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Early experience with robot-assisted Frey's procedure surgical outcome and technique: Indian perspective

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Purpose: Robotic surgery for pancreatic diseases is currently on the rise, feasible, well-accepted, and safe. Frequently performed procedures in relation to pancreatic diseases include distal pancreatectomy and pancreatoduodenectomy. The literature commonly describes robotic lateral pancreaticojejunostomy; however, data on robot-assisted Frey's is scarce.

Methods: We herein, describe our series and technique of robot-assisted Frey's procedure at our tertiary care center between November 2019 and March 2022, and its short-term outcomes in comparison to the open Frey's. Patients with chronic pancreatitis having intractable pain, dilated duct, and no evidence of inflammatory head mass or malignancy were included in the study for robot-assisted Frey's.

Results: In our study, out of 32 patients, nine patients underwent robot assisted Frey's procedure. The duration of surgery was significantly longer in robotic group (570 minutes vs. 360 minutes, $p = 0.003$). The medians of intraoperative blood loss and postoperative analgesic requirement were lower in robotic group, but the difference was not statistically significant (250 mL vs. 350 mL, $p = 0.400$ and 3 days vs. 4 days, $p = 0.200$, respectively). The median length of hospital stay was shorter in the robotic group, though not significant (6 days vs. 7 days, $p = 0.540$). At a median follow-up of 28 months, there was no significant difference in the postoperative complications and short-term outcomes between the two groups.

Conclusion: Robotic surgery offers benefits of laparoscopic surgery in addition it has better visualization, magnification, dexterity, and ergonomics. Frey's procedure is possible robotically with acceptable outcomes in selected patients.

Keywords: Robotic surgery, Frey's procedure, Minimally invasive procedures, Robotic-assisted surgery

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INTRODUCTION

Robotics surgery in pancreatic disease and malignancy is feasible, well-accepted, safe, and gaining momentum. It holds a good promise to become a standard of care in the near future for many procedures. The most commonly performed procedures include distal pancreatectomy and pancreatoduodenectomy. Various studies are in their nascent phases; however, robotic surgery for pancreas is deemed as safe and feasible with decreased length of hospital stay. Pancreatic surgery is challenging due to adjacent major vessels, fear of postoperative fistulas, and the retroperitoneal position of the pancreas [1]. Giulianotti et al. [2] were the first to publish about robotic pancreatoduodenectomy in Europe in 2003; and in the same year, Melvin et al. [3] described it in pancreatic neuroendocrine tumor from the United States.

Professor Charles Frederick Frey (1929–2022) published his new operation for chronic pancreatitis in 1987 describing his procedure in six patients [4]. Frey's procedure consists of local resection of the pancreatic head combined with lateral pancreaticojejunostomy. It is one of the most commonly performed procedures for

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chronic pancreatitis which can be performed open, laparoscopic, and also feasible robotically. Surgery is commonly indicated in chronic pancreatitis for intractable pain. Resection procedures for chronic pancreatitis are preferred over drainage procedures in terms of better pain relief in the former. The literature describes robotic lateral pancreaticojejunostomy; however, data on robot-assisted Frey's procedure is scarce. Robotic Frey's procedure is a recent advancement in the management of chronic pancreatitis and carries the advantage of minimally invasive benefits of laparoscopic surgery including less pain, decreased wound infection, and decreased length of hospital stay plus better visualization, magnification, improved ergonomics, surgeon comfort, increased degree of freedom and elimination of tremors. Herein, we describe our series, outcome and technique of robot-assisted Frey's procedure at our tertiary care center comparing robot-assisted Frey's with open Frey's procedure.

