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ORIGINAL ARTICLE

Robotic distal pancreatectomy with selective closure of pancreatic duct: surgical outcomes

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Abstract

Pancreatic fistula is the main post-operative complication of distal pancreatectomy associated with other further complications, such as intra-abdominal abscesses, wound infection, sepsis, electrolyte imbalance, malabsorption and hemorrhage. Surgeons have tried various techniques to close the stump of the remaining pancreas, but the controversy regarding the impact of stapler closure and suture closure of the pancreatic stump is far from resolved. In this study, we reported our technique and results of robotic assisted distal pancreatectomy with ultrasound identification and consequent selective closure of pancreatic duct. Twenty-one patients underwent consecutive robotic-assisted distal pancreatectomy were included in our study. We describe our technique and analyzed the operative and peri-operative data including mean operative time, intra-operative bleeding, blood transfusions necessity, conversion rate, mortality and morbidity rate, pancreatic fistula rate and grade, time of refeeding and canalization, length of hospital stay and readmission. Median operative time was 260 min. No conversion occurred. Estimated blood loss was 100 mL (range 50–200). No blood transfusions were performed. Mortality rate was 0%. One (5%) patient had a major complication, while 9 (43%) patients had minor complications (grade I). Three (14%) patients developed pancreatic fistula (grade B), while two (10%) patients had a biochemical leak. No late pancreatic fistula and re-operation occurred. The refeeding was started at second day (range 1^–6^) and the median canalization time was 4 days (range 2–7). The median hospital stay was 6 days (range 3–25) with a readmission rate of 0%. Robotic distal pancreatectomy can be considered safe and feasible. Our technique is easily reproducible, with good surgical results.

Keywords Robotic surgery · Distal pancreatectomy · Wirsung closure · Surgical outcomes

Introduction

Resection of the pancreas remains one of the most challenging areas of gastrointestinal surgery, with peri-operative morbidity of 40% and a mortality rate of approximately 5% [1, 2].

In particularly pancreatic fistula formation is a main source of post-operative morbidity in distal pancreatectomy and it is associated with numerous further complications, such as intra-abdominal abscesses, wound infection, sepsis, electrolyte imbalance, malabsorption and hemorrhage [3].

In an attempt to reduce the number of post-operative fistulas, surgeons have tried various techniques to close the stump of the remaining pancreas. Among these, suture closure and stapler closure of the pancreatic remnant are the techniques most often used. The controversy regarding the impact of stapler closure and suture closure of the pancreatic stump on the pancreatic fistula rate is far from resolved because there are many conflicting data in the literature.

In this report, we describe our technique and results of robotic assisted distal pancreatectomy with selective closure of pancreatic duct by placement of a nonabsorbable monofilament suture and with the use of ultrasonic scalpel for pancreatic transection.

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Methods

A total of 53 patients underwent distal pancreatectomy at our department from July 2014 and July 2017. Of these, we studied 21 patients that underwent consecutive robotic-assisted distal pancreatectomy (DP). Our selection criteria to perform robotic DP included: indication for elective distal pancreatectomy for symptomatic benign, premalignant or malignant disease; tumor confined to the pancreas; tumor located at least 1 cm from the celiac axis; absence of previous surgical intervention of other organs besides the distal pancreas or spleen and patients sufficiently fit to undergo robotic distal pancreatectomy according to the surgeon and anesthetist.

All relevant data about robotic pancreatic resection were entered in a prospective database. The study period was started for each patient with the date of surgical procedure.

Demographic data were evaluated as age at the intervention, gender and body mass index (BMI) before surgery.

Operative and peri-operative data included mean operative time, intra-operative bleeding, blood transfusions necessity, conversion rate, time of refeeding and canalization, length of hospital stay and readmission, mortality and morbidity rate, pancreatic fistula rate and grade.

Operative time was calculated as the time between skin incision and port-site closure. Post-operative mortality was defined as death during the same hospital admission or within 90 days of pancreatic resection. The surgical complications were classified according to the Clavien–Dindo scale [4].

