J Hepatobiliary Pancreat Sci (2013) 20:583–589
DOI 10.1007/s00534-013-0615-1

TOPICS

Topics from International Symposium on Pancreas Cancer in Kyoto

Robotic-assisted pancreatic surgery

E. Fernandes · P. C. Giulianotti

Published online: 16 April 2013

Abstract

Background Pancreatic surgery is a challenging application of minimally invasive surgery. Due to the complexity of the surgical technique, requiring dissection along major abdominal vessels as well as delicate reconstruction involving biliary, pancreatic and enteric anastomoses, reports on laparoscopic pancreatic surgery have been scanty. With the advent of robotic-assisted surgery, however, the increased dexterity granted by endo-wristed instruments, the improved three-dimensional vision and the computer filtration of the surgeon's movements have brought minimally invasive pancreatic surgery into a new era.

Methods As the surgical group which has performed the highest number of robotic-assisted pancreatic procedures worldwide, we review the state of the art of minimally invasive robotic-assisted pancreatic surgery. Clinical results from all major robotic-assisted pancreatic surgery series are considered.

Results Preliminary reports from the published major pancreatic surgery series show encouraging results, with morbidity and mortality comparable to open surgery. Preliminary data on cancer survival rates also appear to be similar to open series.

Conclusion Robotic-assisted pancreatic surgery is safe and feasible for all pancreatic diseases. The complexity of pancreatic procedures warrant them to be carried out in specialised centres, where short- and long-term outcomes seem to be similar to the ones achieved in open surgery.

E. Fernandes (✉) · P. C. Giulianotti
Division of General, Minimally Invasive and Robotic Surgery, University of Illinois at Chicago, 840 South Wood Street, Chicago, IL 60612, USA
e-mail: e.fernandes@mclink.it

Keywords Pancreatic surgery · Robotic surgery · Whipple's procedure · Distal pancreatectomy

Introduction

Pancreatic surgery represents a challenge to both open and laparoscopic surgeons, but the delicacy of the surgical dissection deriving from the close anatomical relationship between the pancreas and the portal vein and mesenteric vessels, and the complexity of the reconstruction involving (in pancreatic head resections) restitution of pancreatic and hepatic duct continuity as well as gastric or pyloric continuity, have created some reluctance to adopting the laparoscopic technique even amongst the most skilled surgeons.

To date, only a handful of laparoscopic pancreatic resection series have been published and very few of them report more than 50 cases [1–10]. Gagner et al. [11] previously presented work on laparoscopic pancreatic head resections, but such small series have remained substantially experimental.

The development of the Da Vinci robotic platform (Intuitive Surgical, Sunnyvale, CA, USA) has completely changed the paradigm of minimally invasive pancreatic surgery. The increased dexterity deriving from the endo-wristed instruments, the three-dimensional magnification of the camera system, the software-mediated filtration of surgeon tremor and generally the improved surgeon ergonomics currently allow unprecedented precision of long and complex dissections as well as intra-corporeal reproduction of movements resembling and even improving on the human hand. For these reasons, since the development of the robotic platform, the challenge of pancreatic surgery has been taken up with renewed enthusiasm, with the result that in recent years the number of reports on minimally invasive robotic-assisted pancreatic surgery has been on the rise.

Robotic-assisted pancreato-duodenectomy

The first robotic-assisted pancreato-duodenectomy (RAPD) was performed by our group (Giulianotti, personal communication) in 2001. Following such a breakthrough, a series of 8 RAPDs was published in 2003 [12]. This achievement was possible after having developed skills and experience on the robotic platform in the preceding 4 years. The accomplishment of such challenging procedures made our group further aware that the robotic platform had overcome many limitations of conventional laparoscopic surgery.

We have previously published the results of a study performed in the United States comparing open and robotic-assisted PD, demonstrating that the robotic platform had similar outcomes in term of morbidity and mortality compared to open surgery and also significant advantages in terms of blood loss and lymph node yield [13]. Our overall experience, however, currently amounts to more than 100 RAPDs (Giulianotti, personal communication to Clinical Robotics Surgical Association, CRSA 2012). Important issues such as oncological long-term outcomes are currently under scrutiny, although our preliminary findings indicate that the robotic platform is able to maintain the same oncological safety as open surgery, offering at the same time a minimally invasive approach.

