Surg Endosc (2013) 27:3781–3791
DOI 10.1007/s00464-013-2969-5

200 Consecutive laparoscopic pancreatic resections performed with a robotically controlled laparoscope holder

Andrew A. Gumbs · Roland Croner · Angel Rodriguez · Noah Zuker · Aristoteles Perrakis · Brice Gayet

Received: 19 October 2012 / Accepted: 3 April 2013 / Published online: 4 May 2013

Abstract
Introduction Because of the potential benefit of robotics in pancreatic surgery, we review our experience at two minimally invasive pancreatic surgery centers that utilize a robotically controlled laparoscope holder to see if smaller robots that enable the operating surgeon to maintain contact with the patient may have a role in the treatment of pancreatic disease.
Methods From March 1994 to June 2011, a total of 200 laparoscopic pancreatic procedures utilizing a robotically controlled laparoscope holder were performed.
Results A total of 72 duodenopancreatectomies, 67 distal pancreatectomies, 23 enucleations, 20 pancreatic cyst drainage procedures, 5 necrosectomies, 5 atypical pancreatic resections, 4 total pancreatectomies, and 4 central pancreatectomies were performed. Fourteen patients required conversion to an open approach and eight a hand-assisted one. A total of 24 patients suffered a major complication. Sixteen patients developed a pancreatic leak and 19 patients required reoperation. Major complications occurred in 14 patients and pancreatic leaks occurred in 13 patients. Ten patients required conversion to a lap-assisted or open approach and six patients required reoperation.
Conclusions Currently, a robotically assisted approach using a camera holder seems the only way to incorporate some of the benefits of robotics in pancreatic surgery while maintaining haptics and contact with the patient.

Keywords Pancreato bilio · Instruments · GI · Human/robotic

A. A. Gumbs (✉)
Department of Surgical Oncology, Summit Medical Group, Berkeley Heights, NJ 07922, USA
e-mail: aagumbs@gmail.com

R. Croner · A. Perrakis
Department of Surgery, University Hospital Erlangen, Erlangen, Germany

A. Rodriguez
Department of Surgical Oncology, McGill University, Montreal, QC H3A0G4, Canada

N. Zuker · B. Gayet
Department of Digestive Diseases, Institut Mutualiste Montsouris, University Paris V, 42, Boulevard Jourdan, 75014 Paris, France
e-mail: brice.gayet@imm.fr

Minimally invasive procedures are increasingly being recognized as standard treatments for many intra-abdominal pathologies, such as colorectal and gastric malignancies [1, 2]. However, it has been more difficult to define the safety and efficacy of minimally invasive surgery for both benign and malignant pancreatic disease [3–7]. Minimally invasive techniques for the management of pancreatic cancer have been performed since the 1960s; diagnostic laparoscopy has been used to detect peritoneal metastases [8]. Since the 1990s, laparoscopic enucleations and distal pancreatectomies have been performed with comparable and in some instances improved outcomes compared with open techniques [9–11]. For the treatment of benign tumors, minimally invasive distal pancreatectomies are arguably considered the "gold standard" [12, 13].

In 1992, Gagner and Pomp [14] successfully performed the first minimally invasive pancreatoduodenectomy (MIPD). This was done for the treatment of a patient with chronic pancreatitis. Since that first report, multiple international centers have performed this procedure and have reported their results in the literature [15, 16]. Unfortunately, only a few high-volume centers have published case

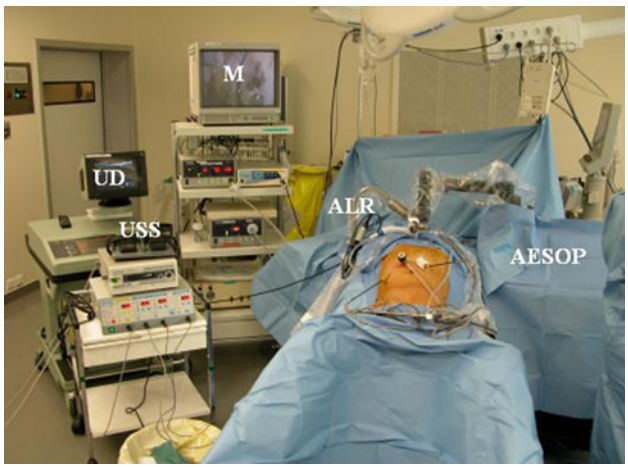

Fig. 1 Operating room setup with a nonsterilizeable robotically controlled laparoscope holder (AESOP, Computer Motion, Inc., Goleta, CA, USA) to the *patient's left*. The *patient* is in the low lithotomy or "French" position. Unlike complete robotic systems where the operating surgeon is not in contact with the actual patient, high-definition monitors (M), laparoscopic ultrasound devices (UD), laparoscopic ultrasonic shears (USS), and an autostatic liver retractor enable the operating laparoscopic surgeon to control all aspects of the case

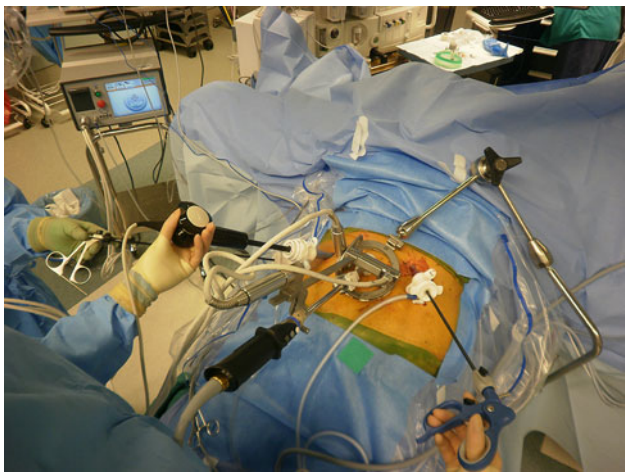

Fig. 2 Operating room setup for a laparoscopic distal pancreatectomy with a sterilizeable robotically controlled laparoscope holder (ViKY, Endocontrol, Grenoble, France). As opposed to AESOP, this device is completely sterilizeable and fits directly on the patient

reports in the double digits and even fewer of these adequately discuss the issues pertaining to suitability for the minimally invasive approach in the treatment of malignancies in the head of the pancreas [17–20].

