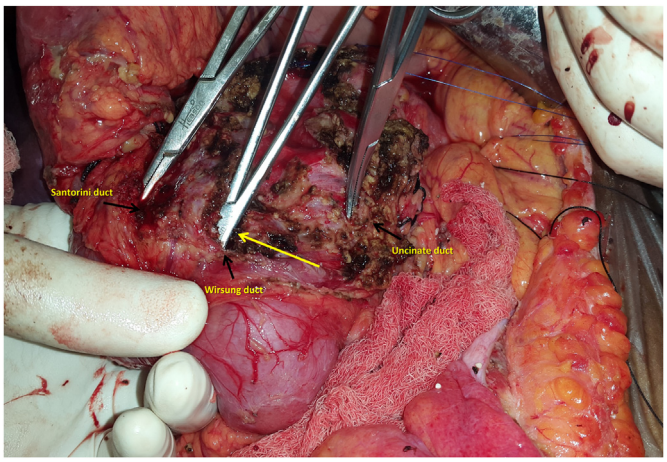

Fig. 3. Intraoperative delineation of opening of pancreatic sphincters. Note: The posterior capsule was everted by the surgeon's hand placed posteriorly and right angled forceps was probed into the ampulla (yellow arrow) for demonstration of the medial wall of the second part of the duodenum to show the entry of ducts into the duodenum.

CECT abdomen, all our patients had calcifications and dilatation of MPD. The median MPD diameter was 5.2 mm (4–8.5 mm).

All patients underwent an open procedure. Median operative time was 355 (280–560) minutes. The mean intraoperative blood loss was 510 (250–1500) ml. The posterior pancreatic capsule was inadvertently opened in two patients; however, this was addressed by primary closure using intermittent polypropylene 3-0 sutures. Bile duct was opened inadvertently in one patient. It was left unrepaired due to the small size and the consideration that side-to-side pancreatojejunostomy would address the leak. No post-operative complications were reported in these patients. Patients with associated bile duct strictures due to chronic pancreatitis underwent side-to-side hepaticojejunostomy with BDPPHR. Four patients with pseudocysts were managed with a combined anastomosis of the cyst and pancreatic duct (authors named this procedure as cysto-ducto-jejunostomy) along with BDPPHR.

There was no post-operative mortality. There was no re-intervention in any of the patients. Over all minor and major postoperative complications were documented in 14/37 (38 %) patients, with the most prevalent being surgical site infection (10/37, 27 %). Clavien-Dindo scores exceeding grade III for postoperative complications were observed in two (5 %) patients only. Complications, such as clinically relevant postoperative pancreatic fistula (CR-POPF), postoperative bleeding, and postoperative mild acute pancreatitis, were reported in one patient each. All patients settled with expectant management.The patient who had bleeding underwent angiography and no source for bleeding was identified. The patient was managed expectantly and the bleeding resolved spontaneously. The median duration of hospital stay was 4.5 days (3–11 days).

Table 1 presents the pre and postoperative Izbicki pain scores (IPS) at 6, 12, and 18 months. The preoperative IPS was recorded at 48 (19–72), demonstrating a significant reduction to 11 (0–52) after 6 months of procedure. Following an 18-month follow-up, the median IPS further decreased to 8.75 (0–61). Notably, complete pain relief was achieved in 20 patients, while 10 patients experienced partial pain relief after 18 months of follow up. Moreover, there was a noteworthy reduction in narcotic use in patients after surgery, with a significant decrease observed after 6 months. Approximately 86 % of patients reported not using opioids at the 18-month mark, reflecting a substantial improvement in pain. There was no difference in the reduction of pain scores in patients with disease onset less than or for more than 3 years prior to the surgery and in patients who were receiving and not receiving opoids preoperatively. At 18 months follow up, the median IPS was low in non alcoholics (8.5) compared to alcoholic CP (9.75) but reduction in the pain scores were not significantly different.