The surgical technique for RAPD has been constantly revised and refined to reach the current standard status. We favour a full robotic-assisted approach and believe that there is no role for hybrid hand-assisted or laparoscopic/robotic approaches.

The port positioning as shown in Fig. 1 is consistent amongst most pancreatic head resections. The camera is placed on the right para-rectal line, along the axis of the superior mesenteric vessels, which mark the centre of the operative field. Two operative arms are placed to each side of the camera allowing space for 1 or 2 assistant ports, with the robotic third arm placed further away to the right side of the abdomen below the costal margin.

The surgical steps largely resemble those of open surgery, as originally described by Whipple [14]. The gastrocolic ligament is first opened to gain access to the lesser sac. The right colon is mobilised to fully expose the head of the pancreas. A complete Kocher manoeuvre is performed until the superior mesenteric vessels are identified. With the advantage of endo-wristed instruments, at this stage careful selected lymph-node sampling can be done. The hepatic hilum is then approached and control of the hepatic artery, common bile duct and gastroduodenal artery is gained. At this stage the retropancreatic tunnel is made between the pancreas and the portal confluence. The stomach and jejunum are transected with stapling devices. The pancreas can be made ready for transection, which is performed with an ultrasound cutting device (Harmonic, Ethicon Endosurgery). All options of reconstruction (classical Whipple vs. pylorus-preserving pancreato-duodenectomy [15]) are available with the robotic-assisted technique, but some preliminary unpublished data (Giulianotti, personal communication, CRSA 2012) suggest that pylorus-preserving pancreatoduodenectomy with trans-gastric 'dunking' pancreato-gastrostomy (Fig. 2) yields the best outcome with regards to complications related to pancreatic anastomotic leak.

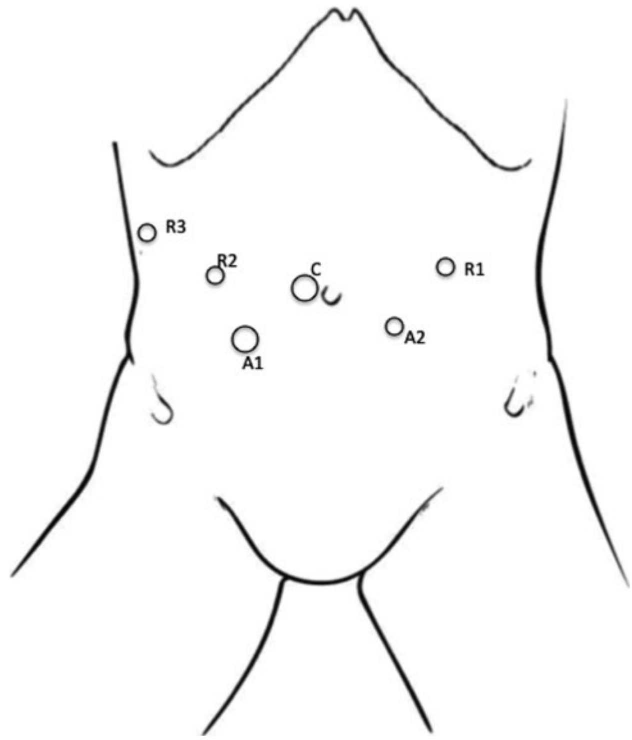

Fig. 1 Port positioning during robotic-assisted pancreatico-duodenectomy. *C* is the 12-mm camera port, *R1*, *2*, *3* are the 8-mm operative robotic ports, *A1* is the 12-mm assistant port, *A2* is the 5-mm assistant port

Unfortunately, given the technical difficulties related to the procedure, we are still lacking large series of robotic-assisted pancreato-duodenectomies. However, a cautious evaluation from some preliminary reports can be made. The first reported series from Zhou et al. [16] showed safe completion of 8 RAPDs with a mean operative time of 718 min, average blood loss of 153 ml and a 100 % rate of RO resection. The absence of peri-operative mortality and the reported 20 % pancreatic fistula rate compare favourably with most open and laparoscopic PD series.

