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Laparoscopic pancreatic surgery with robotic assistance

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Abstract: Laparoscopic surgery has made significant strides in gastroenterology, and it currently accounts for the vast majority of gastrointestinal procedures. This study discusses the present state of the art in robot-assisted laparoscopic pancreatectomy and the prospects for this procedure. In order to better understand the writers' experiences, a study of the literature was conducted. Because of the 3-dimensional high-vision images it produces, the da Vinci Surgical System is considered to be safer than conventional endoscopes. It also has a high articular function with the ability to perform seven types of gripping, a scaling function that allows for adjustment of surgeon hand motion and forceps motion, a filtering function that eliminates shaking of the surgeon's hand, and an image-guided surgery feature. This device is intended to be particularly beneficial for patients who require careful surgical handling due to the functions it possesses. The time required for the operation, which is greater than that required for open surgery, and the additional time required for the use of the da Vinci Surgical System, compared to standard laparoscopic surgery, are two of the most significant issues that remain. However, these difficulties may be remedied due to the accumulation of experience and the adjustment of the method in place. In the future, it looks that robot-assisted laparoscopic pancreatectomy will become standard practice.
*Keywords:*Robot-assisted surgery, da Vinci surgical robot

Introduction

In gastroenterology surgery, laparoscopic surgery has made significant strides, and it currently accounts for the majority of gastrointestinal procedures [1–9]. Because of the reduction of body wall damage, laparoscopic surgery has significantly improved patients' postoperative quality of life (QOL). On the other hand, laparoscopic surgery is complicated for surgeons to conduct because it limits their degrees of freedom in forceps manipulation and necessitates using two-dimensional endoscopic pictures to guide them. In order to address these limitations of laparoscopic surgery, reports of robot-assisted surgery, which enhances the degrees of freedom of forceps manipulation and produces three-dimensional pictures, have started to appear irregularly in the medical literature. Hempen's and colleagues [10] published the first report of cholecystectomy performed using the da Vinci Surgical System (Intuitive Surgical, Inc.), a robot that aids endoscopic procedures. Following the publication of their study, the performance of this kind of robot has significantly improved, and the use of robot-assisted surgery has become more widespread, particularly in the United States and Europe [11–14]. In the areas of urology and cardiovascular surgery, robot-assisted surgery is becoming more prevalent. For example, robot-assisted surgery now accounts for 80 percent of all prostate gland surgeries [14–16], which is a significant increase from previous figures. There has also been an increase in the number of reports on robot-assisted endoscopic surgery in the field of gastroenterology surgery in recent years [17, 18]. This article discusses the present state of the art in robot-assisted laparoscopic pancreatectomy and the prospects for the future.

Laparoscopic surgery is made more accessible with the help of robots.

The da Vinci and Zeus robots are two examples of robots that help in laparoscopic surgery. A comparison between these two robots revealed that da Vinci was better than Zeus. At the moment, only da Vinci is available for purchase. As of June 2010, more than 1660 da Vinci units were in operation for clinical or instructional reasons in over 100 countries across the globe. The da Vinci surgical system was initially

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designed for use in cardiovascular surgery, but its area of use has grown as the number of indications authorized by the FDA (Food and Drug Administration) has increased, and it is now used in almost all disciplines of surgery [19]. The da Vinci Surgical System is comprised of three devices (the surgeon console, the patient care cart, and the vision cart) that are all electronically linked to one another. The surgeon utilizes the surgeon console to do direct manipulation of the patient. While seeing the three-dimensional high-definition pictures, the surgeon manipulates the controller to carry out the operation on the patient. Foot pedals are used during surgery by the surgeon for the clutch, camera, electrocautery, and camera focus, among other things. The surgeon console is situated in a non-sterile zone separate from the patient cart and is operated by the surgeon, who stays in a non-sterile zone while performing his or her duties. The patient cart is the robot that performs surgery on the patient while following the directions from the surgeon console on the surgeon console. The patient cart is equipped with a laparoscope attachment arm as well as three pairs of forceps that are specifically intended for surgical procedures.

