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REVIEW ARTICLE

Robotic pancreaticoduodenectomy in the era of minimally invasive surgery

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Abstract: Minimally invasive surgery has become a worldwide trend to reduce the wound and mitigate pain. However, the role of robotic pancreaticoduodenectomy (RPD) has not been well established in the era of minimally invasive surgery. It would be nearly impossible to apply minimally invasive surgery in the tedious and complicated Whipple operation without an experienced and dedicated pancreas team. The pancreatic team led by Shyr YM and Wang SE at Taipei Veterans General Hospital have already been highly accredited with a Copper Award of Symbol of National Quality (SNQ award), entitled with "Minimally Invasive Robotic Pancreatic Surgery—Small Wound for Major Pancreatic Surgery" in Taiwan in 2019. RPD was claimed to be associated with less blood loss, less delayed gastric emptying, shorter length of postoperative stay, and lower wound infection rate, but longer operative time, as compared with the traditional open pancreaticoduodenectomy (OPD). More than 99% of the patients undergoing minimally invasive RPD are satisfied with the surgical outcomes and would like to recommend RPD to those with periampullary lesions. RPD could be recommended not only to surgeons but also to patients in terms of surgical outcomes and patient satisfaction. Moreover, our study showed a survival benefit for pancreatic head adenocarcinoma in RPD group, with 1-year, 3-year, and 5-year survival of 82.9%, 45.3%, and 26.8%, respectively, as compared with 63.8%, 26.2%, and 17.4% in OPD.

Keywords: Open; Pancreatic head adenocarcinoma; Pancreaticoduodenectomy; Robotic

1. INTRODUCTION

Pancreaticoduodenectomy, so-called "Whipple operation," remains an extremely difficult and challenging abdominal surgical procedure. Traditional open pancreaticoduodenectomy (OPD) usually results in a big and painful wound which would torture the patient postoperatively. Therefore, minimally invasive surgery has become a worldwide trend to reduce the wound and mitigate pain.[1–4] However, The role of robotic pancreaticoduodenectomy (RPD) has not been well established in the era of minimally invasive surgery. It would be nearly impossible to apply minimally invasive surgery in the tedious and complicated Whipple operation without an experienced and dedicated pancreas team. The pancreas team at Taipei Veterans General Hospital have been endeavoring to develop minimally invasive RPD. With the experience of nearly 1500 Whipple operations and over 300 cases of minimally invasive RPD (Fig. 1), some remarkable records in RPD have been achieved, including as follows: (1) early discharge from hospital after RPD, as early as on postoperative day 6, about 1 month earlier than that by traditional OPD; (2) minimally invasive wounds, as small as 3~4 cm by RPD, about one of 10 of the 30~40 cm wound by traditional OPD; (3) "No" blood loss in four cases of RPD, with a mean of 120 cc, as compared to 500 cc blood loss by traditional OPD; (4) short operation time by RPD, as short as 232 minutes (<4 h), shorter than that, 6~8 hours, by traditional OPD; (5) successful RPD in a 95 y/o patient, proving RPD to be a feasible option in the very aged patients; and (6) low surgical mortality, as low as less than 2%. More than 99% of the patients undergoing minimally invasive RPD are satisfied with the surgical outcomes and would like to recommend RPD to those with periampullary lesions.[2] The pancreatic team led by Shyr YM and Wang SE have already been highly accredited with a Copper Award of Symbol of National Quality, Safety and Quality (SNQ award) entitled with "Minimally Invasive Robotic Pancreatic Surgery—Small Wound for Major Pancreatic Surgery" in Taiwan in 2019.