Robotically assisted laparoscopic surgery has been available since the 1990s and began with robotically controlled laparoscope holders [21]. Because of the inability for surgeons to ergonomically perform minimally invasive procedures in the pelvis, complete surgical systems (DaVinci, Intuitive Surgical, Inc., Sunnyvale, CA) have thrived in gynecologic, urologic, and rectal surgery. However, for procedures in the upper abdomen, where the patient can be placed in the low lithotomy ("French") position and the operating surgeons can stand between the patient's legs and operate ergonomically, the complete robotic system has not been as popular [22]. This also may be due to the increased potential for massive hemorrhage when dissecting around the portal vein and inferior vena cava (IVC) in the absence of haptics, and because of the fact that surgeons at the robotic console are not in contact with the actual patient or sterile, resulting in a delay if urgent conversion to an open approach is needed [23]. In addition, the operating surgeon cannot utilize a hand-assisted approach when indicated, causing many robotic surgeons to simply convert to open approaches instead of continuing in a laparoscopic hand-assisted fashion [24]. Because of this, a review of two international centers using a robotically assisted laparoscopic approach to pancreatic pathologies that also enables the operating surgeon to feel was undertaken to see if the results would be comparable to other reports of minimally invasive pancreatectomy.

Methods

From March 1994 to June 2011, a total of 200 laparoscopic pancreatic procedures were performed by 2 surgeons, from North America and Western Europe. Until 2006, all procedures were performed with a nonsterilizeable robotically controlled camera holder (AESOP, Computer Motion, Inc., Goleta, CA); in Western Europe a second, sterilizeable robot (ViKY, Endocontrol, Grenoble, France) became available in 2006, followed by North America in 2007. All laparoscopic procedures begun with the intention of completing the procedure minimally invasively were included in this study. At our institutions, all pancreatectomies are approached laparoscopically unless patients have absolute contraindications to pneumoperitoneum, such as closed angle glaucoma, intracranial hypertension, or bullous emphysema. Patients who were deemed to require a portal vein reconstruction preoperatively also were begun via an open incision. Due to the high variability of procedures performed and the complexity of the vascular dissection, analysis of results was limited to patients who underwent duodenopancreatectomy and left-sided pancreatectomy. Morbidity was classified by using the Clavien System.

A review of published reports of minimally invasive distal pancreatectomy (MIDP) from 1997 until 2010 was undertaken and included the search words "laparoscopic" and "distal pancreatectomy." Robotic reports using the full robotics system (DaVinci, Intuitive Surgical) and/or hand-assisted procedures also were included. Studies with volumes <15 were excluded, except one report by Gumbs et al. because of its high percentage of cases done for cancer. Due to the decreased frequency of laparoscopic duodenopancreatectomy, all published reports were

analyzed. Duplicate and imprecise data were excluded. The following variables from articles found on Pubmed were studied: number of cases, conversion rate, mean operating time, mean estimated blood loss (EBL), mean length of stay, malignancy rates, margin status, and morbidity and mortality rates. A weighted average adjustment form statistical analysis was used to obtain the statistical sum of all the means for the rest of the variables:

$$W_a = (X_1Y_1 + X_2Y_2 + \cdots + X_nY_n) / (X_1 + X_2 + \cdots + X_n)$$

where X is the number of cases in a report and Y is the mean for the variable studied in that report.

Operating room setup of robotically controlled laparoscope holder

The robotically controlled laparoscope holder is placed to the left if the nonsterilizeable laparoscope holder (AESOP, Computer Motion Inc., Santa Barbara, CA) is used regardless of the location of the pancreatic tumor (Fig. 1), but at the level of the right axilla for right-sided lesions if the sterilizeable robot (ViKY, Endocontrol, Grenoble, France) is used and on the left for left-sided lesions (Fig. 2) [21]. Both robots can be controlled with foot pedals or voice activation (Fig. 3).

Laparoscopic distal pancreatectomy

The steps necessary to perform laparoscopic duodenopancreatectomy and distal pancreatectomy have been extensively described in multiple previous publications [4, 17, 25, 26]. When embarking on minimally invasive pancreatic surgery, as with open surgery, we recommend beginning with distal pancreatectomy. Splenic preservation can be attempted in patients without concerns for cancer. A medial to lateral approach is favored, but a lateral to medial approach may be necessary for larger tumors.

Fig. 3 The sterilizeable robotically controlled laparoscope holder (ViKY, Endocontrol, Grenoble, France) with foot pedal

Laparoscopic duodenopancreatectomy

The choledochojejunostomy is created laparoscopically before the pancreatic anastomosis is fashioned. It is created in an end-to-side fashion, the posterior layer is done with running suture and the anterior layer either running or with interrupted stitches. A 5-Fr pediatric feeding tube is used as an internal stent for common bile ducts less than 1 cm in diameter. The pancreatic anastomosis is then fashioned laparoscopically either in one or two layers to the stomach or jejunum depending on the patient's anatomy and the surgeon's preference. All ducts less than 1 cm are similarly stented with a 5-Fr pediatric feeding tube. For tubes smaller than this, angio-catheters may be necessary. The anastomosis to the stomach or duodenum can then be performed laparoscopically or via the extraction site. Two closed suction drains are left in the area of the biliary and pancreatic anastomoses, respectively. Drain amylase levels are checked on postoperative day #3 and removed if patients are tolerating a low-fat diet and levels are not elevated greater than three times the upper limit of the normal serum value.

Results

A total of 72 duodenopancreatectomies, 67 distal pancreatectomies, 23 enucleations, 20 pancreatic cyst drainage procedures, 5 necrosectomies, 5 atypical pancreatic resections, 4 total pancreatectomies, and 4 central pancreatectomies were performed.

The mean age of patients undergoing distal pancreatectomy is 57 years. The mean estimated blood is 100 mL (range 0–1,500 mL) and the mean operating time 203 min (range 120–460 min). Major complications occurred in 14 (21 %) patients, and pancreatic leaks occurred in 13 (19 %) patients (Type A = 5, Type B = 4, Type C = 4). Ten (15 %) patients required conversion to either a lap-assisted or open approach, and six (9 %) patients required reoperation. One patient died on postoperative day 35 due to hemorrhage for a mortality rate of 0 % at 30 days and 1.5 % at 90 days. The average length of stay was 6 days after distal pancreatectomy (range 2–43).