Having a diameter of 8 mm, each of these pairs of forceps can perform critical grasping tasks with 6 degrees of freedom. On the ends of these forceps, it is possible to attach holding forceps, a needle holder, an electrocautery device, freeing forceps, clipping forceps, and other tools, as well as other instruments. The right and left forceps pairs are manipulable, while the remaining pair serves as the assistant's hand in the operation. The vision cart, which is equipped with an image processor and other technology, provides the surgeon with high-definition 3D pictures in high resolution. Thus, the surgeon may get visual information simply by looking at the surgeon console and without needing to wear special glasses in order to do so. This feature, which is not available in traditional laparoscopic surgical equipment, has significantly increased the procedure's safety. Other features of the da Vinci surgical system include its scaling function (which allows the surgeon's hand movements and forceps motions to be adjusted to ratios of 2:1, 3:1, or 5:1) and its filtering function (which eliminates the surgeon's hand vibration). Furthermore, this device can magnify the vision by 910 (optically) or about 915 (mechanically) (if digital zoom is used). The use of these capabilities comes in useful when delicate operational manipulation is necessary (e.g., pancreatic duct-jejunal mucosa anastomosis).

Laparoscopic pancreatectomy with robotic assistance

The number of papers published on robotic surgery in gastroenterology surgery (especially pancreatic surgery) is lower than the number of studies published on robotic surgery in cardiovascular and urological surgery. Himpens et al. [10] conducted the first robot-assisted cholecystectomy in 1998. Since then, the safety and functionality of robotic instruments have increased significantly. Reports on robots' usage in pancreatic surgery have also started to appear in peer-reviewed journals. When Giulianotti et al. [12] used robot-assisted laparoscopic surgery in 2003, they were able to conduct pancreaticoduodenectomy in eight instances and distal pancreatectomy in five cases, respectively. Their study said that the pancreaticoduodenectomy procedure took 490 minutes, and the distal pancreatectomy procedure took 250 minutes. According to the researchers, a death rate of 12.5 percent (1/8 cases) was seen with pancreaticoduodenectomy. According to the study, patients having robot-assisted laparoscopic surgery had a shorter hospital stay than those undergoing open surgery. This was the same year that Melvin et al. [20] reported the first patient to be released from the hospital after undergoing robotic distal pancreatectomy for an endocrine tumor on the second day after the procedure. According to Vasilescu et al. [21], a case of chronic pancreatitis involving the pancreatic tail was described in 2009, and the patient

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was treated by robotic spleen-preserving distal pancreatectomy. In 2010, Narula et al. [22] used a hybrid technique to conduct laparoscopic pancreaticoduodenectomy on eight patients with pancreatic disease. According to the researchers, there were five instances where the procedure was finished and three cases where the operation was modified to open surgery. They went on to say that the da Vinci was crucial in the anastomosis of the pancreas in the previous five instances. In the same year, Giulianotti et al. [23] published a paper detailing 77 instances of pancreatic surgery performed using the da Vinci surgical system. Thirty of these patients had pancreaticoduodenectomy, which was followed by pancreatic gastric anastomosis as part of the reconstructive process. The average operation duration was 421 minutes, and the highest operation time was 660 minutes, and the frequency of pancreatic juice leakage was 31.3 percent. Using three different pancreatic body/tail resection methods, including robotic laparoscopic surgery, laparoscopic surgery, and open surgery, Waters discovered that robotic laparoscopic surgery helped preserve the splenic arteries and veins and was more cost-effective when the length of hospital stay was taken into consideration. In 2010, Horiguchi et al. [24] conducted a robot-assisted full laparoscopic pancreaticoduodenectomy for the first time in Japan, and they found that the amount of blood loss was significantly reduced. When compared to open surgery, this technique requires a considerably shorter amount of hospitalization time. A total of 30 patients underwent robot-assisted laparoscopic pancreatectomy with repair, according to Zureikat et al. [25]. There was only a modest amount of blood lost (320 mL on average), and even though there was a 27 percent incidence of pancreatic juice leakage, there was only a 10 percent incidence of clinically significant pancreatic juice leakage (grade B or C according to the ISGPF criteria [26]).