2. MINIMALLY INVASIVE SURGERY

Minimally invasive surgery has become a worldwide trend in many surgical fields including pancreatic surgery.[5–9] Increasing evidence has demonstrated not only the feasibility of laparoscopic pancreatectomies but also advantages in postoperative outcomes and comparable oncological results.[10–12] However, there are some limitations in using the laparoscopic approach for a major pancreatic surgery such as pancreaticoduodenectomy. Recently, with the advantageous ergonomics of the da Vinci Robotic Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA, USA), several limitations related to the laparoscopic surgery have been overcome. Moreover, given the high-quality three-dimensional and 10 to 15 magnification view, elimination of surgeons' tremor, and articulation of instruments with 540 degrees of motion, robotic approach even

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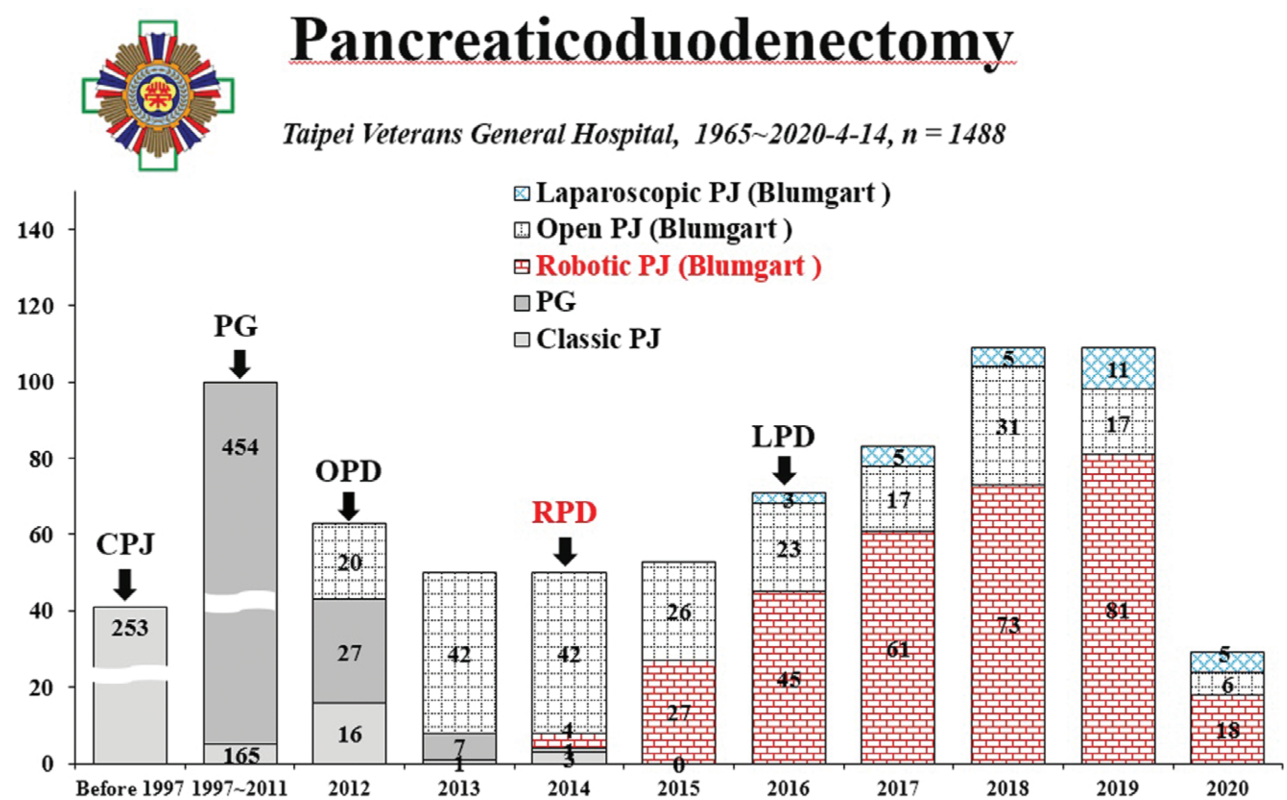

Fig. 1 Case numbers of pancreaticoduodenectomy with various approaches and pancreatic reconstructions at Taipei Veterans General Hospital. CPJ = classic pancreaticojejunostomy; LPD = laparoscopic pancreaticoduodenectomy with modified Blumgart pancreaticojejunostomy; OPD = open pancreaticoduodenectomy with modified Blumgart pancreaticojejunostomy; PG = pancreaticojejunostomy; RPD = robotic pancreaticoduodenectomy with modified Blumgart pancreaticojejunostomy.