In accord with the International Study Group of Pancreatic Fistula (ISGPF), the fistula is defined as an abnormal communication between the pancreatic ductal "system" and another epithelial surface containing pancreas-derived, enzyme-rich fluid. For the diagnosis, any measurable volume of drain fluid on or after post-operative day 3 with amylase level > 3 times the upper limit of normal amylase. To be defined strictly as post-operative fistula pancreatic (POFP,) this condition needs to be clinically relevant, otherwise it is a "biochemical leak", as shown in the additional data (Online Resource 1) [5].

The robotic system is positioned at the head of the patient, and the assistant surgeon is positioned between the legs of the patient. The intra-abdominal pressure was maintained to 12 mmHg. So, four robotic assistant ports and one laparoscopic port are placed.

The lesser sac is entered by dividing the gastrocolic ligament and preserving the gastroepiploic artery. The stomach is then retracted cephalad. With the anterior surface of the pancreas exposed, an intra-operative ultrasound is performed in order to identify the location of Wirsung duct, before pancreatic resection. The operative field and the ultrasound image are simultaneously displayed in real time above the surgeon's goggles (Fig. 1). We used ultrasonic scalpel for pancreatic transection, while near pancreatic duct we used scissors only. In case of bleeding we used bipolar forceps. The Wirsung duct was occluded by selective manual placement of a nonabsorbable monofilament suture, before cutting it (Figs. 2, 3).

All patients received antibiotic prophylaxis. Peripancreatic drainage fluid was collected from a surgically placed drain. Amylase level was measured on post-operative days 1, 3, 5 and every 3 days thereafter as needed. Our policy was to remove drains between 3 and 6 days after the operation in patients without infection-induced systemic inflammatory response syndrome/SIRS) when POFP was absent. Octreotide to prevent PF was not administered in all patients.

Results

Twenty-one patients underwent consecutive robotic-assisted distal pancreatectomy (DP) were evaluated. Three spleen-preserving robotic DP were performed in selected cases. Spleen-preserving distal pancreatectomy was planned only for these three patients who presented benign and low-grade malignant tumors without the indication for a lymph node dissection, with tumor size minor of 3 cm and localized far from splenic vessels. All other procedures included DP with splenectomy.

These patients, 7 (33%) male and 14 (67%) female, had a median age of 64 years (range 27–81). The mean body mass index (BMI) was 28 (range 17–34) and the mean ASA physical status classification was 2. The patient's characteristics are shown in Table 1.

Robot-assisted DP was performed to resect 8 adenocarcinomas, 6 cystic tumors, 5 neuroendocrine tumors and 2 benign lesions.

The two patients with benign lesion underwent pre-operative nuclear magnetic resonance and endoscopic ultrasound. These lesions were of new onset: one lesion was major of 4 cm, while the other one showed major dimensions compared to previous radiological examinations. So all two lesions were pre-operatively suspicious for malignant tumors.

Of the six cystic tumor one was serous cystadenoma, two were mucinous cystadenoma and three were intraductal papillary mucinous neoplasm (IPMN) of the main duct.

Median operative time was 260 min (range 205–390). No conversion to open occurred. In all cases it was possible to highlight Wirsung duct to place a closing stitch. Estimated blood loss was 100 mL (range 50–200). No blood and fresh frozen plasma transfusion were performed. No mortality occurred. One (5%) patient had a major complication, while

