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Review Article

Open Duodenopancreatectomy and Robotic Pancreaticojejunal Anastomosis in High-Risk Fistula Score Pancreatic Cancer: Case Series and Literature Review

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Abstract

Background: Open Pancreaticoduodenectomy (OPD) in pancreatic carcinoma (PC) patients is a complex surgical procedure, with postoperative pancreatic fistula (POPF) being the main complication. Minimally invasive techniques, such as robotic PD (R-PD), offer the potential advantages of a more precise and less traumatic pancreaticojejunal anastomosis, however the demolitive time is longer, technically challenging and require a long learning curve. This study presents a case series and literature review on a combined approach, open PD (OPD) and robotic pancreaticojejunal terminolateral anastomosis (Ra-PJA), in high-risk fistula PC patients (HRFSC-PC). The acronymus of such original approach is OPD-Ra-PJA. **Methods:** A retrospective analysis of six high risk fistula score pancreatic cancer patients undergoing OPD-Ra-PJA. The open approach was performed using a conventional open technique, while the two-layer duct-to-mucosa pancreaticojejunal anastomosis was performed robotically, using a covered expandable coronary artery stent positioned intraoperatively in the pancreatic duct. The primary endpoints were the occurrence of clinically relevant POPF (grades B and C), while the secondary endpoints were postoperative mortality, hospital stay, and re-operation. A literature review on OPD-Ra-PJA was also performed. **Results:** All patients had soft pancreatic tissue and a pancreatic duct diameter of approximately 2 mm, with a mean fistula risk score (a-FRS) of 24.5 ± 4.3. The mean operative time was 336.6 ± 16.9 minutes. Two cases (33.3%) of biochemical leak were detected, which resolved spontaneously. No cases of clinically relevant POPF (grade B-C) were reported. The mean postoperative stay was 14.6 ± 1.7 days. No re-operations or deaths occurred. We found no article describing such approach. The OPD-Ra-PJA approach combines the advantages of open surgery for resection with the precision of robotic surgery for pancreatic anastomosis in high-risk fistula score patients. **Conclusion:** The OPD-Ra-PJA technique represents a useful original variant in the initial approach to robotic pancreatic surgery, allowing for greater precision and less tissue trauma in pancreatic anastomosis in HRFSC-PC patients.

Keywords: Pancreatic Ductal Adenocarcinoma; High fistula score patients; Combined Approach; Open Pancreaticoduodenectomy and Robotic pancreaticojejunal Anastomosis

Core Tip: This study introduces a novel hybrid surgical technique, "Open Pancreaticoduodenectomy with Robot-assisted Pancreaticojejunostomy (OPD-RaPJ)," for high-risk pancreatic fistula patients. The resection phase is open, while the delicate pancreatico-jejunal anastomosis is robotically assisted. Preliminary results in six high-risk patients show no clinically relevant pancreatic fistulas, suggesting robotic assistance improves precision and reduces complications in select patients, without excessive cost or operative time increases. This technique offers a viable alternative to overcome laparoscopy and full robotic approaches, especially in the early learning curve for robotic pancreatic surgery.

Introduction

In 1994, Gagner et al. reported the first successful laparoscopic pancreaticoduodenectomy (LPD) [1]. These advanced minimally invasive surgeries require surgeons to have both training in pancreatic surgery and highly experienced laparoscopic skills, so development has been slow. In Literature only limited series of laparoscopic pancreaticoduodenectomy showing their feasibility, safety, and adequacy have been published. The reconstruction phase during LPD is especially technically demanding and time-consuming, taking longer than that during open PD (OPD) [1]. In 2003, Giulianotti et al reported the world's first robot-assisted PD (RPD) [2]. The use of the da Vinci Surgical System (Intuitive Surgical Inc., Sunnyvale, CA, USA) has over the years progressively gained popularity among pancreatic surgeons. Since then, an increasing number of Surgical Unit have started offering RPD. The recently developed surgical robotic systems can overcome many of the limitations and drawbacks of conventional laparoscopic approach.

In 2023, the Brescia Internationally Validated European Guidelines on Minimally Invasive Pancreatic Surgery (EGUMIPS) [3], the different minimally invasive surgical approaches to the pancreas have been defined: laparoscopic, pure robotic, roboscopic, robot-assisted, open, hand-assisted, single-port, combined laparoscopic/open, robotic/open and converted.