It is recommended for patients with pancreatic tumors that are not accompanied by vascular invasions, such as cancer of the duodenal papilla, tumors of the lower section of the bile duct, and pancreatic cancer with a low-grade malignancy that has not progressed outside of the pancreas. The development of vascular forceps for use in conjunction with the da Vinci robot may make it feasible in the future to do a pancreatectomy in conjunction with portal vein resection using this technique. For the safe execution of da Vinci pancreatectomy, it is essential to evaluate the pattern of branching of the inferior pancreaticoduodenal artery and the arrangement of portal veins using MD-CT vascular imaging before surgery [27].

The procedure for laparoscopic pancreaticoduodenectomy with robot assistance

Under general anesthesia, surgery is done on the patient while he or she is lying in the supine position. First, it is necessary to introduce a laparoscope via an open laparotomy in the umbilical area to examine the intraperitoneal cavity. Into the epigastric area are put three 8 mm trocars (one of which is specifically intended for the da Vinci) and one 12 mm trocar (for assistance). During the procedure, the liver retractor is introduced to compress the lateral liver segment in the direction of the cranioventral artery. These procedures are similar to those performed during traditional laparoscopic surgery. After that, the da Vinci is docked. With its first and third arms fully extended, the da Vinci serves as the surgeon's right hand, holding the forceps and needle holder, respectively, after being docked. The second arm acts as the surgeon's left hand, mainly by holding forceps and other surgical instruments. The first and third arms are employed sequentially, one after the other. One of these arms is responsible for operating manipulation, which is accomplished by developing and freezing the operational field. Moving from one of the first and third arms to the other in the proper sequence is critical.

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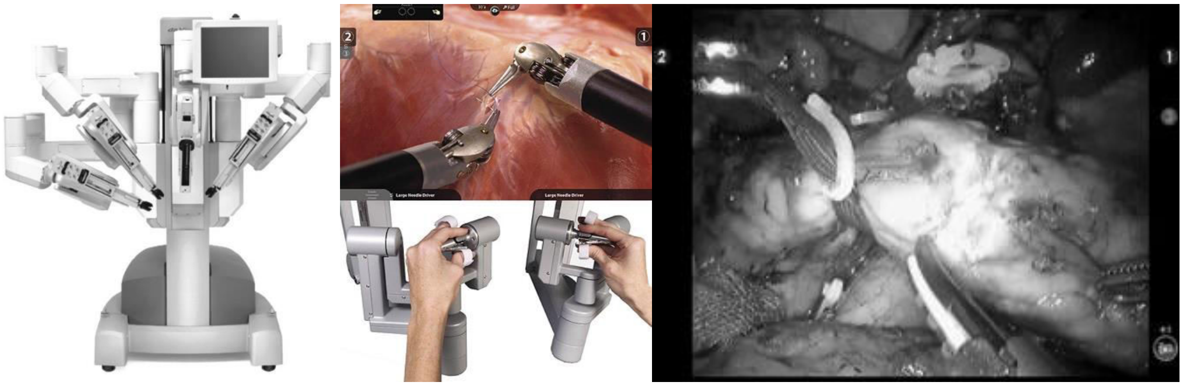

Fig. 1: Da Vinci surgical robot. Coagulation shears are used to dissect the pancreatic parenchyma under laparoscopic guidance.

Fig. 2: In order to perform a precise pancreaticojejunostomy, enlarged views and an adjustable needle holder with a high degree of flexibility are used. a) Four interrupted 3-0 nonabsorbable sutures were used to approximate the pancreatic parenchyma and jejunal seromuscular layer in the pancreas. b) Aplly seven interrupted 6-0 absorbable sutures in order to connect the pancreatic duct to all coats of the jejunum in this procedure. c) Complete pancreatojejunostomy is seen in the intraoperative picture.