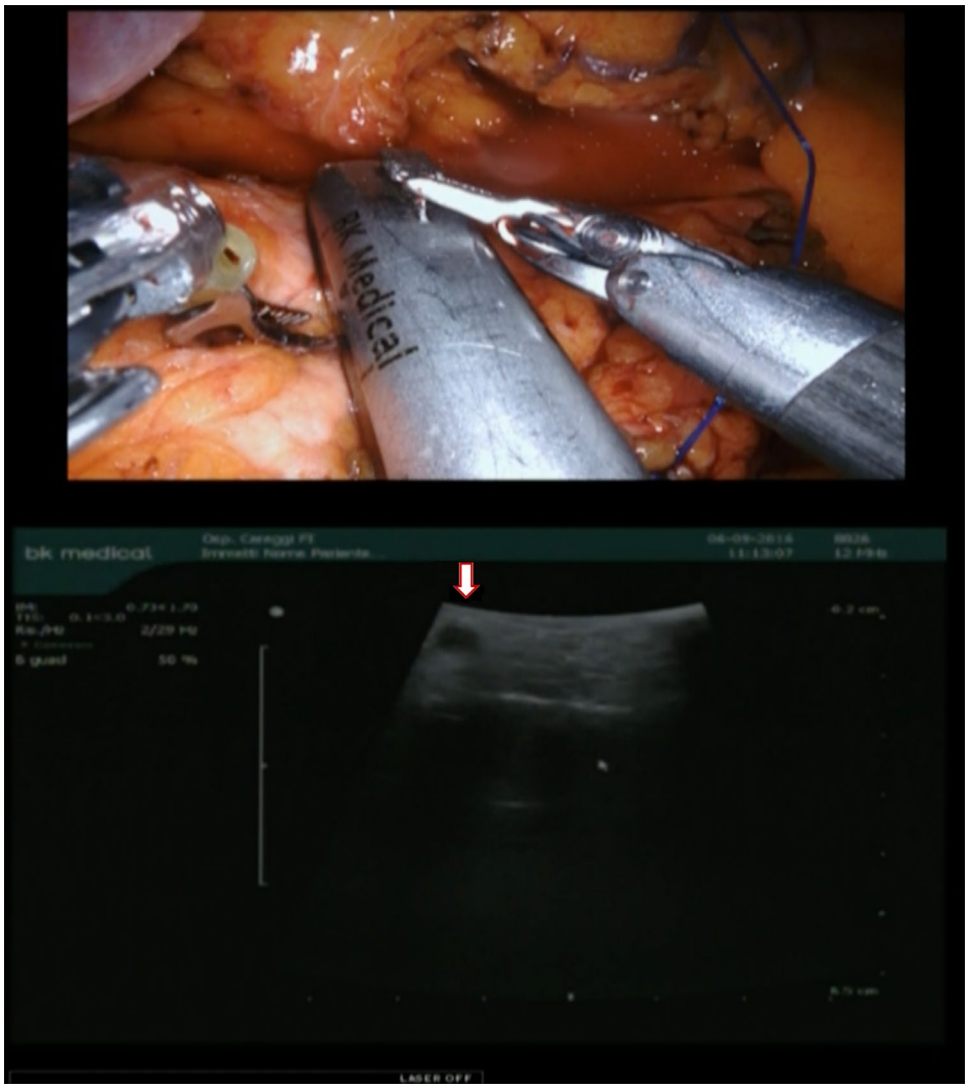

Fig. 1 Operative field and the ultrasound image are simultaneously displayed in real time above the surgeon's goggles

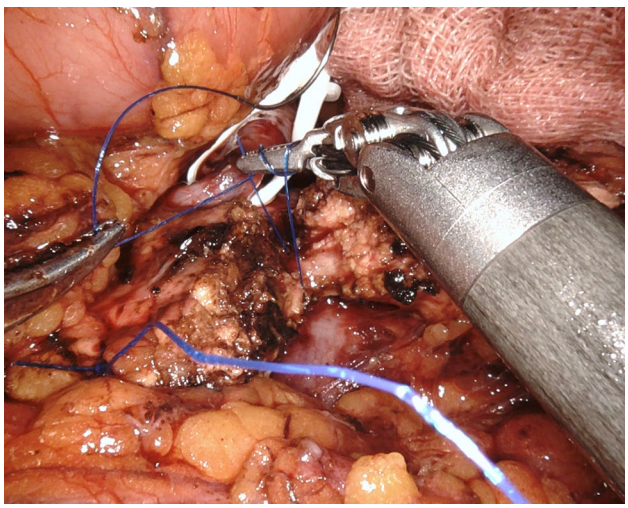

Fig. 2 Wirsung duct was occluded by selective manual placement of a nonabsorbable monofilament suture