Thirty-six (54 %) of the laparoscopic distal pancreatectomies were for malignancy: 20 adenocarcinoma (including 3 mucinous cystadenocarcinoma and 3 arising from an IPMN), 10 neuroendocrine, 4 renal cell metastases, 1 pulmonary metastasis, and 1 due to a gastric cancer invading into the tail of the pancreas. The remaining benign pathology includes 11 mucinous cystadenomas, 9 benign neuroendocrine tumors (including 2 borderline lesions), 4 serous cystic adenomas, 4 IPMN, 2 with chronic pancreatitis, and 1 epithelial cyst. In the patients with

Table 1 Summary of LDP procedures in the literature

Study	No. of cases	Mean OR time (min)	Mean EBL (mL)	Mean length of stay (days)	Mean follow-up (months)	Mortality rate (%)
Paterson et al. [33]	19	260	200	7	NR	0
Park and Heniford [35]	25	222	274	4.1	NR	0
Ayav et al. [34]	15	175	NR	11	26	NR
Edwin et al. [36]	17	205	300	5.5	NR	11.8
Dulucq et al. [28]	20	150	100	11	50	0
Mabrut et al. [12]	98	200	300	7	15	NR
D'Angelica et al. [37]	16	196	125	5.5	3.8	0
Velanovich [38]	15	173	NR	5	NR	0
Pierce et al. [29]	18	236	244	4.5	NR	NR
Melotti et al. [39]	58	179	NR	9	26	0
Fernandez et al. [30]	82	NR	NR	8	14	0
Palanivelu et al. [40]	22	215	NR	4	36	0
Kooby et al. [31]	159	232	371	5.9	NR	0
Sa Cuhna et al. [41]	31	210	200	12.9	23	0
Gumbs and Chouillard [26]	12	300	175	4		8
Laxa et al. [42]	25	238	221	5	NR	0
Kim et al. [43]	93	195	300	10	NR	0
Taylor et al. [44]	46	157	NR	7	NR	0
Casadei et al. [76]	22	145	284	8	NR	0
Vijan et al. [75]	100	214	171	6.1	NR	3
Dinorcia et al. [74]	71	250	150	5	NR	0
Baker et al. [73]	27	236	219	4	NR	0
Finan et al. [72]	44	156	157	5.9	NR	0
Abu Hilal et al. [71]	17	180	100	5	NR	0
Nakamura et al. [49]	21	308.4	249	10	NR	0
Waters et al. [32]	28	224	667	6	NR	0
Waters et al. [32]	17	298	279	4	NR	0 (robotic)
Kooby et al. [6]	23	238.4	422	7.4	10	0
Total	1,141	214.5	250.4	6.7	22.6	0.7

Weight adjusted for the number of cases with reported variables

LDP laparoscopic distal pancreatectomy, *OR* operating room, *EBL* estimated blood loss, *NR* not reported

adenocarcinoma, there was one patient with stage 0 disease, two with stage IA, five with stage IB, three with stage IIA, six with stage IIB, and three with stage 3. Lymph node retrieval average was 10 (range 3–17). In all resections for malignancy, only one patent had an R1 resection for a positive margin rate of 3 %. Follow-up ranges from 8 to 28 months and averages 18 months; 16 (80 %) patients are currently alive, 13 (65 %) of them without evidence of disease.

The mean age for patients undergoing duodenopancreatectomy is 65 years. The mean EBL is 400 mL (range 0–200 mL), and the mean operating room time is 436 min (range 255–660 min). A total of 24 (33 %) patients suffered a major complication. A total of 14 (19 %) patients required conversion to an open approach and 8 (12 %) to a hand-assisted approach. Sixteen (22 %) patients developed a pancreatic leak and 19 patients required reoperation (26 %). Most reoperations were for postoperative hemorrhage [10] or intra-abdominal infection [7]. However, one reoperation was to rule out bowel ischemia, and a second was due to an obstruction at the transverse colon mesentery, both of these were managed laparoscopically. In total, 58 % of patients reoperated on were managed laparoscopically. One patient died on postoperative day 10 due to hemorrhage and infected ascites, for a mortality rate of 1.4 % at 30 and 90 months. Length of stay ranged from 4 to 38 days and averaged 9 days.

Sixty (83 %) of the laparoscopic duodenopancreatectomies were for malignancies: 27 adenocarcinomas, 18 ampullary cancers, 8 distal cholangiocarcinomas, 4 duodenal

Table 2 Number of conversions to open procedures per study

Study	Cases	Conversions
Paterson et al. [33]	19	3
Park and Heniford [35]	25	2
Ayav et al. [34]	15	8
Edwin et al. [36]	17	5
Dulucq et al. [28]	20	1
Mabrut et al. [12]	98	17
D'Angelica et al. [37]	16	2
Velanovich [38]	15	3
Pierce et al. [29]	18	1
Melotti et al. [39]	58	0
Fernandez et al. [30]	82	7
Palanivelu et al. [40]	22	0
Kooby et al. [31]	159	20
Sa Cuhna et al. [41]	31	6
Gumbs and Chouillard [26]	12	25
Laxa et al. [42]	25	1
Kim et al. [43]	93	0
Taylor et al. [44]	46	12
Casadei et al. [76]	22	0
Vijan et al. [75]	100	4
Dinorcia et al. [74]	71	24
Baker et al. [73]	27	1
Finan et al. [72]	44	6
Abu Hilal et al. [71]	17	2
Nakamura et al. [49]	21	1
Waters et al. [32]	28	2
Waters et al. [32]	17	0
Kooby et al. [6]	23	4
Total	1,141	132 (12 %)

Table 3 Complications of LDP procedures

Pancreatic fistula	171 (15 %)
Other	97 (9 %)
Total	268 (23.4 %)

LDP laparoscopic distal pancreatectomy

cancers, and 3 malignant neuroendocrine tumors. The remaining pathologies were benign and included seven intraductal papillary mucinous neoplasms (of which 4 had borderline pathology), two chronic pancreatitis, one pseudopapillary tumor, one osteoclastic tumor, and one duodenal polyp in a patient with familial adenomatous polyposis. Staging was done according to the AJCC guidelines and included all patients with adenocarcinoma and periampullary tumors and included 3 with stage 0 disease, 5 with stage IA, 4 stage IB, 9 stage IIA, 23 stage IIB, 6 stage 3, and 3 stage 4. Fifty-seven patients had an R0 resection and three patients had an R1 resection for a 95 % negative margin rate. An average of 16 (range 6–24) lymph nodes was retrieved. Follow-up ranges from 6 to 30 months and averages 19 months; 36 (60 %) patients are currently alive, 26 (43 %) of them without evidence of disease.

Discussion

This paper describes our experience with laparoscopic pancreatectomy using a robotically controlled laparoscope holder called ViKY (VideoendosKopY) made by Endocontrol, not the complete robotic system, DaVinci, by Intuitive. ViKY costs approximately $60,000 and is sterilizeable and completely reusable and there are no disposable parts. Dr. Zeh's group from the University of Pittsburgh reported that robotic distal pancreatectomy using the complete surgical system may be superior to laparoscopic distal pancreatectomy in conversion rates to open (0 vs. 16 %) [27]. Interestingly, this was in a cohort with 43 % malignancy in the robotic group compared with only 15 % in the laparoscopic group. The robotic cases also had statistically significant negative margin rates and improved lymph node retrieval [27]. These findings could be confounded by the possibility that these surgeons are simply more comfortable using the complete robotic system. Larger series with the complete surgical system are needed to confirm or refute these findings.