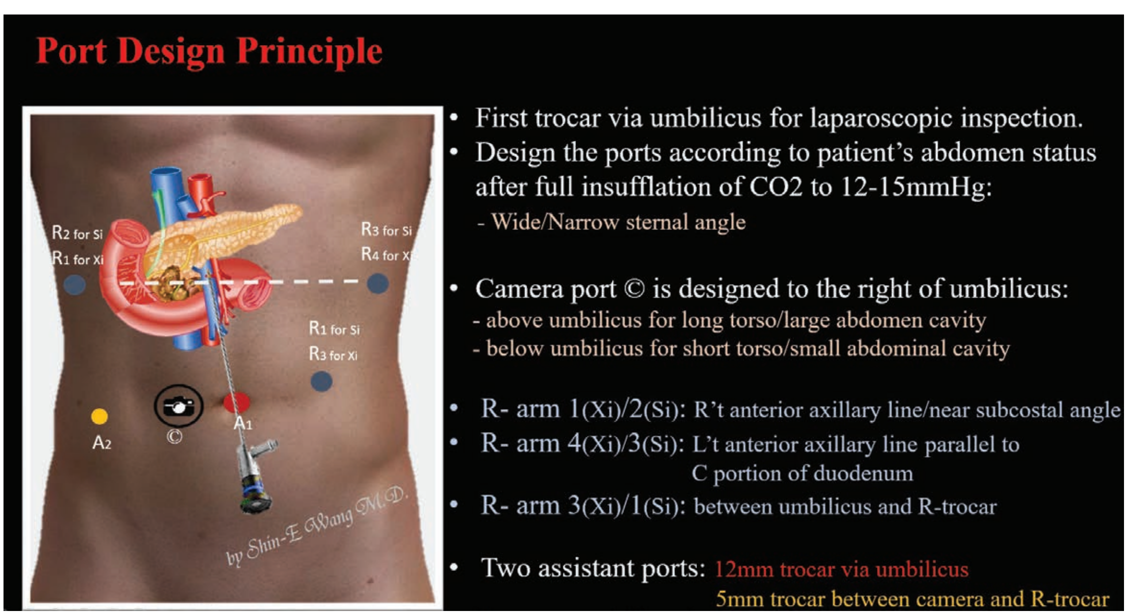

Fig. 2 Six trocar ports include four for robotic instruments and two for assistant instrument. CO_2 = carbon dioxide.

allows to perform more complicated and delicate procedures such as pancreaticoduodenectomy involving extensive dissection and restoration of digestive tract continuity for the pancreas, bile duct, and gastrointestinal tract.[7,10,13] Currently, the main concerns in using the da Vinci Robotic Surgical System is the cost for robotic instruments, which could be one of the reasons for RPD thus far not widely accepted as a routine procedure.[5,14–18]