Among the 37 patients included in the study, eight patients (21.6 %) had preoperative clinical EPI and were on pancreatic enzyme replacement therapy (PERT). Post BDPPHR, new onset EPI occurred in 3 (8 %) patients, necessitating PERT where as the patients who had EPI pre-operatively continued to use PERT. The median weight of the study population was 54.6 kgs pre-operatively and was 52.5 kgs at completion of 18 months after the surgery which was not significantly different. 3 patients in our study maintained weight as their preoperative status whereas weight gain was observed in 12 patients and 25 patients had loss of weight which was not significant. Over the 18-month follow-up period, new-onset diabetes developed in three patients, one requiring insulin therapy and two managing with oral hypoglycemic drugs. Importantly, no worsening of diabetes was noted in any of the preoperatively diagnosed diabetic patients, and sugar levels improved to normal after operation in one patient.

During the follow-up, nine patients experienced acute pain flare-ups spread over 18 months. Two patients of alcoholic CP required multiple hospital admissions and unfortunately they continued alcohol abuse and smoking after the surgery despite counselling. At the end of 18 months post-surgery, 33 (89 %) patients were able to resume regular work, signifying a significant improvement compared to their preoperative work status.Long term complications like pseudocysts or biliary stricture were not observed in any patient.

4. Discussion

Among the resection procedures employed for chronic pancreatitis, Frey's procedure has gained wide acceptance. However, the defined extent of pancreatic head resection in Frey's procedure remains a subject of debate. Originally proposed by Frey and Smith in 1987, the procedure suggested leaving a shell or rim of pancreatic tissue in the posterior aspect between the cored-out head and uncinate process [15]. Frey and Amikura, in 1994, reported local resection achieved by excising the pancreatic head overlaying the ducts of Wirsung and Santorini, along with their tributary ducts [16]. This description has led to some variations in the interpretation of the posterior extent of pancreatic resection, contributing to a degree of confusion in defining the limits of the procedure.

Our technique not only ensures near total removal of the head of pancreas enbloc while preserving the bile duct and duodenum. It is widely presumed that a thick pancreatic tissue need to be retained posteriorly in order to avoid a leak but BDPPHR accurately defined the posterior extent of head resection, specifically identifying the plane between pancreatic tissue and the thick posterior pancreatic capsule [10]. Intrapancreatic bile duct injury was a rare occurrence if the area of the bile duct is dissected carefully. Even if the bile duct gets opened up, its effect on the long term outcome may not be adverse. Gloor et al. described a modified approach to the Beger and Frey procedures, involving the intentional laying open of the intrapancreatic common bile duct during the surgical intervention [17]. Low possibility of post-operative deaths, low morbidity and short hospital stay in the short term substantiates the safety profile of BDPPHR. Mike and Kano described the embryologically so-called fascia of Treitz which corresponds to the retro-duodenopancreatic fascia or the posterior pancreatic fascia [18] which is the posterior limit of resection in our patients. Leaks from the pancreas may not be as severe as in post pancreaticoduodenectomy as this posterior

Table 1
Outcome in the pain domain after Bile Duct Preserving Pancreatic Head Resection (BDPPHR) in patients with chronic pancreatitis(CP).

		Preoperative	Post operative - 6 months	Post operative- 12 months	Post operative- 18 months	p- value
Izbicki pain score	Frequency of pain attack	50 (25–100)	25(0–75)	25 (0–75)	25 (0–75)	<0.001*
	VAS score	80(50–100)	20 (0–70)	20 (0–80)	20 (0–80)	<0.001*
	Pain Medication	15(0–100)	0 (0–15)	0 (0–15)	0 (0–15)	<0.001*
	Inability to work	50 (0–75)	0 (0–75)	0(0–75)	0 (0–75)	<0.001*
	Total Score	48 (19–72)	11 (0–52)	11 (0–55)	8.75 (0–61)	<0.001*
Narcotic use	Morphine use, n (%)	1 (2.7)	0	0	0	<0.001€
	Tramadol daily/weekly, n (%)	9 (24.3)	2 (5.4)	1(2.7)	1 (2.7)	
	Tramadol 1–2 times in month, n (%)	21(56.7)	5 (13.5)	5 (13.5)	4 (10.8)	
	No narcotics, n (%)	6 (16.2)	30 (81.1)	31(83.8)	32(86.5)	
Time of disease-related inability to work	Permanent, n (%)	0	0			<0.001€
	≤1 Year, n (%)	4 (10.8)	2(5.4)			
	≤1 month, n (%)	18 (48.6)	1(2.7)			
	≤1 week, n (%)	9(24.3)	1(2.7)			
	No inability to work, n (%)	6 (16.2)	33 (89.1)			

sheath is thick which decreases or may even prevent POPF. Until now we believe that this thick posterior sheath is an unrecognized and unutilized entity in CP.