MATERIALS AND METHODS

After receiving approval from the Institutional Review Board, we conducted a retrospective analysis of prospectively maintained data from 32 patients who underwent Frey's procedure. Permission and consent for the procedure were obtained, and a total of nine patients with chronic pancreatitis who had intractable pain requiring frequent analgesics and a decreased quality of life underwent robot-assisted Frey's Jawaharlal Institute of Postgraduate Medical Education & Research, Pondicherry between November 2019 and March 2022. All patients with chronic pancreatitis due to various causes requiring surgery with a dilated duct of >7 mm and no evidence of an inflammatory head mass or malignancy, either clinically or on triple-phase contrast-enhanced computed tomography, were included. Patients who were unwilling to undergo robotic surgery had a nondilated main pancreatic duct (MPD) or were suspected of having malignancy were excluded from the study. Patients who had previously undergone major abdominal surgery were also excluded. Surgery was accomplished using the da Vinci Xi surgical system (Intuitive Surgical, Inc., Sunnyvale, CA, USA). There was one open conversion, and one patient underwent Frey's Plus procedure for biliary stricture in the form of a robotic Roux-en-Y hepaticojejunostomy. These data were compared to the open Frey's procedure performed at our institute, and patients were followed up for the detection of new-onset diabetes, the need for analgesics, and the requirement of pancreatic enzyme replacement therapy (PERT).

The perioperative and short-term outcomes of patients who underwent open and robot-assisted Frey's procedure were compared. Categorical variables were expressed as frequencies and continuous variables as median with range. Categorical variables were analyzed using Fisher exact test and continuous variables using the Mann-Whitney U-test. Data were analyzed using IBM SPSS version 19.0 (IBM Corp., Armonk, NY, USA).

Surgical technique

After general anesthesia patient is positioned supine with legs split or French position. Pneumoperitoneum is established with a 12-mm umbilical port and open umbilical pillar technique; named as assistant port (A1). Total of six ports are used, and four robotic ports (R) are placed in horizontal line at the level of umbilicus. R2 and R3 are placed 4 cm each from the assistant port. R1 and R4 are placed 7 cm from R2 and R3 respectively along the same line. One more 12-mm assistant port (A2) is placed 4 cm below and in between R1 and R2 (Fig. 1).

Subsequently, omental bursa is opened and gastrocolic omentum is taken down using energy source (Fig. 2A). Robotic arms are docked from the right side of the patient. The body of the stomach is retracted up anteriorly using silk sutures hitched to the anterior abdominal wall. The inferior border of the pancreas is defined from the transverse mesocolon. Right colic vein and accessory right colic vein are identified and divided using nonabsorbable polymer ligating clips. The dissection is done along the right gastroepiploic vein and divided between the clips. Infrapyloric vessels and the right gastroepiploic artery are identified and divided between the nonabsorbable polymer ligating clips (Fig. 2B). Gastroduodenal artery is identified and ligated in continuity using 3-0 polypropylene to reduce bleeding during pancreatic head coring. Hepatic flexure is mobilized and kocherization of the duodenum is done.

The MPD is identified in the body region by directly opening the duct using a monopolar scissor. However, in cases where the localization is difficult intraoperative ultrasound (IOUS) can be used to identify the duct. MPD is laid open completely in the body, tail, and head region using monopolar and bipolar cautery for adequate drainage (Fig. 2C). Multiple concretions or stones present within the MPD can be extracted using the Maryland

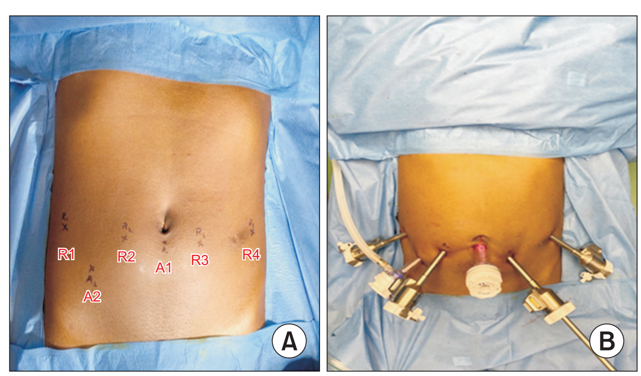

Fig. 1. Port placement. (A) Port A1 and A2 for assist and port R1 to R4 for robotic instruments. (B) View after port insertion.