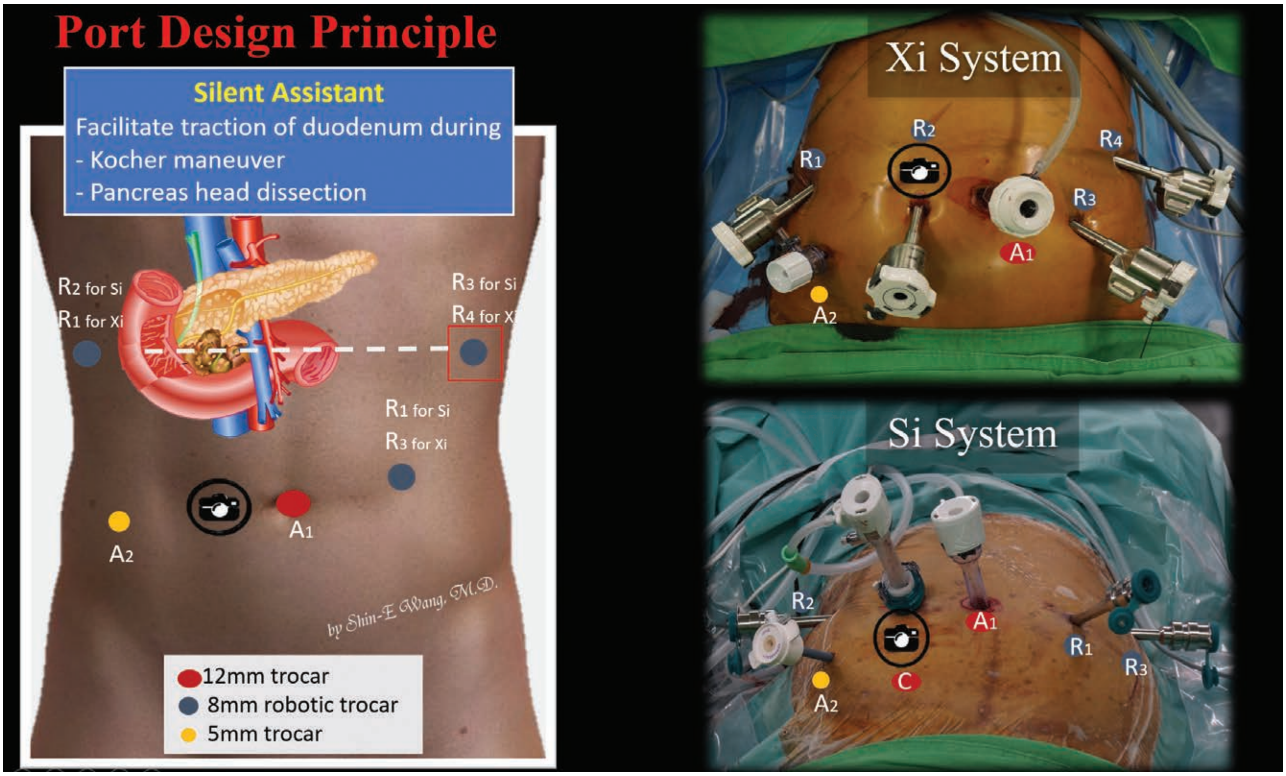

Fig. 3 Trocar design is similar for da Vinci Si and Xi Surgical Systems.

3. ROBOTIC PANCREATICODUODENECTOMY

RPD is performed with the assistance of da Vinci Si or Xi Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA, USA) at Taipei Veterans General Hospital. For both da Vinci Si and Xi Surgical System, six ports (four robotic trocars and two accessory ports) are used (Fig. 2). The trocar design is similar for da Vinci Si and Xi Surgical Systems (Fig. 3). A trans-umbilical incision is made for the insertion of a 12-mm accessory port, and pneumoperitoneum is established at a pressure of <15 mm Hg. A 12-mm camera port is placed. Three 8-mm robotic working ports are placed, including one at the right anterior axillary line about 2 cm below subcostal region, another one at the left midclavicular line slightly above the umbilicus level and the third at the left anterior axillary line about 2 cm below the subcostal region. The 12-mm camera port is set up at about 5 cm to the right of umbilicus. By this design for camera port, the robotic scope can clearly see the relationship of pancreatic head and superior mesenteric vein (SMV)/superior mesenteric artery (SMA) (Fig. 4).The other 5-mm accessory port is placed on the right midclavicular line slightly below the camera port.[19]

The technique for pancreatic reconstruction in RPD is a modified Blumgart pancreaticojejunostomy (PJ) previously described in detail.[1,19,20] Briefly, Blumgart PJ is performed using two or three transpancreatic U-sutures with 3-0 monofilament synthetic absorbable sutures made of polydioxanone (PDS) (Johnson & Johnson Medical N.V., Belgium), with one placed cranial and one or two caudal to the pancreatic duct. Each of the U-sutures is placed at a distance of 0.8 to 1 cm from the pancreatic cutting-edge. These sutures with needles on them are not tied at this time but instead are left loose and kept separate, held with robotic instruments until all of the inner duct-to-mucosa sutures are placed and tied. A series of simple interrupted sutures with 4-0 absorbable synthetic