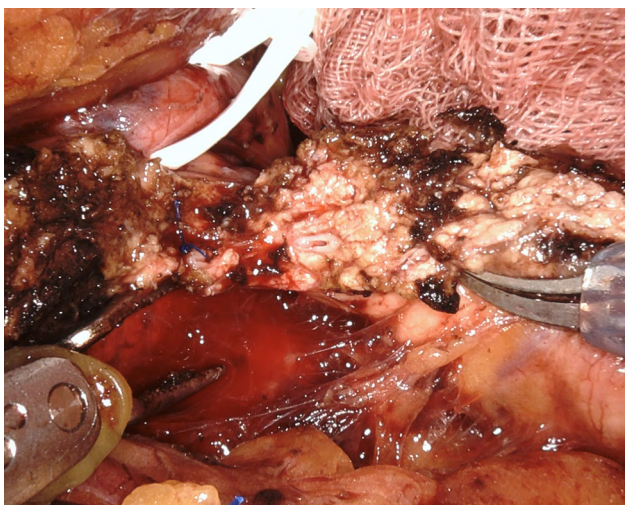

Fig. 3 Proximal pancreatic shear with Wirsung duct closed and distal pancreatic shear

Table 1 Characteristics of patients (pts)

Total of distal pancreatectomy	53 pts
Robotic distal pancreatectomy	21 pts (40%)
Male	7 pts (33%)
Female	14 pts (67%)
Median age	64 years (range 27–81)
Body mass index (BMI)	28 (range 17–34)
ASA	2
Type of tumor	8 adenocarcinoma (38%) 6 cystic tumor (29%) 5 neuroendocrine tumor (24%) 2 benign lesions (9%)

Table 2 Peri-operative outcome

Type of surgery	3 spleen-preserving (14%) 18 distal pancreatectomy with splenectomy (86%)
Operative time	260 min (range 205–390)
Conversion rate	0%
Intra-operative blood loss	100 mL (range 50–200)
Post-operative bleeding	0%
Blood and fresh frozen plasma transfusions	0%
Mortality	0%
Major morbidity	1 pts (5%)
Biochemical leak	2 pts (10%)
Grade B pancreatic fistula	3 pts (14%)
Late pancreatic fistula rate	0%
Re-operation rate	0%
Median hospital stay	6 days (range 3–25)
Readmission rate	0%

9 (43%) patients had minor complications (grade I). The major complication was a pleural effusion that required the positioning of thoracic drain (grade IIIa). No cases of post-operative bleeding occurred.

Three (14%) patients developed pancreatic fistula (grade B), while two (10%) patients had a biochemical leak. The patients with biochemical leak were treated by maintaining the drainage and with antibiotic therapy. The drains were removed at the seventh day and the and the patients were discharged at sixth and eighth post-operative day. Patients with grade B fistula showed sign of infection, without organ failure and the abdominal drainage was kept for 3 weeks. No late pancreatic fistula and re-operation occurred.

Refeeding was started at second day (range 1^–6^) and the median canalization time was 4 days (range 2–7). The median hospital stay was 6 days (range 3–25) with a readmission rate of 0%. Peri-operative outcomes are shown in Table 2.

Discharge criteria included full mobilization with the ability to perform activities of daily living, adequate oral feeding, recovery of bowel function patients, pain control with oral analgesia, absence of complications. Patients received the phone numbers to contact the hospital in case of need and they were visited as outpatients within 5 days from discharge.

Discussion

The resection of the pancreas is associated with peri-operative morbidity of 40%, particularly the formation of pancreatic fistula is one the most important complications [1, 2].

To reduce the rate of post-operative fistulas, surgeons have tried various techniques to close the stump of the remaining pancreas. The suture closure and stapler closure of the pancreatic stump are the most often used techniques; nevertheless, the controversy regarding the results on the pancreatic fistula rate is far from resolved, because there are some different data in the literature.