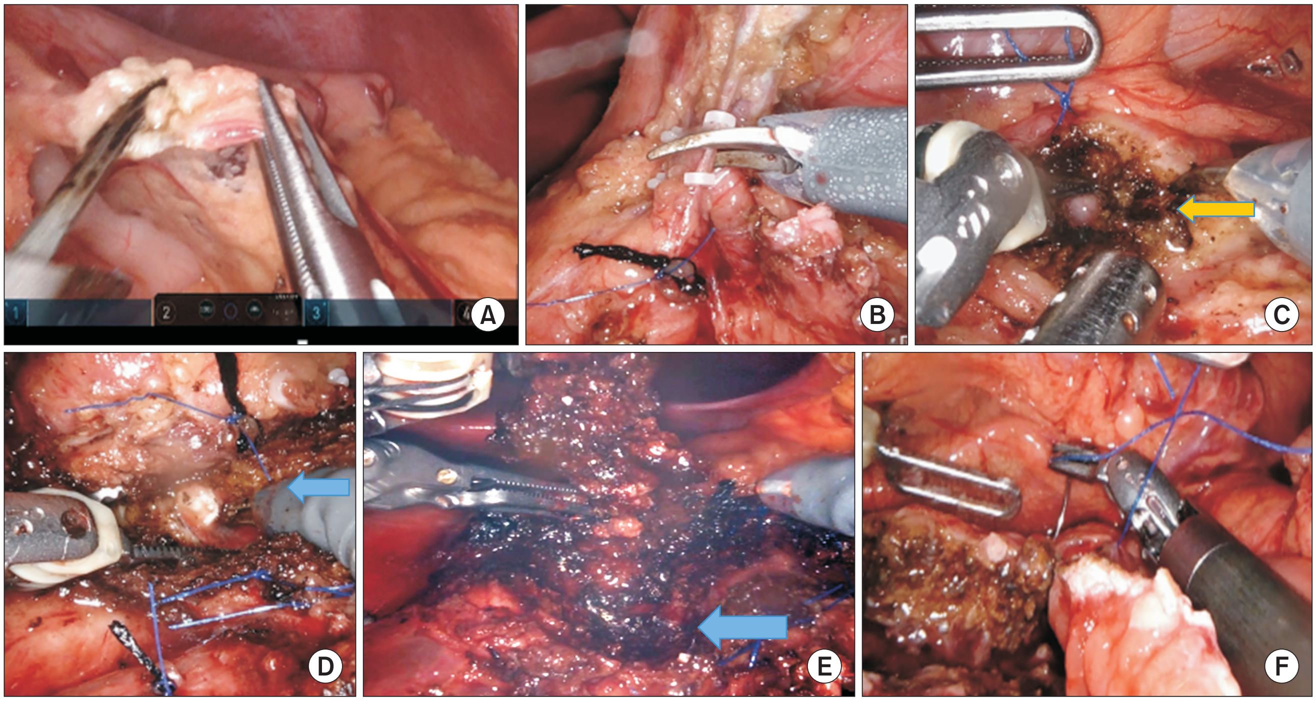

Fig. 2. Procedures of robot-assisted Frey's procedure. (A) Opening lesser sac. (B) Dividing right gastroepiploic artery. (C) Laying opening of main pancreatic duct (MPD; yellow arrow). (D) Stones (blue arrow) retrieval from MPD. (E) Head coring (blue arrow). (F) Side-to-side pancreaticojejunostomy.