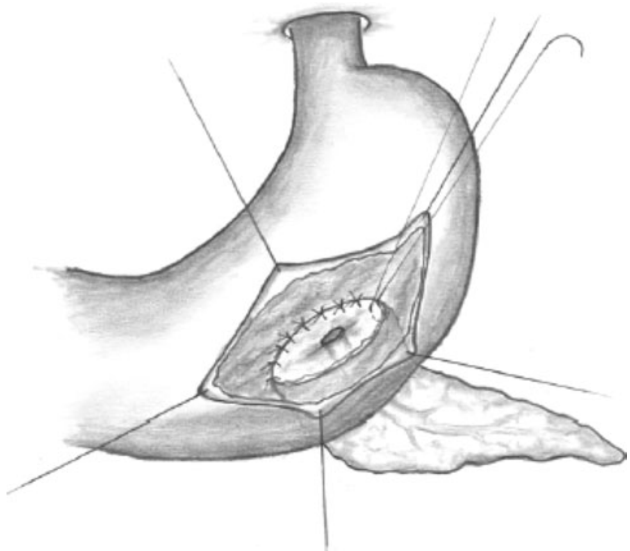

Fig. 2 Trans-gastric 'dunked' pancreato-gastrostomy. The reconstruction involves an anterior opening in the stomach, which serves as an entry to 'dunk' the pancreatic stump through a posterior gastrostomy

Narula et al. [17] have reported a series of 5 RAPDs performed with a mean operative time of 420 min and no peri-operative mortality.

More recent reports boast higher numbers of cases. Zeh et al. [18] reported a series of 50 RAPDs with a mean operative time of 568 min, average blood loss of 350 ml, 16 % conversion rate and a median length of hospital stay of 10 days. Zhan et al. [19] reported 16 cases of RAPDs within a larger series of 47 pancreatic procedures, with a mean operative time of 479 min, average blood loss of 633 ml and 6 % rate of pancreatic fistula.

Despite a physiological degree of variability across these series, some conclusions can be already drawn: (1) RAPD is a safe procedure and carries morbidity and mortality similar to open PD; (2) RAPD does not jeopardise the oncological radicality in the presence of pancreatic malignancy, (3) it would appear that in spite of longer operative times, RAPD causes less blood loss and can shorten length of hospital stay [20]. The scepticism around the long-term outcome of RAPD is, in our view, not justified, as there is no reason to believe that the oncological outcome would unfavourably compare with the open approach. This belief is based on the observation that RAPD is able to adhere strictly to the most modern oncological surgical criteria, i.e. resection margin and lymph node yield, as well as tissue manipulation.

Even through retrospective series, RAPD appears to have better short-term outcomes compared to open and conventional laparoscopic surgery [13, 16, 20–23]. However, there is still no consensus on how RAPD compares to pure laparoscopic PD. Retrospective studies show that robotic-assisted procedures have a shorter operative time compared to laparoscopic ones, but similar outcomes in term of overall complications, hospital stay and peri-operative mortality [1, 3, 20, 22, 24]. It is difficult to quantify the impact of the robotic approach over conventional laparoscopy. It would certainly be impractical to design prospective randomised trials to compare these 2 techniques. The perceived better feasibility of RAPD compared to laparoscopic PD is such that we may never achieve level 1 evidence to finally clarify this issue. The already mentioned advantages of the robotic platform may translate to lower conversion rate and even allow safe performance of additional steps such as vascular resections [25] that are feasible laparoscopically only by the most expert groups [26]. Our group has experience in this aspect and can confidently state that a formal comparison with conventional laparoscopy would not be possible. Furthermore, we believe that the added value of robotic-assisted surgery also comes from the integrated technology of the robotic platform, the potentials of which have recently begun to be explored.

Robotic-assisted distal pancreatectomy

If RAPD is approached with caution despite very favourable preliminary reports, it is the robotic-assisted approach to distal pancreatectomy (RADP) that has recently raised the enthusiasm of many pancreatic surgeons.

Distal pancreatectomy would always lend itself to a minimally invasive approach better than PD due to the lack of reconstructive time. The first laparoscopic distal pancreatectomy was described by Cuschieri et al. [27]. The robotic platform has fostered enthusiasm for this procedure such that an increasing number of centres offer a minimally invasive approach for distal pancreatic pathologies. The advantages of the robotic platform are exploited at their best in the careful dissection of the tail of the pancreas, in the dissection of the splenic artery and vein and in the separation of the pancreatic tail from the splenic hilum. The endo-wristed instruments allow a comfortable swing between the neck and the tail of the pancreas up to the splenic hilum, especially in obese patients. We consider that spleen-preserving distal pancreatectomy should be the gold standard for benign/premalignant lesions of the tail of the pancreas.