The absence of reported mortality within 30 days following BDPPHR is a notable finding, supporting the safety of surgical procedure. Similarly, both the Frey procedure and the Izbicki procedure had reported no 30-day mortality in their respective experiences [19,20]. Beger et al. documented a single hospital mortality among 128 patients who underwent the procedure [21]. The low incidence of severe complications in our series, as indicated by Clavien-Dindo scores, further underscores the overall favorable safety profile of BDPPHR. In the study reported by Frey's et al., 22 % of patients experienced postoperative complications, with 8 % developing clinically relevant postoperative pancreatic fistula (CR-POPF) requiring drainage [16]. Izbicki et al. reported a 15.4 % incidence of postoperative morbidity, including bile leak and CR-POPF reported in one patient each [20].

The theory of pathogenesis of the pain syndrome depicts that pancreatic head is pacemaker of the pain and the seat for most the local complications of pancreatitis [17]. Our patients in this series reported significant pain relief, as measured by the Izbicki score with 81 % of patients reporting either complete or partial relief. Both Frey et al. and Mayer et al. highlighted improvements in pain in 87 % of patients [19], while the study by Izbicki reported complete relief in 95 % of cases [20]. The ESCAPE trial, focusing on early surgical intervention, revealed that 58 % of patients experienced complete or partial pain relief [5]. In the context of the "minimal Frey's procedure," Sakata et al. reported complete pain relief in 65 % of patients at one-year follow-up [22]. The substantial decrease in narcotic use observed in our study underscores the effectiveness of BDPPHR in pain management, with approximately 86 % of patients entirely free from opioids at the end of the 18-month follow-up. Frey et al. and Amikura et al. reported a significant reduction in narcotic use in 74.5 % of patients [16]. Recognizing pain as a pivotal factor in determining work status, our study revealed that 89 % of patients could resume work without interruption at 18-months follow up period. These findings collectively emphasize the positive impact of BDPPHR on pain relief, narcotic use, and overall functional outcomes, supporting its efficacy in improving patients' quality of life. Moreover, over the 18 months follow up, none of the patients had pseudocyst or biliary stricture.

21 % of our patients had clinical EPI before operation. Postoperatively, 8 % of patients developed new-onset steatorrhea. Similarly, patients who underwent longitudinal pancreatojejunostomy and Frey's procedure experienced new onset steatorrhea in 10 % and 11 % respectively [19,20] pointing to the fact that aggressive resection does not increase the incidence of exocrine insufficiency. Despite the overall positive outcomes, our study draws attention to challenges associated with weight gain. We observed that occurrence of weight gain in only 12 patients indicating the complexity of addressing nutritional aspects in the postoperative period especially in developing countries like India. This also explains the low BMI in majority of out patients. Comparatively, weight gain was reported in 72 % following Frey's procedure, 87 % in longitudinal pancreatojejunostomy, and 81 % in the Beger procedure [19,23,24].

New onset diabetes mellitus was observed in 8 % of patients in our study, necessitating medication for the control of hyperglycemia. There was no worsening of diabetes in preoperatively diagnosed patients, and high sugar values improved to normal in one patient. Frey et al. reported that 11 % of patients developed new onset diabetes, with worsening diabetes observed after surgery in one patient [19]. Additionally, Buchler et al. observed new onset diabetes in 2 % of patients following Beger procedure [25]. However, two latent deaths occurred in our series due to continued failure to abstain from alcohol, leading to complications and the development of malnutrition. Frey et al. reported a 10 % late mortality in his study, with two patients expired due to continued alcohol abuse [15]. These observations emphasize the importance of addressing lifestyle factors postoperatively and the need for comprehensive care to optimize long-term outcomes following pancreatic surgeries.

In summary, the differences and advantages of this technique are as follows.