dissector or a suction device (Fig. 2D). Preplaced hemostatic sutures are taken in the head region close to duodenal C-loop before coring the pancreatic head. The coring is done with the help of monopolar and bipolar cautery leaving a 5-mm rim of pancreatic tissue close to duodenal C-loop (Fig. 2E). Subsequently, the ampulla is probed with a 5-French infant feeding tube to detect any ampulla strictures. The Roux limb of the jejunum is created approximately 25 cm from the duodenojejunal flexure with a 60-mm endoscopic gastrointestinal (GI) blue stapler. Roux loop can be brought through the mesocolic window to the left or right of the middle colic artery in the retrocolic fashion. Side-to-side pancreaticojejunostomy is done with 3-0 polypropylene suture in a continuous fashion (Fig. 2F). Jejunojejunostomy is done around 40 cm distal to pancreaticojejunostomy with 45-mm endoscopic GI blue stapler. Enterotomy is closed in two layers using 3-0 polydioxanone, continuous inner suture, and outer polypropylene 3-0 suture in a continuous fashion. Drains are kept in the lesser sac near the pancreaticojejunostomy anastomosis and brought out through the left and right flanks, respectively (Supplementary Video 1).

Following surgery nasogastric tube was planned to be removed on postoperative day 1 (POD 1) if the output was less than 200 to 300 mL. On POD 1, patients were given oral liquids, and if they tolerated them well, they were gradually transitioned to a semi-solid diet by POD 3, and drain amylase was measured on POD 3. Drains were removed based on the drain amylase and drain output. Postoperative pain was managed with epidural anesthesia and intravenous analgesics and subsequently with oral analgesics until discharge.

RESULTS

During the study period, 32 patients underwent Frey's procedure for chronic pancreatitis. Of the 32 patients, nine underwent robot-assisted Frey's procedure, which includes one patient in whom robot-assisted Frey's procedure was converted to open due to excessive bleeding from the gastrocolic trunk. The gastrocolic trunk was densely adherent to the pancreas due to dense fibrosis, causing difficulty in dissection. The remaining 23 patients underwent open Frey's procedure (Table 1). One patient in the robotic group and 11 patients in the open group had endocrine deficiency preoperatively. None of the patients had exocrine deficiency before surgery. One patient in the robotic group and two patients in the open group had obstructive jaundice due to biliary stricture, which was managed with preoperative biliary drainage and subsequently underwent a hepaticojejunostomy in addition to Frey's procedure. One patient in the open group had a pseudocyst in the tail region of the pancreas, which was drained along with Frey's procedure.

The operative time was significantly higher in the robotic-assisted Frey's group. The intraoperative blood loss was not significantly different between the groups (Table 2). Three patients

Table 1. Demographic and clinical features of patients who underwent robot-assisted and open Frey's procedure

Characteristic	Robot-assisted Frey's procedure	Open Frey's procedure
No. of patients	9	23
Age (yr)	35 (13–56)	39 (20–60)
Male sex	7 (77.8)	16 (69.9)
Etiology		
Alcoholic	2 (22.2)	8 (34.8)
Idiopathic	7 (77.8)	15 (65.2)
Duration of symptoms (yr)	4 (0.5–14)	3 (0.25–15)
Associated biliary stricture	1 (11.1)	2 (8.7)
Pseudocyst	0 (0)	1 (4.3)
Endocrine insufficiency	1 (11.1)	11 (47.8)
Exocrine insufficiency	0 (0)	0 (0)
Comorbidity		
Hypothyroidism	0 (0)	1 (4.3)
Hyperparathyroidism	0 (0)	1 (4.3)

Values are presented as number only, median (range), or number (%).

in the robotic group and five patients in the open group required IOUS for localization of the pancreatic duct. There was no post-operative mortality or significant difference in the postoperative complications between the two groups. None of the patients in either group had clinically relevant postoperative pancreatic fistulae. In the robotic group, one patient experienced self-limiting GI bleeding (no source was revealed with imaging and endoscopy evaluation), and another had paralytic ileus, which resolved with conservative measures. In the open group, one patient had a bile leak, and seven patients had superficial surgical site infections, which improved with conservative measures. Though the postoperative analgesic requirement and hospital stay were lower in the robotic group, it was not significantly different between the groups. At a median follow-up of 28 months (range, 3–32 months), one patient in the open group developed exocrine deficiency, requiring PERT. No patient had new-onset diabetes and was free of analgesics in both groups (Table 2).