Minimally invasive distal pancreatectomy

To date 1,141 cases of MIDP have been reported in the literature (Table 1). The adjusted mean EBL in these cases is 250 mL (range 100–667 mL), the mean adjusted operating time is 215 min (range 145–308 min), the adjusted mean LOS is 7 days, and mean follow-up is 23 months. Conversions occurred in 12 % of cases because of uncontrollable hemorrhage, unclear margin status, inability to localize the lesion, and adhesions (Table 2). The reported resection status was reported in only 208 cases (18 %); margins were found to be positive in 11 % of cases for an R0 resection rate of 89 %. Reported lymph node retrieval ranged from 5 to 15.

Complications occurred in 23.4 % (268 patients) of cases. As in the open experience, pancreatic fistula was the most common cause of morbidity and occurred in 14.9 % of cases (171 patients; Table 3). Other reported morbidity includes delayed gastric emptying, postoperative hemorrhage, infection, deep venous thrombosis, and anemia found in 97 cases (8.5 %). Mortality was reported in 8 cases (<1 %).

Initial concerns regarding MIDP included concerns regarding the safety of the approach and its cost-

Table 4 Summary of MIPD procedures in the literature

Study	No. of cases	Mean OR time (min)	Mean EBL (mL)	Mean length of stay (days)	Mean follow-up (months)	Mortality rate (%)
Cuschieri [68]	2	NR	NR	NR	NR	NR
Uyama et al. [67]	1	373	560	28	3	0
Gagner and Pomp [14]	10	510	NR	22.3	19	0
Masson et al. [70]	1	480	NR	12	NR	0
Vibert et al. [22]	1	450	600	32	6	0
Kimura et al. [66]	1	580	550	NR	NR	0
Staudacher et al. [65]	7	416	325	12	4.5	0
Dulucq et al. [28]	11	268	83	13.6	19	1
Mabrut et al. [12]	3	300	300	7	15	0
Dulucq et al. [64]	25	287	107	16.2	19.2	4
Zheng et al. [63]	1	390	50	30	6	0
Lu et al. [62]	5	528	770	NR	NR	20
Menon et al. [61]	1	750	NR	NR	12	0
Tang [60]	6	263	185	36.5	8	0
Gumbs et al. [5]	1	NR	NR	NR	NR	0
Gumbs and Gayet [17]	35	360	300	NR	NR	NR
Gumbs et al. [69]	3	274	143	20	20	0
Cai et al. [59]	1	510	800	14	23	0
Sa Cuhna et al. [41]	1	510	300	18.7	20	0
Pugliese et al. [58]	19	461	180	19	32	0
Cho et al. [78]	15	338	445	16.4	NR	0
Jarufe [57]	3	330	NR	16	NR	0
Casadei et al. [56]	1	485	NR	14	14	0
Shinohara et al. [55]	3	737.7	810.7	28	NR	0
Palanivelu et al. [19]	75	357	74	8.2	NR	1.3
Narula et al. [54]	8	420	NR	9.6	6	0
Kendrick and Cusati [20]	65	368	240	7	7.2	1.5
Giulianotti et al. [16]	60	421	394	22	50.5	0
Buchs et al. [53]	41	435.2[a]	389.3[a]	12.2[a]	NR	2.4
Marquez et al. [77]	1	900	1,200	19	15	0
Gumbs et al. [4]	5	485	450	11	11	0
Zureikat et al. [52]	14	456	300	8	9.5	7.1
Horiguchi et al. [51]	3	703	118	26	NR	0
Ammori and Ayiomamitis[50]	7	629	350	11.1	37	0
Total	436	396.3[a]	267.1[a]	13.7[a]	23[a]	1.8

MIPD minimally invasive pancreatoduodenectomy, *OR* operating room, *EBL* estimated blood loss, *NR* not reported

[a] Weight adjusted for the number of cases with reported variables

effectiveness [12, 28–32]. Nonetheless, numerous studies became available that demonstrated the safety, feasibility, and cost-neutral aspect of this technique [12, 28–44]. Unfortunately, there are still no randomized, controlled trials comparing MIDP to the open approach. Operating room times also do not appear significantly different when compared to the open literature. Morbidity and mortality rates appear similar to the open literature (Tables 1, 3) [12, 28–44]. As with open distal pancreatectomy, pancreatic fistula remains the most prevalent complication after MIDP and depends on numerous parameters including presence or absence of soft pancreatic parenchyma and the malignancy status of the pancreatic disease. Although essentially all maneuvers and modalities attempted to reduce the pancreatic leak rate after distal pancreatectomy have also been attempted in minimally invasive approaches, there is still no "gold standard" for pancreatic parenchymal transection [26, 45].

Table 5 Number of conversions to open procedures per study

Study	No. of cases	No. of conversions to open
Cuschieri [68]	2	0
Uyama et al. [67]	1	0
Gagner and Pomp [14]	10	4
Masson et al. [70]	1	1
Vibert et al. [22]	1	0
Kimura et al. [66]	1	0
Staudacher et al. [65]	7	3
Dulucq et al. [28]	11	1
Mabrut et al. [12]	3	0
Dulucq et al. [64]	25	3
Zheng et al. [63]	1	0
Lu et al. [62]	5	0
Menon et al. [61]	1	0
Tang [60]	6	1
Gumbs et al. [5]	1	1
Gumbs and Gayet [17]	35	NR
Gumbs et al. [69]	3	1
Cai et al. [59]	1	0
Sa Cuhna et al. [41]	1	0
Pugliese et al. [58]	19	6
Cho et al. [78]	15	0
Jarufe [57]	3	0
Casadei et al. [56]	1	0
Shinohara et al. [55]	3	0
Palanivelu et al. [19]	75	0
Narula et al. [54]	8	3
Kendrick and Cusati [20]	65	3
Giulianotti et al. [16]	60	11
Buchs et al. [53]	41	2
Marquez et al. [77]	1	0
Gumbs et al. [4]	5	0
Zureikat et al. [52]	14	2
Horiguchi et al. [51]	3	0
Ammori ad Ayiomamitis [50]	7	0
Total	401	42 (10.5 %)

NR not reported

Minimally invasive pancreaticoduodenectomy

Since 1992, 436 MIPD procedures have been reported in the literature (Table 4), series with multiple publications. The adjusted mean EBL was reported in 409 (94 %) of the 436 published cases and was 267 mL (range 50–1,200 mL). The adjusted mean operating time was 396 min (range 263–750 min); interestingly, in series with at least 20 patients the mean operating time ranges decrease to 287–435 min. The mean LOS was 14 days (range 7–37 days) and was reported in 391 (90 %) cases.