The pancreatic head is excised en-bloc along with all the ducts rather than coring in piecemeal, opening the ducts and clearing the stones. Pancreatic sphincter openings in the ampulla are amputated. It is not necessary to retain pancreatic tissue posteriorly since the posterior pancreatic fascia in patients of CP is thick and will retain the duodenal architecture intact. The pancreato-enteric anastomosis can be done with a single loop with sutures to the duodenal wall in the head region and to the pancreatic duct/parenchyma in the body and tail region which decreases the risk of injuring the duodenal vasculature and at the same time addressing potential bile leak and leak from the pancreatic rim if any. Hence, our procedure is equally radical to Beger's procedure but also avoids a second anastomosis and more radical than Frey's procedure and coring. This procedure also has very low mortality, low morbidity, short hospital stay and has the potential for excellent long term results especially in the relief of pain. The authors recommend BDPPHR as a standard surgical technique in patients with CP.

References

[1] Ho C-K, Kleeff J, Friess H, Büchler MW. Complications of pancreatic surgery. HPB (Oxford) 2005;7:99–108. https://doi.org/10.1080/13651820510028936.

[2] Wilson Gregory C, Kevin Turner, Delman Aaron M, Wahab Shaun, Ofosu Andrew, Smith Milton T, Choe Kyuran A, Patel Sameer H, Ahmad Syed A. Long-term survival outcomes after operative management of chronic pancreatitis: two decades of experience. J Am Coll Surg April 2023;236(4): 601–10. https://doi.org/10.1097/XCS.0000000000000575.

[3] Ghorbani P, Dankha R, Brisson R, D'Souza MA, Löhr J-M, Sparrelid E, et al. Surgical outcomes and trends for chronic pancreatitis: an observational cohort study from a high-volume centre. J Clin Med 2022;11:2105. https://doi.org/10.3390/jcm11082105.

[4] Keck T, Adam U, Makowiec F, Riediger H, Wellner U, Tittelbach-Helmrich D, Hopt UT. Short- and long-term results of duodenum preservation versus resection for the management of chronic pancreatitis: a prospective, randomized study. Surgery 2012 Sep;152(3 Suppl 1):S95–102. https://doi.org/10.1016/j.surg.2012.05.016. PMID: 22906892.

[5] Issa Y, Kempeneers MA, Bruno MJ, Fockens P, Poley J-W, Ahmed Ali U, et al. Effect of early surgery vs endoscopy-first approach on pain in patients with chronic pancreatitis: the ESCAPE randomized clinical trial. JAMA 2020;323: 237–47. https://doi.org/10.1001/jama.2019.20967.

[6] Andersen DK, Frey CF. The evolution of the surgical treatment of chronic pancreatitis. Ann Surg 2010 Jan;251(1):18–32. https://doi.org/10.1097/SLA.0b013e3181ae3471. PMID: 20009754.

[7] Traverso LW. The surgical management of chronic pancreatitis: the Whipple procedure. Adv Surg 1999;32:23–39. PMID: 9891738.

[8] Tan CL, Zhang H, Yang M, Li SJ, Liu XB, Li KZ. Role of original and modified Frey's procedures in chronic pancreatitis. World J Gastroenterol 2016 Dec 21;22(47):10415–23. https://doi.org/10.3748/wjg.v22.i47.10415. PMID: 28058022; PMCID: PMC5175254.

[9] Liu X, Hu Z, Zhou X, Qin J, Xing Z, Liang Y, Duan J, Liu J, Liu J. How to implement minimally invasive duodenum-preserving total pancreatic head resection for patients with pancreatic head lesions: a retrospective study. Medicine (Baltim) 2023 Aug 4;102(31):e34608. https://doi.org/10.1097/MD.0000000000034608. PMID: 37543764; PMCID: PMC10402987.

[10] Nitesh PNB, Pottakkat B. Bile duct preserving pancreatic head resection (BDPPHR): can we conclusively define the extent of head resection in surgery for chronic pancreatitis? Ann Hepatobiliary Pancreat Surg 2020;24:309–13. https://doi.org/10.14701/ahbps.2020.24.3.309.