The "Combined Robot-assisted/open" is a combined approach robotic and open; the resection phase of the procedure is performed with a robot-assisted approach and during the reconstructive phase, at least one of the anastomoses is performed by a mini-laparotomy. Pancreatic fistula is the leading complication after pancreatic resections. It is defined as the output via a drain, a drain track, or a surgical wound (on or after postoperative day 3) of any measurable volume of fluid containing pancreatic juice (amylase content greater than 3 times the upper normal serum value). A clinical grading system for postoperative pancreatic fistula (A, B, C) has been proposed, by the International Study Group of Pancreatic Fistula (ISGPF) [4]. After pancreaticoduodenectomy, the reported rate of POPF is highly variable, ranging from 2% to more than 20% [5,6].

The following factors are related to pancreatic fistula: gender, age, preoperative jaundice, intraoperative blood loss, operative time, pancreatic texture, BMI, diameter of the main pancreatic duct, and pancreatic jejunal anastomosis [7].We propose an original approach for High-Risk fistula score pancreatic cancer patients in which the Open DP is performed open, and the most difficult (delicate) pancreatic reconstruction is made with a Robotic-assistance (OPD-RaPJ) procedure. At the best of our knowledge this approach has never been reported in the literature and is not described in the 2023 Brescia Internationally Validated European Guidelines on Minimally Invasive Pancreatic Surgery (EGUMIPS) [3].

Materials and Methods

We started our robotic program in June 2022 with Da Vinci Xi e dual consol. Up to now we have performed a total of (number) the pancreatic procedure are (number and type). This is a small cohort series of patients undergoing elective pancreaticoduodenectomy (PD) and robotic pancreaticojejunal anastomosis by the single surgeon (FC) at the St. Giuseppe Moscati Hospital in Avellino, Italy.

Inclusion criteria were adult patients requiring a PD for a periampullary mass with a high fistula score (according to alternative fistula score) [8]. Exclusion criteria included patients requiring a PD with a low fistula score; participants requiring total, distal, and central pancreatectomy; the presence of vascular involvement (borderline resectable or locally advanced tumours).

In total, six patients with a high fistula score were included in this study.

All patients underwent an open PD with third-level meso-pancreatic resection, standard lymphadenectomy [9] [10]. All patients included had a high fistula score and were selected for a robotic pancreatic anastomosis.The robotic system is positioned on the left side of the patient. Only three robot arms are used: for the optics and for the surgeon's right and left hands. Two surgeons are present in the operative field and one in the consol.

In all cases, a robotic 2-layer end-to-side duct-to-mucosal pancreaticojejunostomy (DTM-PJ) is performed in accordance with the "Huscher technique" [11] with the placement of an internal covered expandable coronary artery stent in the pancreatic duct. Briefly a posterior running suture with 4-0 polypropylene stitches and lapra-ty is performed. Three 6-0 polypropylene stitches are placed in the posterior aspect of the wirsung duct and the jejunal

wall. These stitches are tied and a covered expandable coronary stent advanced through the jejunal wall in the wirsung duct using a modified Seldinger technique. We used 28 mm length and 2.5 mm diameter stents only, expanded with a pressure from 8 to 10 bar.

The jejunal limb is punctured without the need for an enterotomy. The main pancreatic duct is canulated with a guidewire equipped with a pressure sensor. The CAS is advanced over the guidewire, the balloon is expanded with controlled pression and then fixed into the Wirsung duct. Having the stent in place three anterior 6-0 polypropilene stiches are placed between the anterior wall of the wirsung duct and the jejunal mucosa. The stent is deployed having care to properly cover the pancreaticojejunal anastomosis. An anterior running suture between the jejunal wall and the pancreatic stump is realised using four – 0 polypropylene stitches and lara-ty. The reconstruction is completed using a robotic end-to-side hepaticojejunostomy and an open side-to-side gastrojejunostomy.

The primary endpoint was the appearance of "clinically relevant" post-operative pancreatic fistula (POPF) grades B and C, according to the classification of the International Study Group of Pancreatic Fistula (ISGPF) 2016 revised [12]. The second endpoints were post-operative mortality, hospital- stay, and Re-operation. PubMed, Scopus, and Google Scholar databases were searched systematically through PubMed, Scopus, and Google Scholar databases were searched systematically. The terms Pancreatic ductal adenocarcinoma (PDAC), High fistula score patients (HRFS), Combined approach, Open pancreaticoduodenectomy and robotic pancreaticojejunal anastomosis (OPD-RaPJ) were used in order to identify all available studies on open duodenopancreatectomy and robotic pancreaticojejunal anastomosis in high-risk fistula score pancreatic cancer.