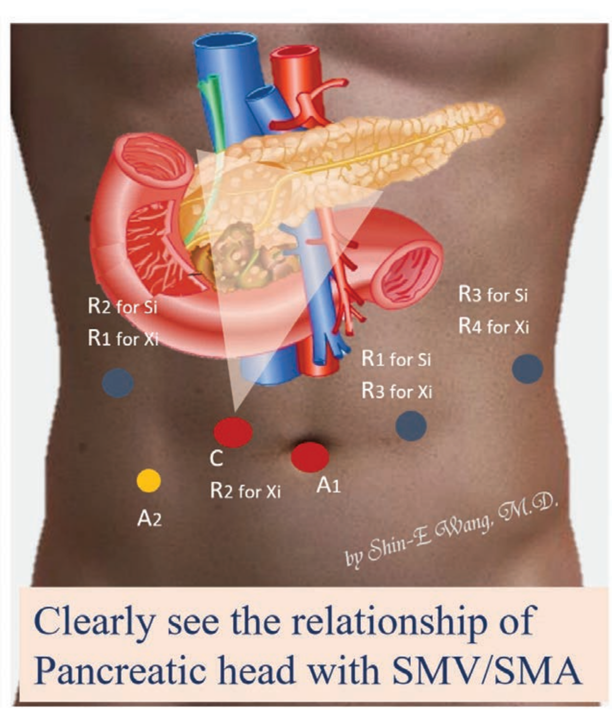

Fig. 4 The cameral port indicated with red dot and "C" or "R2 for Xi" is placed to the right of umbilicus. Thus, the robotic scope can clearly see the relationship of pancreatic head and SMV/SMA when separating the pancreatic head/uncinated process from these vessels. SMA = superior mesenteric artery; SMV = superior mesenteric vein.

monofilament suture made of polydioxanone (MonoPlus, B. Braun Surgical S.A., Spain) are then carefully and accurately placed for duct-to-mucosa anastomosis, usually six for a nondilated pancreatic duct and eight sutures for a dilated one. These inner sutures are tied one by one from 6 o'clock with pair-watch technique. After the duct-to-mucosal sutures are tied, the outer anterior horizontal mattress sutures on the jejunum using previously held U-sutures are completed and tied one by one on the anterior surface of the pancreas. The term "mesopancreas dissection" is used to describe the extent of lymph node dissection, proposed by Inoue et al.[21] Mesopancreas dissections are categorized into three levels according to the extent of dissection around and along the SMA: Level 1: Simple mesopancreas division along the right side of SMV; Level 2: Mesopancreas division along the right side of SMA, leading to en bloc resection of the corresponding lymph nodes and mesojejunum, but not including the nerve plexus around the SMA; and Level 3: En bloc mesopancreas resection with periadventitial dissection including nerve plexus along the right side of SMA.[21–23]

4. SURGICAL OUTCOMES

RPD was claimed to be associated with less blood loss, less delayed gastric emptying, shorter length of postoperative stay, and lower wound infection rate, but longer operative time, as compared with the traditional OPD.[14,24–27] Based on our study with 105 patients undergoing RPD, the most common complication was chyle leakage (18.1%), followed by postoperative pancreatic fistula (5.7%), intra-abdominal abscess (4.8%), delayed gastric emptying (3.8%), and post pancreatectomy hemorrhage (3.8%).[2] The would cosmesis is shown in Figure 5. A questionnaire study conducted for patient satisfaction and quality-of-life after RPD showed that more than 99% of the patients undergoing minimally invasive RPD are satisfied with the surgical outcomes and would like to recommend RPD to those with periampullary lesions.[2] RPD could be recommended not only to surgeons but also to patients in terms of surgical outcomes and patient satisfaction.[1,2,14]

5. SURVIVAL OUTCOMES

The survival outcome after RPD has been seldom reported in the literature.[14] A preliminary survival study was conducted for pancreatic head adenocarcinoma with 85 patients in RPD group and 81 in OPD. We found there was a survival benefit in RPD group, with 1-year, 3-year, and 5-year survival of 82.9%, 45.3%, and 26.8%, respectively, as compared with 63.8%, 26.2%, and 17.4% in OPD. There was no survival difference for other periampullary adenocarcinomas including ampullary adenocarcinoma, distal common bile duct adenocarcinoma, and duodenal adenocarcinoma between RPD and OPD groups. Although selection bias would be inevitable in the retrospective study, survival outcomes for pancreatic head and periampullary adenocarcinomas seem not to be compromised by RPD. A further study with large sample size and long-term