[11] Bloechle C, Izbicki JR, Knoefel WT, Kuechler T, Broelsch CE. Quality of life in chronic pancreatitis–results after duodenum-preserving resection of the head of the pancreas. Pancreas 1995;11:77–85. https://doi.org/10.1097/00006676-199507000-00008.

[12] Phillips ME, Hopper AD, Leeds JS, Roberts KJ, McGeeney L, Duggan SN, et al. Consensus for the management of pancreatic exocrine insufficiency: UK practical guidelines. BMJ Open Gastroenterol 2021;8:e000643. https://doi.org/10.1136/bmjgast-2021-000643.

[13] Issa Y, van Santvoort HC, van Goor H, Cahen DL, Bruno MJ, Boermeester MA. Surgical and endoscopic treatment of pain in chronic pancreatitis: a multidisciplinary update. Dig Surg 2013;30:35–50. https://doi.org/10.1159/000350153.

[14] Aslam M, Jagtap N, Karyampudi A, Talukdar R, Reddy DN. Risk factors for development of endocrine insufficiency in chronic pancreatitis. Pancreatology 2021 Jan;21(1):15–20. https://doi.org/10.1016/j.pan.2020.11.011. Epub 2020 Nov 24. PMID: 33257226.

[15] Frey CF, Smith GJ. Description and rationale of a new operation for chronic pancreatitis. Pancreas 1987;2:701–7. https://doi.org/10.1097/00006676-198711000-00014.

[16] Frey CF, Amikura K. Local resection of the head of the pancreas combined with longitudinal pancreaticojejunostomy in the management of patients with chronic pancreatitis. Ann Surg 1994;220:492–504. https://doi.org/10.1007/BF02348284. ; discussion 504-507.

[17] Gloor B, Friess H, Uhl W, Büchler MW. A modified technique of the Beger and Frey procedure in patients with chronic pancreatitis. Dig Surg 2001;18:21–5. https://doi.org/10.1159/000050092.

[18] Mike M, Kano N. Laparoscopic surgery for colon cancer: a review of the fascial composition of the abdominal cavity. Surg Today 2015 Feb;45(2):129–39. https://doi.org/10.1007/s00595-014-0857-9. Epub 2014 Feb 11. PMID: 24515451.

[19] Frey CF, Mayer KL. Comparison of local resection of the head of the pancreas combined with longitudinal pancreaticojejunostomy (frey procedure) and duodenum-preserving resection of the pancreatic head (beger procedure). World J Surg 2003;27:1217–30. https://doi.org/10.1007/s00268-003-7241-z.

[20] Izbicki JR, Bloechle C, Broering DC, Kuechler T, Broelsch CE. Longitudinal V-shaped excision of the ventral pancreas for small duct disease in severe chronic pancreatitis: prospective evaluation of a new surgical procedure. Ann Surg 1998;227:213–9.

[21] Beger HG, Büchler M, Bittner RR, Oettinger W, Roscher R. Duodenum-preserving resection of the head of the pancreas in severe chronic pancreatitis. Early and late results. Ann Surg 1989;209:273–8. https://doi.org/10.1097/00000658-198903000-00004.

[22] Sakata N, Egawa S, Motoi F, Goto M, Matsuno S, Katayose Y, et al. How much of the pancreatic head should we resect in Frey's procedure? Surg Today 2009;39:120–7. https://doi.org/10.1007/s00595-008-3816-5.

[23] Mannell A, Adson MA, McIlrath DC, Ilstrup DM. Surgical management of chronic pancreatitis: long-term results in 141 patients. Br J Surg 1988;75: 467–72. https://doi.org/10.1002/bjs.1800750522.

[24] Beger HG, Mayer B, Poch B. Resection of the duodenum causes long-term endocrine and exocrine dysfunction after Whipple procedure for benign tumors - results of a systematic review and meta-analysis. HPB (Oxford) 2020;22:809–20. https://doi.org/10.1016/j.hpb.2019.12.016.

[25] Büchler MW, Friess H, Bittner R, Roscher R, Krautzberger W, Müller MW, et al. Duodenum-preserving pancreatic head resection: long-term results. J Gastrointest Surg 1997;1:13–9. https://doi.org/10.1007/s11605-006-0004-z.