Results

The characteristics of six patients are shown in (Table 1).

Sex (age)	**M (76)**	**M (71)**	**M (62)**	**M (74)**	**M (73)**	**M (75)**	**(n=6)**
Comorbidity	Ischemic heart disease Chronic renal failure Diabetes	No	No	Ischemic stroke	ischemic heart disease coronary bypass	No	3/6 (50%)
ASA	III	III	III	II	IV	II	
BMI	24.6	30.3	23.3	28	32	24	27.0 ± 3.3
Diameter of MPD (mm)	2.1	2	2	2	2.5	2.5	2.2 ± 0.2
Pancreatic texture	Soft	Soft	Soft	Soft	Soft	Soft	
a-FRS	**20.9**	**28.5**	**19.8**	**25.8**	**31.3**	**20.9**	**24.5 ± 4.3**
Operative time (min)	360	320	350	320	350	320	336.6 ± 16.9
Histological type T N Stage	Adenocarcinoma of the duodenum 3 2 IIIb	Pancreatic adenocarcinoma 3 1 IIb	Cholangio carcinoma 2 1 IIIc	Adenocarcinoma of the duodenum 3 1 IIIa	Cholangioc arcinoma 2 0 II	Pancreatic adenocarcinoma 1 0 Ia	
Biochemical leak **CR-POPF**	**Yes** No	No No	No No	No No	No No	**Yes** No	2/6 (33.3%)
Postoperative bleeding	No	No	No	No	No	No	

Re-operation	No	No	No	No	No	No	
Hospital stay (Days)	15	13	13	13	17	17	14.6 ± 1.7
30-day mortality	No	No	No	No	No	No	

All patients have soft pancreatic tissue; the diameter of the pancreatic duct is about 2 mm; and the alternative fistula risk score (a-FRS) [8] for predicting the occurrence of CR-POPF after PD was high (24.5 ± 4.3). The mean operating time was 336.6 ± 16.9 minutes; histological tumour types were two adenocarcinoma of the pancreatic head, two of the duodenum, and two extrahepatic cholangiocarcinoma. Two cases (2/6; 33.3%) of biochemical leak were detected and resolved spontaneously; no case of CR-POPF, bleeding, or biliary fistula was reported. The mean post-operative stay was 14.6 ± 1.7 days; in our short series, there was no relaparotomy or death.

Discussion

In the literature there are many studies comparing the perioperative and surgical outcomes of robotic vs open PD, RPD is considered as a safe and feasible surgical approach even for overweight or elderly patients [13,14]. Instead, few studies comparing the outcomes of laparoscopic vs robotic PD, a meta-analysis of RCTs and matched studies demonstrated no differences in perioperative outcomes between LPD and RPD [15].

Laparoscopic surgery, however, has technical limitations, which include restricted degrees of motion of the laparoscopic instruments, reductions in hand-eye coordination, and impairments in the depth perception by the 2-dimensional image. Most importantly, the long, rigid laparoscopic instruments result in the ready transmission and exaggeration of tiny movements from the surgeon, making delicate procedures, particularly fine anastomoses, difficult.

Moreover, the resection phase covers a wide operative field that requires frequent changes in surgical targets and instruments. However, during the reconstruction phase, the surgical field of view is fixed, for which a more static and delicate technique is required. The laparoscopic approach has fluidity of movement for a wide range of operative fields, whereas the robotic approach has the advantage of high-fidelity motion with increased instrument dexterity. Therefore, the tailored use of minimally invasive modalities according to each phase would be helpful for the surgeon's adaptation to MIPD [16].

Recently developed robotic technology allows surgeons to perform pancreaticoduodenectomy. The learning curve of RPD ranges from 20 to 40 procedures [17], but proficiency is reached only after 250 operations. Once proficiency is achieved, the results of RPD may be superior to those of OPD [18]. In our reversed combined open/robot-assisted technique, the reconstructive phase is performed with the assistance of the robot as an early stage of our learning curve to total robotic pancreatic surgery.