In 2010, we reported the largest series of RADPs ever published [28]. Since then, we have carried out many more procedure to achieve nearly 80 cases.

In RADP, similar technical principles to those of RAPD apply. We favour a fully robotic-assisted approach as opposed to hybrid laparoscopic/robotic or robotic/hand-assisted procedures. The port placement resembles the one used for RAPD with the camera placed to the right of the umbilicus along the axis of the mesenteric vessels. The rest of the ports are oriented to form a concave line around the body-tail of the pancreas. The third arm is placed way lateral to the right of the patient. The lesser sac is entered by cutting the gastro-colic ligament and by ligating the short gastric vessels. The superior and inferior borders of the pancreas are dissected starting at the neck of the pancreas. Control of the critical spleno-mesenteric venous junction as well as the splenic artery is achieved so as to proceed to dissection of the tail of the pancreas from the pancreatic bed up to the splenic hilum. The pancreas can be transected with an ultrasound sealing device or staplers.

The relatively short operative time and fast recovery have made this procedure very popular among pancreatic surgeons.

The striking aspect of RADP is that it compares favourably with both open and laparoscopic distal pancreatectomy (LDP). Waters et al. [29] have reported a series of 77 distal pancreatectomies showing a slightly longer operative time for the robotic-assisted procedures (298 vs. 222 min) but less blood loss (279 vs. 661 ml). The spleen preservation rate was 65 % in the robotic-assisted group and 29 % in the laparoscopic one. There were no fistulas in the robotic-assisted group and an 11 % rate in the laparoscopic arm. Finally, oncological outcomes were similar in the 2 groups but patients in the robotic-assisted arm had a significant shorter length of hospital stay (4 vs. 8 days). Kang et al. [30, 31], in a retrospective review of 45 patients (20 RADP and 25 LDP), had similar results in terms of blood loss, hospital stay, fistula rate and perioperative mortality. The spleen preservation rate, however, was 95 % in the robotic-assisted group and 64 % in the laparoscopic one. In our experience, the spleen preservation rate on an intention-to-treat basis was 80 %. Daouadi et al. [32] at the University of Pittsburgh compared a series of 30 cases of RADP with a matched historical control group of 94 conventional laparoscopic cases and found that the conversion rate in the RADP cohort was significantly less than in the LDP one. The operative time was also shorter in the robotic-assisted group. This work is comforting in respect of the fact that the operative time of robotic-assisted procedures could eventually be lower than laparoscopic ones. It is reasonable to think that within a well-trained minimally invasive unit, this would be the natural evolution of the robotic platform.

We believe that RADP could become the gold standard for distal pancreatic disease. There is now widespread consensus that higher spleen preservation rate and less blood loss can be achieved with the robotic approach [4–8]. Even shorter operative times than laparoscopic surgery are achievable within experienced unit. These factors are incontrovertible evidence of the superiority of the RADP approach compared to conventional laparoscopy or open surgery [33, 34]. Even for malignant diseases, RADP could be considered the option of choice, as there is currently enough evidence that favourable resection margins and lymph node yield are comparable to laparoscopic and open distal pancreatectomies.

Central pancreatectomy

Central pancreatectomy is a procedure rarely warranted, and it is indicated for lesions of the neck/body of the pancreas that do not require excision of the distal pancreas for oncological reasons. When such criteria are satisfied and there is a need for a parenchymal-sparing procedure, central pancreatectomy is considered. Leaving two pancreatic stumps with the distal one needing reconstruction remains an inconvenient aspect for pancreatic surgeons and still represents a discouraging reason for taking up the challenge of central pancreatectomy.

In 2010 we published a series of 3 robotic-assisted central pancreatectomies (RACPs), demonstrating reasonable operative times, blood loss and fistula rates (30 %).

The surgical technique resembles the one adopted for distal pancreatectomy, favouring a pancreato-gastrostomy reconstruction for the distal pancreas.