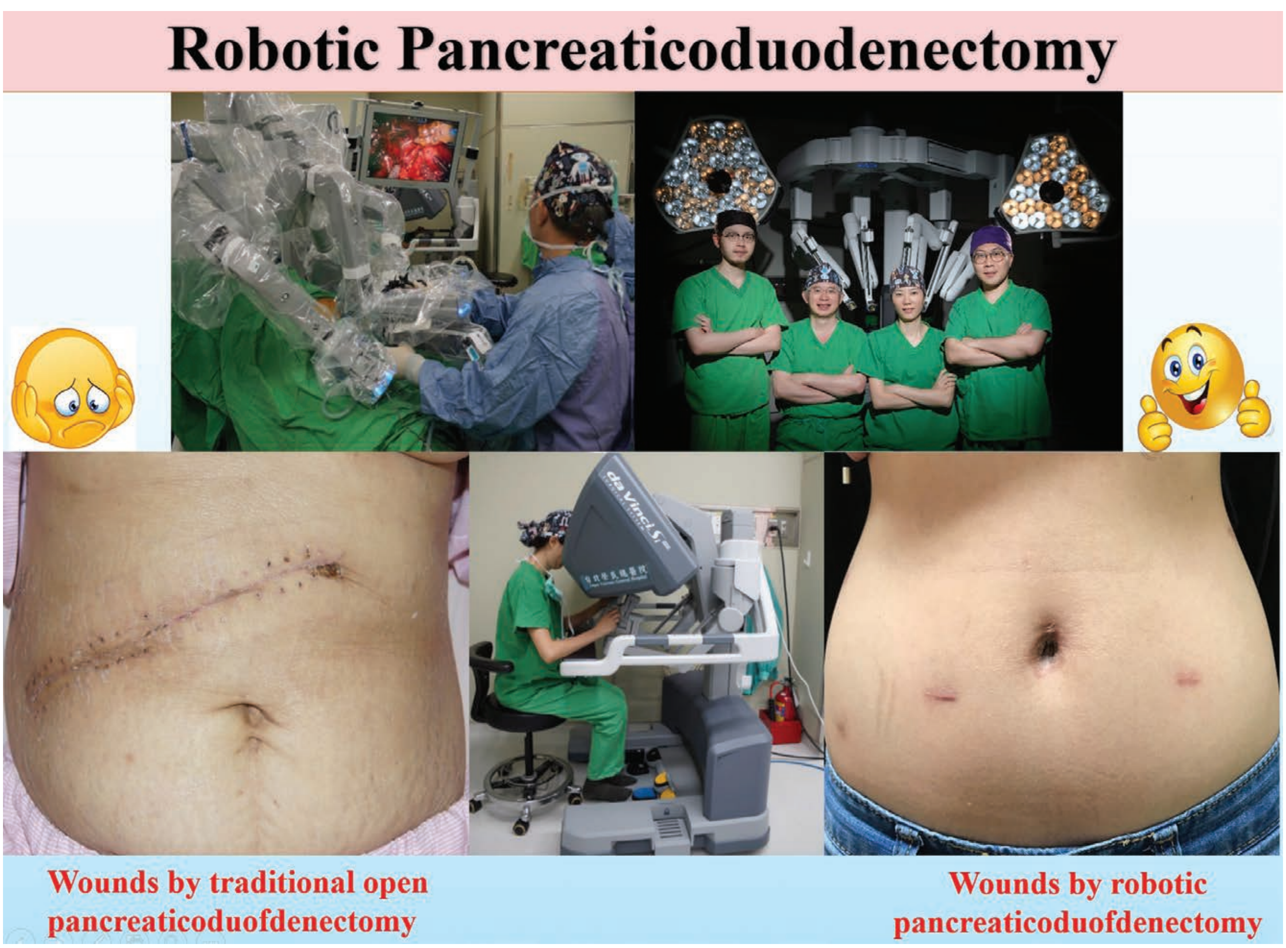

Fig. 5 Wound cosmesis after robotic and traditional open pancreaticoduodenectomy by pancreatic surgical team at Taipei Veterans General Hospital.

follow-up or prospective randomized control trial is needed to make a solid conclusion.

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