Table 6 Complications of MIPD procedures

Biliary/pancreatic fistula	71 (18 %)
Intraperitoneal bleeding	17 (4.3 %)
Delayed gastric emptying	17 (4.3 %)
DVT/PE	9 (2.3 %)
Surgical site infection	7 (1.8 %)
Bowel obstruction	6 (1.5 %)
Intra-abdominal collection	6 (1.5 %)
GI bleed	6 (1.5 %)
Anemia	5 (1.3 %)
Other	7 (1.7 %)
Total	151 (38.2 %)

MIPD minimally invasive pancreatoduodenectomy, *DVT* deep venous thrombosis, *PE* pulmonary embolus, *GI* gastrointestinal

The adjusted mean follow-up was 23 months (range 3–51 months) and was only reported in 251 (58 %) cases. In these series, 10.5 % of the cases required conversion to an open approach (Table 5). Conversions occurred for the following reasons: invasion into the portomesenteric confluence, uncontrollable intraoperative hemorrhage, positive margin on intraoperative frozen section, planned conversion for the reconstruction, and robotic malfunction.

Morbidity occurred in 151 (38 %) of the 395 cases that reported complication rates. Pancreatic and or biliary fistula occurred in 71 (18 %) patients (Table 6). Other complications included: intraperitoneal hemorrhage 17 (4 %) cases, delayed gastric emptying 17 (4 %) cases, deep venous thrombosis/pulmonary embolism in 9 (2 %) cases, wound infection in 7 (1.8 %) cases, intra-abdominal abscess in 6 (2 %) cases, postoperative ileus in 6 (2 %) cases, gastrointestinal hemorrhage in 6 (2 %) cases, and anemia in 5 (1 %) cases. Remaining reported complications included pneumonia, urinary tract infections, and colitis. The mortality rate was reported in 92 % of cases (399 patients) and is 2 % (7 patients).

In cases of malignancy margins were reported in 255 cases, 243 patients had an R0 resection for a positive margin rate of 5 % (Table 7). A mean of 15 (range 5–54) lymph nodes were retrieved. The majority of tumors removed were for adenocarcinoma and periampullary tumors: 154 (50 %) adenocarcinoma and 82 (27 %) periampullary (Table 8). Chronic pancreatitis is the most common nonmalignant disease treated and accounts for 8 % (29 patients) of all cases.

Gagner's review of minimally invasive duodenopancreatectomy, published in 2009, reviewed the experience with 146 cases and noted a conversion rate of 46 % [46]. In our review, the conversion rate has decreased to 11 % in the literature; in our series it is 19 % probably due to our high rate of malignancy (Table 5). Morbidity rates in high-

Table 7 Summary of malignant cases with retrieved mean number of lymph nodes and rate of R0 resections per study

Study	No. of malignant cases	Mean no. of lymph nodes	Cases with R0 margins (%)
Cuschieri [68]	2	NR	NR
Uyama et al. [67]	1	24	100
Gagner and Pomp [14]	8	7	NR
Vibert et al. [22]	1	NR	
Kimura et al. [66]	1	NR	100
Staudacher et al. [65]	2	26	NR
Dulucq et al. [28]	7	14	100
Mabrut et al. [12]	3	NR	100
Dulucq et al. [64]	19	18	100
Zheng et al. [63]	1	20	100
Lu et al. [62]	5	NR	NR
Menon et al. [61]	1	17	100
Tang [60]	5	NR	100
Gumbs et al. [5]	NR	16	NR
Gumbs and Gayet [17]	NR	13	100
Cai et al. [59]	1	5	NR
Sa Cuhna et al. [41]	1	NR	100
Pugliese et al. [58]	18	11.6	100
Cho et al. [78]	6	18.5	100
Jarufe [57]	1	19	100
Casadei et al. [56]	1	36	NR
Shinohara et al. [55]	3	54	100
Palanivelu et al. [19]	72	14	97
Narula et al. [54]	1	16	NR
Kendrick and Cusati [20]	45	15	89
Giulianotti et al. [16]	45	13[a]	89
Buchs et al. [53]	31	NR	NR
Gumbs [4]	4	18	100
Zureikat et al. [52]	12	18.5	100
Horiguchi et al. [51]	2	NR	100
Ammori and Ayiomamitis [50]	7	19.2	100
Total	306	15.2[a]	95[a]

NR not reported

[a] Weight adjusted for the number of cases

Table 8 Pathologic findings in MIPD procedures

Pathologic finding	No. of cases
Pancreatic carcinoma	154
Periampullary carcinoma	82
IPMN	31
Chronic pancreatitis	29
Bile duct carcinoma	20
Cholangiocarcinoma	19
Neuroendocrine tumor	13
Duodenal carcinoma	11
Cystadenoma	7
Metastasis	4
Gastric cancer	3
Stromal tumor	3
Duodenal adenoma	2
Choledochal cyst	2
Trauma	1
Other	3

MIPD minimally invasive pancreatoduodenectomy, *IPMN* intraductal papillary mucinous neoplasm

volume pancreatic centers have been reported to be as high as 54 %, which is comparable to the rate reported in the minimally invasive literature (38 %) and in our series [47]. Our relatively high rate of reoperation (26 %) is more due to a culture of aggressive reoperation early in our experience and is tempered by our relatively low rate of major complications dealt with by our interventional radiologists (7 %). Some of the early cases of delayed hemorrhage were due to the use of only clips on large vessels. Now, large vessels are either stapled with laparoscopic vascular staplers or clips are oversewn with prolene suture. Currently, most of our major complications are dealt with by interventional radiology. Unlike most series, our series has a high malignancy rate, implying that with adequate experience both benign and malignant tumors and not just periampullary tumors can be approached safely and successfully laparoscopically. This is supported by the fact that mortality rates after minimally invasive duodenopancreatectomy are extremely low in both the literature review and in our series.