Kang et al. [30, 31] published a series with 5 cases reporting a mean operative time of 480 min and blood loss of 200 ml. The fistula rate was 20 %. Unpublished data from Abood et al. report a series of 9 RACPs with a mean operative time of 425 min, a mean blood loss of 187 ml and a fistula rate of 77 % (although ISGPF grade B and C were <20 %). Sa Cunha et al. and Rotellar et al. have published series of 6 and 9 patients, respectively. Their results are somewhat similar, with median blood loss of less than 150 ml and operative times of 225 and 435 min, respectively. Fistula rates were 33 and 22 % but the reconstruction of choice of Sa Cunha's group was a pancreato-gastrostomy whilst Rotellar et al. preferred a Roux-en-Y pancreato-jejunostomy [35–37]. The initial reports are therefore encouraging, although we do not feel any conclusion can be drawn with regards to this specific procedure.

Total pancreatectomy

Total pancreatectomy (TP) is a technically demanding procedure required in selected cases where chronic pancreatitis, multifocal neuroendocrine tumours or diffuse intraductal papillary mucinous neoplasm are present [38, 39]. For malignant cases, it is warranted when multiple foci of adenocarcinoma are detected. We have published a series of 5 TPs [25]. In the case of no malignant involvement of the pancreatic neck, our approach was to divide the procedure into 2 parts: a left pancreatectomy followed by a pancreato-duodenectomy. En-bloc spleen-preserving total pancreatectomy was carried out in 1 patient affected by branch duct IPMN associated with dilatation of the main duct. In our series the short-term outcomes were favourable, with a mean operative time of 456 min, a mean blood loss of 310 ml, and a mean hospital stay of 7 days. These data compare favourably to any historical series of total pancreatectomy [40–42]. Zureikat et al. (personal communication) have reported a series of 5 robotic-assisted TPs showing similar benefits to those of RAPD and RADP. In conclusion, RATP is safe and effective and should be considered as a valuable option for pre-malignant conditions requiring complete removal of the pancreatic gland.

Other procedures

The robotic platform has been used for a variety of other pancreatic procedures.

Robotic-assisted cysto-gastrostomy is a possible application of robotic pancreatic surgery, and has been successfully employed in different centres [27, 43]. Our published experience of pancreato-enterostomy for drainage-derivation of the pancreas amounts to 21 procedures [28] with results comparable to those of laparoscopic surgery [43].

We at the University of Illinois, have taken advantage of the robotic platform to carry out Puestow's procedure, i.e. pancreatic duct diversion due to its persistent dilatation secondary to chronic pancreatitis. After a series of 8 patients, the outcome of this procedure was extremely favourable, as we observed a resolution of pain symptoms in 80 % of patients. No anastomotic fistulas were observed. Other reports on lateral pancreato-jejunostomy are also favourable but they are present in the literature in the form of case reports and no definitive conclusions can be drawn at this stage [44, 45].

The robotic platform has also been used for less popular procedures in pancreatic surgery. Zeh et al. [18, 46] at the University of Pittsburgh have used the robotic platform to carry out 2 Frey's procedures. Being included within a larger series of robotic-assisted pancreatic surgery, there were no details in the publication regarding specific outcomes. Peng et al. [19] have recently reported a series of 4 robotic-assisted duodenum-preserving pancreatic head resections (Beger's procedure). There was no peri-operative mortality and mean operative time was 298 min with an average blood loss of 425 ml. The mean post-operative stay was 26.7 days, with a 75 % rate of pancreatic fistulas, all managed conservatively. Although preliminary, this is the first report of a series of Beger's procedures and demonstrates the feasibility of the technique.

At the University of Illinois at Chicago, our transplant department has also successfully used the robotic platform to carry out combined live donor nephrectomy and pancreatectomy [24, 47].