DISCUSSION

Chronic pancreatitis is an irreversible inflammatory process of the pancreas that is frequently associated with exocrine and endocrine insufficiencies. It has a varied etiology, with alcohol

Table 2. Perioperative and short-term outcomes of patients who underwent robot-assisted and open Frey's procedure

Parameter	Robot-assisted Frey's procedure (n = 9)	Open Frey's procedure (n = 23)	*p* value
Duration of surgery (min)	570 (365–960)	360 (245–660)	0.003
Blood loss (mL)	250 (100–1,400)	350 (75–800)	0.400
IOUS for duct identification	3 (33.3)	5 (21.7)	0.654
Hepaticojejunostomy	1 (11.1)	2 (8.7)	>0.999
Pseudocyst drainage	0 (0)	1 (4.3)	>0.999
Postoperative analgesic requirement (day)	3 (2–5)	4 (3–9)	0.200
Postoperative hospital stays (day)	6 (5–12)	7 (4–20)	0.540
Pancreatic fistulae			
Biochemical POPF	3 (33.3)	6 (26.1)	0.685
CR-POPF	0 (0)	0 (0)	NA
Postoperative GI bleeding	1 (11.1)	0 (0)	0.281
Bile leak	0 (0)	1 (4.3)	>0.999
Surgical site infection	0 (0)	7 (30.4)	0.149
Short-term follow-up			
New-onset diabetes	0 (0)	0 (0)	NA
PERT requirement	0 (0)	1 (4.3)	>0.999
Pain relief (free of analgesics)	9 (100)	23 (100)	NA

Values are presented as median (range) or number (%).
IOUS, intraoperative ultrasound; POPF, postoperative pancreatic fistula; NA, not applicable; CR-POPF, clinically relevant POPF; GI, gastrointestinal; PERT, pancreatic enzyme replacement therapy.

consumption being the most prevalent cause worldwide. Patients primarily present with constant, recurrent, radiating pain, parenchymal or ductal calcification, and exocrine or endocrine insufficiency. It is an enfeebling condition requiring surgical intervention in almost 40% to 75% of patients in the course of their illness [5]. Surgical approaches are predominantly divided into resection, drainage, and hybrid procedures. Resection approaches like distal pancreatectomy, pancreatoduodenectomy, and total pancreatectomy impart better long-term pain relief but at the cost of increased morbidity and mortality [6]. Hybrid approaches are preferred over drainage alone, as the former has better long-term outcomes. Hybrid surgeries, including Beger's and Frey's procedures, can be accomplished by an open, laparoscopic, or robotic approach. Several randomized controlled trials have concluded that Frey's procedure is superior to other drainage and resection procedures for chronic pancreatitis in terms of long-term outcomes and associated morbidity [4,7,8].

Since the inception of da Vinci surgical system in the 1990s for robotic surgeries, there has been a constant rise in the number of procedures performed annually all over the world. There has been a substantial rise in the use of robotic pancreatic surgery, especially in the last decade, but it is still restricted to the centers of excellence [9]. The limiting factors were cost, learning curve, and lack of adequate training programs [10,11]. Another short-term limiting factor identified in our study was the sudden global outbreak of coronavirus disease 2019 in November 2019, which coincided with the start of robotic Freys in our institute. The validity of the best surgical approach for chronic pancreatitis is still debated. Laparoscopic surgery offers similar pain relief and a shorter hospital stay as compared to the open approach. While comparing laparoscopic and robotic approaches, the latter has additional benefits apart from less pain, less morbidity, a better cosmetic outcome, and a decreased length of hospital stay [12]. The key advantages are binocular three-dimensional visualization, magnification, degree of freedom, elimination of tremors, dexterity, excellent hemostatic energy devices, and improved ergonomics [12,13]. Our study also reflects a trend toward improved postoperative analgesia, decreased postoperative length of hospital stay, and comparable morbidity rates in patients undergoing robotic surgery. Though long-term follow-up is required to evaluate the key postoperative outcomes, such as pain relief and endocrine and exocrine insufficiency, which require PERT, the short-term follow-up results show comparable outcomes to the open Frey's procedure.