The greater omentum is incised to allow entry into the omental bursa. The trunk of the gastrocolic vein and the right gastroepiploic vein is identified and dissected. The anterior plane of the superior mesenteric vein is exposed, and the tissue between this plane and the dorsal plane of the pancreas is freed, followed by tunneling between the pancreas and the portal vein at the pancreatic isthmus. The blood vessels along the lesser and greater curvatures of the stomach are treated. The stomach is dissected with a stapler (ET45, Ethicon Endo-Surgery) at a point 3 cm oral to the pyloric ring. The duodenum is everted, and tape is applied to the left renal vein while exposing the anterior plane of the inferior vena cava to confirm the direction of the root of the superior mesenteric artery. In cases of malignant tumors, the presence/absence of metastasis to the periaortic lymph nodes at the lower edge of the renal vein is determined. The transverse colon is lifted in the cranioventral direction. The peritoneum and the colonic ligament are fixed at two points (right and left) to yield a visual field, enabling observation of the ligament Treitz. This ligament is dissected, and the first jejunal artery (branching from the left side of the superior mesenteric artery) is ligated to the inferior pancreaticoduodenal artery, which shares a common trunk. The upper segment of the jejunum is dissected with ETS 45 at a point about 5 cm from the ligament of Treitz. The gallbladder is freed from the liver bed, and the common hepatic duct is identified. The common hepatic artery is checked, and the gastroduodenal artery is freed, followed by clipping and dissection with an ultrasound incision and coagulation device. At this point in time, blood flow into the pancreatic head is blocked, enabling the prevention of bleeding from the pancreatic head and duodenum due to the retention of venous blood [28]. The tunneled pancreas is then resected. The pancreatic parenchyma is dissected with an ultrasound incision and coagulation device, checking the main pancreatic duct (Fig. 1). The dissected oral segment of the jejunum is pulled out from the dorsal plane of the mesentery to the right side. Then, freeing between the head of the pancreas and the right edge of the portal vein is carried out in the direction from the uncinate process of the pancreas to its cranial part. Finally, the common hepatic duct is dissected to complete pancreaticoduodenectomy. The tissue specimens are collected into a plastic bag, which is removed via the wound created in the umbilical region.

Reconstruction is performed with the modified Child's procedure.

Pancreatojejunal anastomosis, bile duct-jeju- num anastomosis, and gastrojejunal anastomosis are per- formed in this order. Pancreatic parenchyma-jejunal serosa and muscle layer anastomosis is performed with 3-0 non-absorbable thread by the modified Kakita's procedure [29] (Fig. 2a). Thread is applied through the pancreatic parenchyma to the jejunal serosa and muscle layer. Ligation with four stitches is usually performed. To avoid tangling these threads, a piece of gauze pre-immersed in water is applied to them. Next, pancreatic duct-jejunum anastomosis is performed. In cases in which the main pancreatic duct has become dilated, uninterrupted suturing with 5-0 absorbable thread is performed for pancreatic ductjejunal mucosa anastomosis. In cases in which the pancreatic duct has not dilated, knotted suturing (with six stitches) is performed (Fig. 2b). Upon completion of pancreatic ductjejunal mucosa anastomosis, the threads used for suturing the pancreatic parenchyma-jejunal serosa and muscle layer are ligated one after another (Fig. 2c). The stent tube is guided out of the body through incomplete drainage, using the Witzel method. Uninterrupted suturing with 4-0 absorbable thread is performed for bileduct jejunum anastomosis on the anterior and posterior walls. The stent tube is not used for bile duct-jejunum anastomosis. No stent tube is inserted into the region of the bile ductjejunal anastomosis. Gastrojejunal anastomosis is performed mechanically (delta anastomosis [30]). Upon completion of all anastomoses, the da Vinci is undocked. The assistant confirms hemostasis, after which warm saline washing and aspiration are performed. A drain is then inserted into the anterior plane of the pancreatic anastomosis and the posterior plane of the bile duct-jejunal anastomosis, and the abdomen is closed.

Conclusion

Robot-assisted laparoscopic pancreatectomy has been outlined above. This procedure involves more minor abdominal wounds and less abdominal wall destruction than conventional open surgery for pancreaticoduodenectomy and thus yields better QOL for patients immediately after surgery. If the use of the da Vinci spreads globally, the number of reports on it will also increase in the field of pancreatic surgery. Most important in performing this procedure is ensuring the safety of surgery, i.e., performing operations with adequate knowledge of pancreatic surgery (including anatomical knowledge) and endoscopic surgery. Issues of importance remaining in robot-assisted laparoscopic pancreatectomy include its time of operation, which is longer than that of open surgery, and the extra time needed for the application of the da Vinci compared with ordinary laparoscopic surgery. These issues may be resolved through the accumulation of experience and modifications of the procedure. Robot-assisted laparoscopic pancreatectomy appears likely to become a standard procedure shortly.

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