Conclusions

Before the beginning of the robotic era, minimally invasive laparoscopic pancreatic surgery was merely a chimera for many surgeons. Even the most gifted laparoscopic surgeons would take a very prudent approach when considering laparoscopic pancreatic resections. The advent of the robotic platform with endo-wristed instruments, three-dimensional vision and better ergonomics has created a renewed interest in minimally invasive pancreatic surgery. Thanks to the robotic platform an increasing number of hepato-biliary centres are developing robotic programs in order to offer minimally invasive treatments for many pancreatic diseases. Despite a limited number of series, most reports quoted in this review prove that the robotic platform represents a 'point of no return'. If on the one hand it is difficult to assess the superiority of the robotic approach over the open or laparoscopic one, on the other hand the fact that the robotic platform is the only way of performing certain procedures in a minimally invasive fashion makes its development a natural event. The other reason why the fast-paced and ever-evolving development of the robotic platform is a non-reversible process is linked to the development of the technological software interface between the robotic hardware and patient. Fluorescence, enhanced anatomy, and tissue-specific biomarkers for intra-operative tissue localisation are tools that are quickly becoming a reality. It is not possible to imagine a move away from these advancements, which will contribute to the performance of safer, faster and more effective surgery. One of the major concerns about robotic surgery is of course cost. Data about costs are lacking and have been explored in a limited manner for single procedures such as distal pancreatectomy [29]. Short hospital stays deriving from minimally invasive procedures do translate into cost cuts for health care institutions, although whether the robotic platform is overall cost-effective is more difficult to evaluate. A common mistake made in the evaluation of robotic-related costs is to refer to a single procedure. It is possible that the robotic platform may contribute to additional costs with regards to one procedure; but it is the overall cost reduction of performing a wide range of procedures in a minimally invasive fashion that must be evaluated. Being an expensive investment, the overall cost-effectiveness should be calculated on the total number of cost reductions deriving from all robotic-assisted procedures which would have been otherwise performed open or laparoscopically. Bearing this in mind, we have no doubt that the robotic platform will eventually prove to be cost-effective. Other aspects that are often overlooked relate to the advantages of minimally invasive surgery in the long term. Being less traumatic, minimally invasive surgery invariably permits a fast return to work and is less prone to the long-term complications of more traumatic surgery such as adhesions, incisional hernias and chronic pain. Furthermore, the robotic platform will eventually become more affordable over time, especially when different competitors share the market, which is currently a monopoly. Pancreatic surgery remains one of the most successful fields of application of the robotic platform and its use is growing at an astonishing pace. The prudency in waiting for more robust prospective trials before considering such a platform as the 'gold standard' is justified; however, it is likely, as has happened in the past, that the surgical community will accept it as standard practice before any prospective randomised trial has been carried out.