Since these, several clinical observational studies have become available and reported risk for pancreatic fistula under different closure methods for pancreatic remnant.

The choice of the different techniques in all studies was not randomized, but was dependent on either the preference of the surgeon or the availability of facilities at each hospital.

Takeuchi et al. described a statistically significant reduction in pancreatic fistula rate after stapler closure compared with suture closure (0% vs 34.8%; $P=0.035$) [6].

However, the opposite result of multivariate analysis was shown by Kleef et al. that stapler closure was associated with increased morbidity following distal pancreatectomy (OR, 1.76; $P=0.042$) [7].

There are only two RCTs comparing stapler versus scalpel resection followed by hand-sewn closure of the pancreatic remnant for distal pancreatectomy [8, 9].

Neither of the techniques has been shown to be superior to the other, and there is no need for surgeon to change their preferred surgical approach. The current evidence suggests that both techniques are safe and have comparable post-operative complications. In some cases, the anatomical situation might dictate the method used. With regard to the use of other novel techniques of remnant closure, there is a need for additional clinical trial to evaluate their safety and effectiveness.

Bassi et al. [8] mentioned surgeon's experience as a key factor to success in pancreatic surgery.

Main duct ligation and subsequent suture closure of the pancreatic stump has been the standard management of the

cut surface. Distal pancreatic closure with a stapler was advocated to be a simple and safe technique [10].

With main pancreatic duct ligation, major leakage of pancreatic juice rarely occurs, but even small pancreatic secretions can lead to abscess formation, subsequent sepsis, and hemorrhage [11, 12].

The intervening years have seen mini-invasive surgery gaining wide diffusion in surgical practice and seems to afford better operative outcomes and long-term survival comparable to that of standard open interventions [13].

However, currently only few, well-trained centers have substantive experience on laparoscopic pancreas surgery, due to technical difficulties encountered in achieving safe dissection in deep, retroperitoneal structures for which curved or angulated sectioning lines are oftentimes indicated [14, 15].

So, for pancreatic surgery, several issues unique to standard laparoscopy have been partially addressed by robotic platforms, which permit increased range of motion within the abdominal cavity and improve surgical dexterity with the endowrist instruments.

A recent review of the relevant literature showed good results in terms of surgical and oncologic principles for robotic distal pancreatectomy [16].

In our technique, the use of intra-operative ultrasound helps to locate the Wirsung and the magnification of the robotic image allows to put the stitch easily even in small Wirsung duct. A fully robot-integrated ultrasonography, which currently affords maneuverability in all robotic degrees of freedom, permits better localization and precise visualization of the Wirsung duct. Both the operative field and the ultrasound image are simultaneously displayed in real time above the surgeon's goggles: this allows a precise understanding of anatomy. Furthermore, the selective ligature with nonabsorbable suture wire prevent secretions from Wirsung duct and the use of ultracision decrease secretion by small pancreatic ducts, avoiding microtraumas of the pancreas present in the use of stapler. In fact, three (14%) patients only developed pancreatic fistula (grade B), while two (10%) patients had a biochemical leak and no late pancreatic fistula occurred.

In case of bleeding, the use of bipolar forceps helps us in the hemostasis. So, in our study, no case of postoperative bleeding occurred and the estimated blood loss was 100 mL, lower than literature [17, 18].

In conclusion, robotic distal pancreatectomy can be considered safe and feasible, as shown in literature. Our technique is easily reproducible, with good surgical results.

Author contributions Study conception and design: BP, LM. Acquisition of data: BP, LM, LB. Analysis and interpretation of data: BP, LM, LB, MF, MA and AC. Drafting of manuscript: LM, BP, MA, LB. Critical revision of manuscript: BP, LM, LB, MF, MA and AC.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Research involving human participants and/or animals All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation and with the Helsinki Declaration of 1964 and later versions.

Informed consent Informed consent was obtained from all patients.

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