The vast majority of reoperations occurred early in our experience with laparoscopic duodenopancreatectomy and was precisely due to the fact that the minimally invasive Whipple procedure is such an experimental and controversial procedure. In fact, 80 % (15 patients) of our reoperations occurred in our first 25 patients. Since then, our reoperation rate has decreased to 11 % (4 patients). As our experience grows, it is hopeful that we will continue to enjoy a decrease in reoperation rate. In addition, due to the fact that patients were done laparoscopically, perhaps our threshold to reenter the abdomen was lower because a diagnostic laparoscopy may be easier tolerated than a second-look laparotomy. Compared to The John's Hopkins experience of 650 consecutive pancreaticoduodenectomies, they reported a reoperation rate of only 3.5 % [47]. Nonetheless, we are effectively at the equivalent of their first 10 % of cases (62 vs. 650). When we have an experience of 650 laparoscopic duodenopancreatectomies, a comparison of reoperation rates may be more useful. Interestingly, after only 1/10th of their experience, our mortality rates are already equivalent: 1.4 vs. 1.4 % [47].

Fig. 4 Prototype of hand-held robotically controlled laparoscopic instruments (JAIMY, Endoconrol, Grenoble, France)

Wound infections have been noted in 10 % of patients after open Whipple procedures, which is markedly elevated compared with the 2 % incidence after laparoscopic duodenopancreatectomies (Table 6). Delayed gastric emptying also has been found in almost 20 % of cases after open duodenopancreatectomies compared with only 4 % in the minimally invasive literature (Table 6). All of these factors contribute to length of hospitalization; however, due to the high degree of variability in policies regarding discharge criteria among different countries, it is difficult to meaningfully comment on differences in length of stay between the modalities [16].

As with all procedures as surgeon's get through their learning curves, operating room times decrease. Kendrick et al. noted a decrease in operating time from 7.7 to 5.3 h when comparing his first 10 cases with his last 10 cases in a series of 62 patients [20]. Because of this, it is still recommended that minimally invasive surgeon's began with tumors less than 2 cm, without involvement of the portomesenteric vessels and with pancreatic ducts larger than 4 mm [3].

Conclusions

In reviewing the literature and this series of MIDP and duodenopancreatectomy with a robotically controlled laparoscope holder, it becomes clear that this approach has similar morbidity and mortality rates compared with other minimally invasive techniques, specifically laparoscopy, hand-assisted approaches, and use of a complete robotic system. Furthermore, adequate R0 resection rates and lymph node retrieval can be attained. Patients who required conversion to an open approach more commonly had malignant disease and an increased body mass index (BMI) [48]. Because of this, patients with these criteria should be more vigorously considered for an open or hand-assisted approach from the onset, especially early in a surgeon's learning curve [6, 49]. As mentioned, the hand-assisted approach has potential benefits but is not possible for the operating surgeon when using the complete surgical system.

Perhaps the greatest concern for the use of complete robotics in minimally invasive pancreatic surgery is the absence of haptics and inability of the operating surgeon to maintain contact with the patient when using the complete robotic system. In the future, hand-held and smaller robotically controlled laparoscopic instruments used in conjunction with a robotically controlled laparoscope holder may enable pancreatic surgeons to enjoy the benefits of robotics and maintain the sense of touch (Fig. 4).

Disclosures Professor Gayet is a consultant for Endocontrol. Drs. Gumbs, Croner, Rodriges, Zucker, and Perrakis have no conflict of interest or financial ties to disclose.

References

1. Kitano S, Shiraishi N (2004) Current status of laparoscopic gastrectomy for cancer in Japan. Surg Endosc 18(2):182–185
2. Zheng MH, Feng B, Lu AG, Li JW, Wang ML, Mao ZH et al (2005) Laparoscopic versus open right hemicolectomy with curative intent for colon carcinoma. World J Gastroenterol 11(3):323–326
3. Gumbs AA, Rodriguez Rivera AM, Milone L, Hoffman JP (2011) Laparoscopic pancreatoduodenectomy: a review of 285 published cases. Ann Surg Oncol 18(5):1335–1341
4. Gumbs AA, Rodriguez-Rivera AM, Hoffman JP (2011) Minimally invasive pancreatic surgery of the entire gland: initial experience. Minerva Chir 66(4):269–280
5. Gumbs AA, Gres P, Madureira F, Gayet B (2008) Laparoscopic vs open resection of pancreatic endocrine neoplasms: single institution's experience over 14 years. Langenbecks Arch Surg 393(3):391–395
6. Kooby DA, Hawkins WG, Schmidt CM, Weber SM, Bentrem DJ, Gillespie TW et al (2010) A multicenter analysis of distal pancreatectomy for adenocarcinoma: is laparoscopic resection appropriate? J Am Coll Surg 210(5):779–785, 786–787
7. Kooby DA (2008) Laparoscopic pancreatic resection for cancer. Expert Rev Anticancer Ther 8(10):1597–1609
8. Ammori BJ (2003) Pancreatic surgery in the laparoscopic era. JOP 4(6):187–192
9. Ammori BJ (2004) Applications of minimally invasive surgery in the management of inflammatory and neoplastic diseases of the pancreas. J Hepatobiliary Pancreat Surg 11(2):107–111
10. Matsuno S, Egawa S, Arai K (2001) Trends in treatment for pancreatic cancer. J Hepatobiliary Pancreat Surg 8(6):544–548
11. Underwood RA, Soper NJ (1999) Current status of laparoscopic surgery of the pancreas. J Hepatobiliary Pancreat Surg 6(2):154–164
12. Mabrut JY, Fernandez-Cruz L, Azagra JS, Bassi C, Delvaux G, Weerts J et al (2005) Laparoscopic pancreatic resection: results of a multicenter European study of 127 patients. Surgery 137(6): 597–605
13. Kneuertz PJ, Patel SH, Chu CK, Fisher SB, Maithel SK, Sarmiento JM et al (2012) Laparoscopic distal pancreatectomy: trends and lessons learned through an 11-year experience. J Am Coll Surg 215:167–176
14. Gagner M, Pomp A (1997) Laparoscopic pancreatic resection: is it worthwhile? J Gastrointest Surg 1(1):20–25 discussion 25–26
15. Mosca F, Giulianotti PC, Balestracci T, Di Candio G, Pietrabissa A, Sbrana F et al (1997) Long-term survival in pancreatic cancer: pylorus-preserving versus Whipple pancreatoduodenectomy. Surgery 122(3):553–566
16. Giulianotti PC, Sbrana F, Bianco FM, Elli EF, Shah G, Addeo P et al (2010) Robot-assisted laparoscopic pancreatic surgery: single-surgeon experience. Surg Endosc 24(7):1646–1657