References

1. Kendrick ML, Cusati D. Total laparoscopic pancreaticoduodenectomy: feasibility and outcome in an early experience. Arch Surg. 2010;145(1):19–23.
2. Kim SC, Song KB, Jung YS, Kim YH, do Park H, Lee SS, et al. Short-term clinical outcomes for 100 consecutive cases of laparoscopic pylorus-preserving pancreatoduodenectomy: improvement with surgical experience. Surg Endosc. 2013;27(1):95–103.
3. Palanivelu C, Rajan PS, Rangarajan M, Vaithiswaran V, Senthilnathan P, Parthasarathi R, et al. Evolution in techniques of laparoscopic pancreaticoduodenectomy: a decade long experience from a tertiary center. J Hepatobiliary Pancreat Surg. 2009;16(6):731–40.
4. Fernandez-Cruz L, Cosa R, Blanco L, Levi S, Lopez-Boado MA, Navarro S. Curative laparoscopic resection for pancreatic neoplasms: a critical analysis from a single institution. J Gastrointest Surg. 2007;11(12):1607–21. Discussion 21–22.
5. Jayaraman S, Gonen M, Brennan MF, D'Angelica MI, DeMatteo RP, Fong Y, et al. Laparoscopic distal pancreatectomy: evolution of a technique at a single institution. J Am Coll Surg. 2010;211(4):503–9.
6. Kooby DA, Gillespie T, Bentrem D, Nakeeb A, Schmidt MC, Merchant NB, et al. Left-sided pancreatectomy: a multicenter comparison of laparoscopic and open approaches. Ann Surg. 2008;248(3):438–46.
7. Dulucq JL, Wintringer P, Mahajna A. Laparoscopic pancreaticoduodenectomy for benign and malignant diseases. Surg Endosc. 2006;20(7):1045–50.
8. Gumbs AA, Gayet B. The laparoscopic duodenopancreatectomy: the posterior approach. Surg Endosc. 2008;22(2):539–40.
9. Cuschieri A. Laparoscopic surgery of the pancreas. J Roy Coll Surg Edinb. 1994;39(3):178–84.
10. Pugliese R, Scandroglio I, Sansonna F, Maggioni D, Costanzi A, Citterio D, et al. Laparoscopic pancreaticoduodenectomy: a retrospective review of 19 cases. Surg Laparosc Endosc Percutan Tech. 2008;18(1):13–8.
11. Gagner M, Palermo M. Laparoscopic Whipple procedure: review of the literature. J Hepatobiliary Pancreat Surg. 2009;16(6):726–30.
12. Giulianotti PC, Coratti A, Angelini M, Sbrana F, Cecconi S, Balestracci T, et al. Robotics in general surgery: personal experience in a large community hospital. Arch Surg. 2003;138(7):777–84.
13. Buchs NC, Addeo P, Bianco FM, Ayloo S, Benedetti E, Giulianotti PC. Robotic versus open pancreaticoduodenectomy: a comparative study at a single institution. World J Surg. 2011;35(12):2739–46.
14. Whipple AO, Parsons WB, Mullins CR. Treatment of carcinoma of the ampulla of Vater. Ann Surg. 1935;102(4):763–79.
15. Traverso LW, Longmire WP Jr. Preservation of the pylorus in pancreaticoduodenectomy. Surg Gynecol Obstet. 1978;146(6):959–62.
16. Zhou NX, Chen JZ, Liu Q, Zhang X, Wang Z, Ren S, et al. Outcomes of pancreatoduodenectomy with robotic surgery versus open surgery. Int J Med Robot. 2011;7(2):131–7.
17. Narula VK, Mikami DJ, Melvin WS. Robotic and laparoscopic pancreaticoduodenectomy: a hybrid approach. Pancreas. 2010;39(2):160–4.
18. Zeh HJ, Zureikat AH, Secrest A, Dauoudi M, Bartlett D, Moser AJ. Outcomes after robot-assisted pancreaticoduodenectomy for periampullary lesions. Ann Surg Oncol. 2012;19(3):864–70.
19. Zhan Q, Deng XX, Han B, Liu Q, Shen BY, Peng CH, et al. Robotic-assisted pancreatic resection: a report of 47 cases. Int J Med Robot: MRCAS; 2012.
20. Chalikonda S, Aguilar-Saavedra JR, Walsh RM. Laparoscopic robotic-assisted pancreaticoduodenectomy: a case-matched comparison with open resection. Surg Endosc. 2012;26(9):2397–402.
21. Choi CH, Lee JW, Lee YY, Kim HJ, Song T, Kim MK, et al. Comparison of laparoscopic-assisted radical vaginal hysterectomy and laparoscopic radical hysterectomy in the treatment of cervical cancer. Ann Surg Oncol. 2012;19(12):3839–48.
22. Asbun HJ, Stauffer JA. Laparoscopic vs open pancreaticoduodenectomy: overall outcomes and severity of complications using the Accordion Severity Grading System. J Am Coll Surg. 2012;215(6):810–9.
23. Lai EC, Yang GP, Tang CN. Robot-assisted laparoscopic pancreaticoduodenectomy versus open pancreaticoduodenectomy—a comparative study. Int J Surg. 2012;10(9):475–9.
24. Giulianotti PC, Kuechle J, Salehi P, Gorodner V, Galvani C, Benedetti E, et al. Robotic-assisted laparoscopic distal pancreatectomy of a redo case combined with autologous islet transplantation for chronic pancreatitis. Pancreas. 2009;38(1):105–7.
25. Giulianotti PC, Addeo P, Buchs NC, Ayloo SM, Bianco FM. Robotic extended pancreatectomy with vascular resection for locally advanced pancreatic tumors. Pancreas. 2011;40(8):1264–70.
26. Kendrick ML, Sclabas GM. Major venous resection during total laparoscopic pancreaticoduodenectomy. HPB (Oxford). 2011;13(7):454–8.
27. Cuschieri A, Jakimowicz JJ, van Spreeuwel J. Laparoscopic distal 70 % pancreatectomy and splenectomy for chronic pancreatitis. Ann Surg. 1996;223(3):280–5.
28. Giulianotti PC, Sbrana F, Bianco FM, Elli EF, Shah G, Addeo P, et al. Robot-assisted laparoscopic pancreatic surgery: single-surgeon experience. Surg Endosc. 2010;24(7):1646–57.
29. Waters JA, Canal DF, Wiebke EA, Dumas RP, Beane JD, Aguilar-Saavedra JR, et al. Robotic distal pancreatectomy: cost effective? Surgery. 2010;148(4):814–23.
30. Kim DH, Kang CM, Lee WJ, Chi HS. The first experience of robot assisted spleen-preserving laparoscopic distal pancreatectomy in Korea. Yonsei Med J. 2011;52(3):539–42.