However, due to its high cost, it is not widely utilized. Furthermore, in the anastomotic phase, it is necessary to reduce the risk of fistula or dehiscence with greater stability, better vision, high surgical precision and less tissue trauma especially in patients with a high risk of anastomotic fistula. For this reason, we have chosen the robotic technique; moreover, from our experience we have understood that the da Vinci system Xi maintains its stability even if the trocars are not inserted into the abdominal wall.

Our results document the absence of CR-POPF in the six patients, with an acceptable increase in operative time. A 2020 Zhang W. et al. [19] meta-analysis of multiple worldwide centres evaluated the safety and efficacy of robot-assisted and open pancreaticoduodenectomy in the treatment of pancreatic diseases. The results of this meta-analysis showed that RPD was significantly better than open surgery in the estimated bloodloss, wound infection rate, reoperation rate, postoperative hospital stay, transfusion, overall complications and clinical POPF. Additionally, no significantly different were found in the retrieved lymph node, R0 rate, bile leakage rate, delayed gastric emptying, postoperative 90-day mortality, POPF, severe complications. In terms of operation time, open surgery was better than robot surgery.

The robotic approach provides surgeons with a three-dimensional stereoscopic view of the surgical field, restoring hand-eye coordination. The Endowrist® instrumentation replicates human hand movements with seven degrees of freedom and eliminates hand tremors. In the case of PD, these advantages, particularly the capabilities of the articulated arm, make it feasible to perform secure duct-to-mucosa anastomoses [20].

Copãescu C. et al. described the technical protocol of hybrid-PD (laparoscopy-robotic) and analyzed the outcomes and efficiency of this approach. They concluded that the robotic surgery excels in providing a fixed field and fine movement required during the anastomosis phase, making it more suitable for this specific aspect of the procedure [21].We believe that the major advantage of using a hybrid approach is during the most delicate phase of the

intervention, the pancreatico – jejunal anastomosis in patients with HFRS. Moreover, this original approach is not described (3) and to the best of our knowledge is not reported in the literature review.

In agreement with the International Consensus of Experts on laparoscopic pancreaticoduodenectomy which confirmed that robotic surgery for PD can offer several advantages, especially for digestive tract reconstruction. However, due to its high cost, it is not widely utilized [22]. In our original technique, a robotic needle driver and a forceps were used at a cost of around €642. Also, this cost increase is acceptable considering the savings linked to the lesser hospitalization of the patients.

Conclusion

In our hybrid open/robotic assisted technique, the reconstructive phase is assisted by the robot; we think that this variant of technique is useful in the initial phase of approach to robotic surgery of the pancreas. The making of the anastomoses, in particular the pancreatic one which, as is well known, is burdened by a high risk of fistulisation, with a robot-assisted technique, guarantees greater stability, precision of the surgical procedure, less tissue trauma minimizing complications.

We believe that the use of the robot during the reconstructive time, even during open surgery, makes it possible to obtain maximum precision without an excessive increase in costs and surgical times.

We can also state that the Da Vinci Xi robot maintains its stability even when applied to the open abdomen, expanding its field of application without increasing costs. To the best of our knowledge this approach is not described in the current literature.

Author contributions

Francesco Crafa and Alfonso Amendola were responsible for drafting the manuscript, as well as the acquisition, analysis and interpretation of data. Enrico Coppola Bottazzi, Serafino Vanella, Adele Noviello, Mario Baiomonte contributed to the conception and design of the current study. Maddalena Donnarumma, Rosa Murano and Tommaso Palma collected the patient's clinical data.

Approved statement

All authors read and approved the final manuscript.

Informed consent statement

The patients gave informed consent for this study and the publication of its results.

Conflict of interest statement

The authors declare no conflicts of interest.