17. Gumbs AA, Gayet B (2008) The laparoscopic duodenopancreatectomy: the posterior approach. Surg Endosc 22(2):539–540
18. Palanivelu C, Jani K, Senthilnathan P, Parthasarathi R, Rajapandian S, Madhankumar MV (2007) Laparoscopic pancreaticoduodenectomy: technique and outcomes. J Am Coll Surg 205(2):222–230
19. Palanivelu C, Rajan PS, Rangarajan M, Vaithiswaran V, Senthilnathan P, Parthasarathi R et al (2009) Evolution in techniques of laparoscopic pancreaticoduodenectomy: a decade long experience from a tertiary center. J Hepatobiliary Pancreat Surg 16(6): 731–740
20. Kendrick ML, Cusati D (2010) Total laparoscopic pancreaticoduodenectomy: feasibility and outcome in an early experience. Arch Surg 145(1):19–23
21. Gumbs AA, Crovari F, Vidal C, Henri P, Gayet B (2007) Modified robotic lightweight endoscope (ViKY) validation in vivo in a porcine model. Surg Innov 14(4):261–264
22. Vibert E, Denet C, Gayet B (2003) Major digestive surgery using a remote-controlled robot: the next revolution. Arch Surg 138(9): 1002–1006
23. Kendrick ML, Sclabas GM (2011) Major venous resection during total laparoscopic pancreaticoduodenectomy. HPB (Oxford) 13(7):454–458
24. Gagner M, Gentileschi P (2001) Hand-assisted laparoscopic pancreatic resection. Semin Laparosc Surg 8(2):114–125
25. Gumbs AA, Gayet B, Hoffman JP (2011) Video: laparoscopic Whipple procedure with a two-layered pancreatojejunostomy. Surg Endosc 25(10):3446–3447
26. Gumbs AA, Chouillard EK (2012) Laparoscopic distal pancreatectomy and splenectomy for malignant tumors. J Gastrointest Cancer 43(1):83–86
27. Daouadi M, Zureikat AH, Zenati MS, Choudry H, Tsung A, Bartlett DL et al (2013) Robot-assisted minimally invasive distal pancreatectomy is superior to the laparoscopic technique. Ann Surg 257(1):128–132
28. Dulucq JL, Wintringer P, Stabilini C, Feryn T, Perissat J, Mahajna A (2005) Are major laparoscopic pancreatic resections worthwhile? A prospective study of 32 patients in a single institution. Surg Endosc 19(8):1028–1034
29. Pierce RA, Spitler JA, Hawkins WG, Strasberg SM, Linehan DC, Halpin VJ et al (2007) Outcomes analysis of laparoscopic resection of pancreatic neoplasms. Surg Endosc 21(4): 579–586
30. Fernandez-Cruz L, Cosa R, Blanco L, Levi S, Lopez-Boado MA, Navarro S (2007) Curative laparoscopic resection for pancreatic neoplasms: a critical analysis from a single institution. J Gastrointest Surg 11(12):1607–1621 discussion 1621–1622
31. Kooby DA, Gillespie T, Bentrem D, Nakeeb A, Schmidt MC, Merchant NB et al (2008) Left-sided pancreatectomy: a multicenter comparison of laparoscopic and open approaches. Ann Surg 248(3):438–446
32. Waters JA, Canal DF, Wiebke EA, Dumas RP, Beane JD, Aguilar-Saavedra JR et al (2010) Robotic distal pancreatectomy: cost effective? Surgery 148(4):814–823
33. Patterson EJ, Gagner M, Salky B, Inabnet WB, Brower S, Edye M et al (2001) Laparoscopic pancreatic resection: single-institution experience of 19 patients. J Am Coll Surg 193(3): 281–287
34. Ayav A, Bresler L, Brunaud L, Boissel P (2005) Laparoscopic approach for solitary insulinoma: a multicentre study. Langenbecks Arch Surg 390(2):134–140
35. Park AE, Heniford BT (2002) Therapeutic laparoscopy of the pancreas. Ann Surg 236(2):149–158
36. Edwin B, Mala T, Mathisen O, Gladhaug I, Buanes T, Lunde OC et al (2004) Laparoscopic resection of the pancreas: a feasibility study of the short-term outcome. Surg Endosc 18(3):407–411
37. D'Angelica M, Are C, Jarnagin W, DeGregoris G, Coit D, Jaques D et al (2006) Initial experience with hand-assisted laparoscopic distal pancreatectomy. Surg Endosc 20(1):142–148
38. Velanovich V (2006) Case–control comparison of laparoscopic versus open distal pancreatectomy. J Gastrointest Surg 10(1): 95–98
39. Melotti G, Butturini G, Piccoli M, Casetti L, Bassi C, Mullineris B et al (2007) Laparoscopic distal pancreatectomy: results on a consecutive series of 58 patients. Ann Surg 246(1):77–82
40. Palanivelu C, Shetty R, Jani K, Sendhilkumar K, Rajan PS, Maheshkumar GS (2007) Laparoscopic distal pancreatectomy: results of a prospective non-randomized study from a tertiary center. Surg Endosc 21(3):373–377
41. Sa Cunha A, Rault A, Beau C, Laurent C, Collet D, Masson B (2008) A single-institution prospective study of laparoscopic pancreatic resection. Arch Surg 143(3):289–295 discussion 295
42. Laxa BU, Carbonell AM 2nd, Cobb WS, Rosen MJ, Hardacre JM, Mekeel KL et al (2008) Laparoscopic and hand-assisted distal pancreatectomy. Am Surg 74(6):481–486 discussion 486–487
43. Kim SC, Park KT, Hwang JW, Shin HC, Lee SS, Seo DW et al (2008) Comparative analysis of clinical outcomes for laparoscopic distal pancreatic resection and open distal pancreatic resection at a single institution. Surg Endosc 22(10):2261–2268
44. Taylor C, O'Rourke N, Nathanson L, Martin I, Hopkins G, Layani L et al (2008) Laparoscopic distal pancreatectomy: the Brisbane experience of forty-six cases. HPB (Oxford) 10(1):38–42
45. Bassi C, Butturini G, Molinari E, Mascetta G, Salvia R, Falconi M et al (2004) Pancreatic fistula rate after pancreatic resection. The importance of definitions. Dig Surg 21(1):54–59
46. Gagner M, Palermo M (2009) Laparoscopic Whipple procedure: review of the literature. J Hepatobiliary Pancreat Surg 16(6): 726–730
47. Yeo CJ, Cameron JL, Sohn TA, Lillemoe KD, Pitt HA, Talamini MA et al (1997) Six hundred fifty consecutive pancreaticoduodenectomies in the 1990s: pathology, complications, and outcomes. Ann Surg 226(3):248–257 discussion 257–260
48. Jayaraman S, Gonen M, Brennan MF, D'Angelica MI, DeMatteo RP, Fong Y et al (2010) Laparoscopic distal pancreatectomy: evolution of a technique at a single institution. J Am Coll Surg 211(4):503–509
49. Nakamura Y, Uchida E, Aimoto T, Matsumoto S, Yoshida H, Tajiri T (2009) Clinical outcome of laparoscopic distal pancreatectomy. J Hepatobiliary Pancreat Surg 16(1):35–41
50. Ammori BJ, Ayiomamitis GD (2011) Laparoscopic pancreaticoduodenectomy and distal pancreatectomy: a UK experience and a systematic review of the literature. Surg Endosc 25(7):2084–2099
51. Horiguchi A, Uyama I, Miyakawa S (2011) Robot-assisted laparoscopic pancreaticoduodenectomy. J Hepatobiliary Pancreat Sci 18(2):287–291
52. Zureikat AH, Breaux JA, Steel JL, Hughes SJ (2011) Can laparoscopic pancreaticoduodenectomy be safely implemented? J Gastrointest Surg 15(7):1151–1157
53. Buchs NC, Addeo P, Bianco FM, Gangemi A, Ayloo SM, Giulianotti PC (2010) Outcomes of robot-assisted pancreaticoduodenectomy in patients older than 70 years: a comparative study. World J Surg 34(9):2109–2114
54. Narula VK, Mikami DJ, Melvin WS (2010) Robotic and laparoscopic pancreaticoduodenectomy: a hybrid approach. Pancreas 39(2):160–164
55. Shinohara T, Uyama I, Kanaya S, Inaba K, Isogaki J, Horiguchi A et al (2009) Totally laparoscopic pancreaticoduodenectomy for locally advanced gastric cancer. Langenbecks Arch Surg 394(4): 733–737
56. Casadei R, Marchegiani G, Laterza M, Ricci C, Marrano N, Margiotta A et al (2009) Total pancreatectomy: doing it with a mini-invasive approach. JOP 10(3):328–331