31. Kang CM, Kim DH, Lee WJ, Chi HS. Conventional laparoscopic and robot-assisted spleen-preserving pancreatectomy: does da Vinci have clinical advantages? Surg Endosc. 2011;25(6):2004–9.
32. Daouadi M, Zureikat AH, Zenati MS, Choudry H, Tsung A, Bartlett DL, et al. Robot-assisted minimally invasive distal pancreatectomy is superior to the laparoscopic technique. Ann Surg. 2013;257(1):128–32.
33. Iacobone M, Citton M, Nitti D. Laparoscopic distal pancreatectomy: up-to-date and literature review. World J Gastroenterol. 2012;18(38):5329–37.
34. Hwang HK, Kang CM, Chung YE, Kim KA, Choi SH, Lee WJ. Robot-assisted spleen-preserving distal pancreatectomy: a single surgeon's experiences and proposal of clinical application. Surg Endosc. 2013; 27(3):774–81.
35. Sa Cunha A, Rault A, Beau C, Collet D, Masson B. Laparoscopic central pancreatectomy: single institution experience of 6 patients. Surgery. 2007;142(3):405–9.
36. Rotellar F, Pardo F. Laparoscopic middle pancreatectomy minimizes the procedure and maximizes the benefit. Surgery. 2010; 147(6):895.
37. Rotellar F, Pardo F, Montiel C, Benito A, Regueira FM, Poveda I, et al. Totally laparoscopic Roux-en-Y duct-to-mucosa pancreaticojejunostomy after middle pancreatectomy: a consecutive nine-case series at a single institution. Ann Surg. 2008;247(6):938–44.
38. Nakao A, Takeda S, Inoue S, Nomoto S, Kanazumi N, Sugimoto H, et al. Indications and techniques of extended resection for pancreatic cancer. World J Surg. 2006;30(6):976–82. Discussion 83–4.
39. Glanemann M, Shi B, Liang F, Sun XG, Bahra M, Jacob D, et al. Surgical strategies for treatment of malignant pancreatic tumors: extended, standard or local surgery? World J Surg Oncol. 2008;6:123.
40. Blondet JJ, Carlson AM, Kobayashi T, Jie T, Bellin M, Hering BJ, et al. The role of total pancreatectomy and islet autotransplantation for chronic pancreatitis. Surg Clin N Am. 2007;87(6):1477–501.
41. Ris F, Niclauss N, Morel P, Demuylder-Mischler S, Muller Y, Meier R, et al. Islet autotransplantation after extended pancreatectomy for focal benign disease of the pancreas. Transplantation. 2011;91(8):895–901.
42. Wahoff DC, Papalois BE, Najarian JS, Kendall DM, Farney AC, Leone JP, et al. Autologous islet transplantation to prevent diabetes after pancreatic resection. Ann Surg. 1995;222(4):562–75. Discussion 75–9.
43. Palanivelu C, Senthilkumar K, Madhankumar MV, Rajan PS, Shetty AR, Jani K, et al. Management of pancreatic pseudocyst in the era of laparoscopic surgery—experience from a tertiary centre. Surg Endosc. 2007;21(12):2262–7.
44. Meehan JJ, Sawin R. Robotic lateral pancreaticojejunostomy (Puestow). J Pediatr Surg. 2011;46(6):e5–8.
45. Eid GM, Entabi F, Watson AR, Zuckerbraun BS, Wilson MA. Robotic-assisted laparoscopic side-to-side lateral pancreaticojejunostomy. J Gastrointest Surg. 2011;15(7):1243.
46. Zeh HJ 3rd, Bartlett DL, Moser AJ. Robotic-assisted major pancreatic resection. Adv Surg. 2011;45:323–40.
47. Oberholzer J, Tzvetanov I, Mele A, Benedetti E. Laparoscopic and robotic donor pancreatectomy for living donor pancreas and pancreas-kidney transplantation. J Hepatobiliary Pancreat Surg. 2010;17(2):97–100.