The shortcomings pertaining to robotic surgery include lack of haptics, cost, length of surgery, size of device, need for an experienced surgeon, and problems regarding port position in multiple quadrant surgeries [13,14]. These are being tackled by various means, with studies underway for developing haptic gloves for improving tactile sensation during surgery [15]. The length of surgery and surgical outcomes are bound to shorten as the learning curve flattens and the surgeon gains experience [16]. The cost and size of the device will come down in the near future, as various other companies have entered the manufacturing market for robotic devices and various patents of the leading company are expiring. Cost analysis was not conducted for this study; however, in our institute, the cost incurred is similar to open surgery, as it is a government-funded institute charging minimal operative charges contrary to the high cost of robotic surgery elsewhere, which amounts to approximately 350 U.S. dollars. This benefit can be extended due to a decreased length of hospital stay, less immediate postoperative pain, a reduced requirement for intravenous analgesics, and a decreased incidence of incisional hernia in the minimally invasive group in comparison to open surgery. Another challenge in robotic surgery for chronic pancreatitis can be the identification of MPD, especially in patients with bulky pancreas. IOUS can be helpful in dealing with such situations effectively; it was used in three cases of robot-assisted Frey's procedure [17].

In chronic pancreatitis, the pancreatic head is thought to be the pain pacemaker; therefore, adequate pancreatic head resection or coring is critical for pain relief [18]. Technically, with robotic Frey's procedure, head coring is adequately achieved due to the increased degree of movement with better energy devices to control bleeding and remove an adequate volume of pancreatic tissue, which is similar to open surgery. In laparoscopic surgery, there is a fear of under-doing head coring due to poor control of bleeding and difficulty in coring, as well as performing anastomoses, especially in the head region, where angulation is difficult due to a lower degree of freedom. Hitching the stomach to the abdominal wall for retraction, ligation of the gastroduodenal artery in continuity to reduce bleeding from pancreatic parenchymal dissection, taking preplaced deep parenchymal sutures for hemostasis plus retraction during coring, using the cutting mode to transect pancreatic ducts while minimizing the coagulation effect, and measuring the Roux loop with a suture are few tips and tricks which may facilitate robot-assisted Frey's procedure. It is also useful to make the jejunal enterotomy smaller in size as compared to the pancreatic duct as it stretches while anastomosing, and to use saline irrigation while transecting parenchyma with an energy device [17,19]. Though robot-assisted Frey's procedure is challenging and has a considerable learning curve, it can be accomplished safely with good results in carefully selected cases (dilated pancreatic duct, no portal hypertension, and recent acute pancreatitis episode).

In conclusion, the hybrid nature of Frey's procedure makes it a favorable approach to dealing with the pathophysiology of chronic pancreatitis. It can be accomplished robotically with acceptable outcomes in selected patients having dilated MPD, without inflammatory head mass or previous laparotomy. Our data on robot-assisted Frey's procedure is small, but it definitely hints toward its safety, feasibility, decreased hospital stay, improved outcomes, and adaptability when compared to open procedure. However, larger well-designed trials are needed to compare the outcomes of open and minimally invasive techniques. Better technological improvement, decreased cost and adequate training of the surgeons are needed as the patient demand for robotic surgery is likely to increase in over time.

NOTES

Ethical statements

This study was approved by the Institutional Review Board of Jawaharlal Institute of Postgraduate Medical Education & Research, and the informed consent was taken from all the patients (No. JIP/ IEC/2022/243).

Authors' contributions

Conceptualization, Formal analysis, Methodology, Data curation, Visualization: All authors
Writing–original draft: AS, SG, RK
Writing–review & editing: All authors
All authors read and approved the final manuscript.

Conflict of interest

All authors have no conflicts of interest to declare.

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Supplementary materials

Supplementary materials can be found via https://doi.org/10.7602/jmis.2022.25.4.145.

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