Data sharing statement

Not additional data are available

References

1. Gagner M, Pomp A(1994) Laparoscopic pylorus-preserving pancreatoduodenectomy. Surg Endosc 8: 408-410.
2. Giulianotti PC, Coratti A, Angelini M, sbrana F, Cecconi, et al. (2003) Robotics in general surgery: personal experience in a large community hospital. Arch Surg 138 :777-784.
3. Abu Hilal M, van Ramshorst TME, Boggi U, Dokmak S, Edwin B, et al. (2023) The Brescia Internationally Validated European Guidelines on Minimally Invasive Pancreatic Surgery (EGUMIPS) Ann surg 279: 45-57.
4. Bassi C, Marchegiani G, Dervenis C, Sarr M, Abu Hilal M, et al. (2017) The 2016 update of the International Study Group (ISGPS) definition and grading of postoperative pancreatic fistula: 11 Years After. Surgery. 161: 584-591.
5. Kawaida H, Kono H, Hosomura N, Amemiya H, Itakura J, et al. (2019) Surgical techniques and postoperative management to prevent postoperative pancreatic fistula after pancreatic surgery. World J Gastroenterol. 25:3722-3737.
6. Marchegiani G, Andrianello S, Salvia R, Bassi C (2019) Current Definition of and Controversial Issues Regarding Postoperative Pancreatic Fistulas. Gut Liver 13:149-153.
7. Zhang JY, Huang J, Zhao SY, Liu X, Xiong ZC, et al. (2021) Risk Factors and a New Prediction Model for Pancreatic Fistula After Pancreaticoduodenectomy. Risk Manag Healthc Policy 14: 1897-1906.
8. Mungroop TH, van Rijssen LB, van Klaveren D, Smits FJ, van Woerden V, et al. (2019) Alternative fistula risk score for pancreatoduodenectomy (a-FRS): design and international external validation. Ann Surg 269: 937-943.
9. Klotz R, Hackert T, Heger P, Probst P, Hinz U, et al. (2022) The TRIANGLE operation for pancreatic head and body cancers: early postoperative outcomes. HPB (Oxford) 24: 332-341.
10. Chen J, Ahmed AA, Ge J, Cai Z, Hu X, et al. (2024) Radiological classification of the Heidelberg triangle and its application in laparoscopic pancreaticoduodenectomy for malignancies. World J Surg Onc 22: 4.
11. Huscher CGS, Lazzarin G (2022) Coronary artery stent for securing pancreatico-jejunal anastomosis after PD: The "Huscher technique", Pancreatology 22: 1057-1058.
12. Bassi C, Marchegiani G, Dervenis C, Sarr M, Abu Hilal M, et al. (2017) The 2016 update of the International Study Group (ISGPS) definition and grading of postoperative pancreatic fistula: 11 Years After. Surgery 161 :584-591.
13. Li J, Qian L, Shi Y, Shen B, Peng C (2023) Short-term outcomes between robot- assisted and open pancreaticoduodenectomy in patients with high body mass index: A propensity score matched study. Cancer Med 12: 15141-15148.

14. Mederos MA, Starr S, Park JY, King JC, Tomlinson JS, et al. (2023) Robotic versus open pancreaticoduodenectomy in elderly patients: a propensity score-matched analysis. HPB (Oxford) 25: 301-310.

15. Zhang JY, Huang J, Zhao SY, Liu X, Xiong ZC, et al. (2021) Risk Factors and a New Prediction Model for Pancreatic Fistula After Pancreaticoduodenectomy. Risk Manag Healthc Policy 14: 1897-1906.

16. Jang JY, Chong EH, Kang I, Yang SJ, Lee SH, et al. (2023) Laparoscopic pancreaticoduodenectomy and laparoscopic pancreaticoduodenectomy with robotic reconstruction: single-surgeon experience and technical notes. J Minim Invasive Surg 26: 72-82.

17. Jones LR, Zwart MJW, de Graaf N, Wei K, Qu L, et al. (2024) Learning curve stratified outcomes after robotic pancreatoduodenectomy: International multicenter experience. Surgery 176: 1721-1729.

18. Napoli N, Kauffmann EF, Vistoli F, Amorese G, Boggi U, et al. (2021) State of the art of robotic pancreatoduodenectomy. Updates Surg 73: 873-880.

19. Zhang W, Huang Z, Zhang J, Che X (2021) Safety and efficacy of robot-assisted versus open pancreaticoduodenectomy: a meta-analysis of multiple worldwide centers. Updates Surg 73: 893-907.

20. Park SE, Choi HJ, You YK, Hong TH (2021) Effectiveness and stability of robot-assisted anastomosis in minimally invasive pancreaticoduodenectomy. Ann Surg Treat Res 100: 329-337.

21. Copăescu C, Dumbravă B (2023) Is the Robotic Assisted Hybrid Approach Increasing the MIS efficiency for Pancreaticoduodenectomy? Chirurgia (Bucur) 118: 302-313.

22. Qin R, Kendrick ML, Wolfgang CL, Edil BH, Palanivelu C, et al. (2020) International expert consensus on laparoscopic pancreaticoduodenectomy. Hepatobiliary Surg Nutr 9: 464-483.