57. Jarufe N (2009) Totally laparoscopic pancreaticoduodenectomy: surgical technique and initial experience. Rev Chil Cir 61
58. Pugliese R, Scandroglio I, Sansonna F, Maggioni D, Costanzi A, Citterio D et al (2008) Laparoscopic pancreaticoduodenectomy: a retrospective review of 19 cases. Surg Laparosc Endosc Percutan Tech 18(1):13–18
59. Cai X, Wang Y, Yu H, Liang X, Xu B, Peng S (2008) Completed laparoscopic pancreaticoduodenectomy. Surg Laparosc Endosc Percutan Tech 18(4):404–406
60. Tang C (2007) Local experience of laparoscopic pancreatectomy. Hong Kong Med Diary 12:15–20
61. Menon KV, Hayden JD, Prasad KR, Verbeke CS (2007) Total laparoscopic pancreaticoduodenectomy and reconstruction for a cholangiocarcinoma of the bile duct. J Laparoendosc Adv Surg Tech A 17(6):775–780
62. Lu B, Cai X, Lu W, Huang Y, Jin X (2006) Laparoscopic pancreaticoduodenectomy to treat cancer of the ampulla of Vater. JSLS 10(1):97–100
63. Zheng MH, Feng B, Lu AG, Li JW, Hu WG, Wang ML et al (2006) Laparoscopic pancreaticoduodenectomy for ductal adenocarcinoma of common bile duct: a case report and literature review. Med Sci Monit 12(6):CS57–CS60
64. Dulucq JL, Wintringer P, Mahajna A (2006) Laparoscopic pancreaticoduodenectomy for benign and malignant diseases. Surg Endosc 20(7):1045–1050
65. Staudacher C, Orsenigo E, Baccari P, Di Palo S, Crippa S (2005) Laparoscopic assisted duodenopancreatectomy. Surg Endosc 19(3):352–356
66. Kimura Y, Hirata K, Mukaiya M, Mizuguchi T, Koito K, Katsuramaki T (2005) Hand-assisted laparoscopic pylorus-preserving pancreaticoduodenectomy for pancreas head disease. Am J Surg 189(6):734–737
67. Uyama I, Sugioka A, Matsui H, Fujita J, Komori Y, Hasumi A (2001) Laparoscopic pancreas-preserving total gastrectomy for proximal gastric cancer. A case and technical report. Surg Endosc 15(2):217–218
68. Cuschieri A (1994) Laparoscopic surgery of the pancreas. J R Coll Surg Edinb 39(3):178–184
69. Gumbs AA, Gres P, Madureira FA, Gayet B (2008) Laparoscopic vs. open resection of noninvasive intraductal pancreatic mucinous neoplasms. J Gastrointest Surg 12(4):707–712
70. Masson B, Sa-Cunha A, Laurent C, Rault A, Collet D (2003) Laparoscopic pancreatectomy: report of 22 cases. Ann Chir 128(7):452–456
71. Abu Hilal M, Jain G, Kasasbeh F, Zuccaro M, Elberm H (2009) Laparoscopic distal pancreatectomy: critical analysis of preliminary experience from a tertiary referral centre. Surg Endosc 23(12):2743–2747
72. Finan KR, Cannon EE, Kim EJ, Wesley MM, Arnoletti PJ, Heslin MJ et al (2009) Laparoscopic and open distal pancreatectomy: a comparison of outcomes. Am Surg 75(8):671–679 discussion 679–680
73. Baker MS, Bentrem DJ, Ujiki MB, Stocker S, Talamonti MS (2009) A prospective single institution comparison of peri-operative outcomes for laparoscopic and open distal pancreatectomy. Surgery 146(4):635–643 discussion 643–645
74. DiNorcia J, Schrope BA, Lee MK, Reavey PL, Rosen SJ, Lee JA et al (2010) Laparoscopic distal pancreatectomy offers shorter hospital stays with fewer complications. J Gastrointest Surg 14(11):1804–1812
75. Vijan SS, Ahmed KA, Harmsen WS, Que FG, Reid-Lombardo KM, Nagorney DM et al (2010) Laparoscopic vs open distal pancreatectomy: a single-institution comparative study. Arch Surg 145(7):616–621
76. Casadei R, Ricci C, D'Ambra M, Marrano N, Alagna V, Rega D et al (2010) Laparoscopic versus open distal pancreatectomy in pancreatic tumours: a case–control study. Updates Surg 62(3–4):171–174
77. Marquez S, Marquez TT, Ikramuddin S et al (2010) Laparoscopic and da Vinci robot-assisted total pancreaticoduodenectomy and intraportal islet autotransplantation: case report of a definitive minimally invasive treatment of chronic pancreatitis. Pancreas 39(7):1109–1111
78. Cho A, Yamamoto H, Nagata M et al (2009) A totally laparoscopic pylorus-preserving pancreaticoduodenectomy and reconstruction. Surg Today 39(4):359–362