Robotic-Assisted Pancreaticoduodenectomy (Whipple)

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Pancreaticoduodenectomy (PD) has long been considered the *sine qua non* of surgical mastery among abdominal operations. The procedure has challenged some of the greatest surgeons in the modern era due to the need for meticulous dissection and flawless reconstructive techniques. With the advent of laparoscopic techniques, interest in the application of laparoscopy to PD has grown [1]; however, the technical complexity of the operation has prevented its widespread adoption and dissemination [2]. Robotic-assisted laparoscopic surgery offers some advantages over traditional laparoscopic surgery by providing improved degrees of freedom of motion, greater precision through computer assistance, and improved visualization, allowing a greater number of practitioners to incorporate minimally invasive techniques in the management of pancreatic diseases. Multiple single institutional high-volume center reports of robotic-assisted PD (RAPD) have confirmed its safety and efficacy (with outcomes comparable to the open operation [3]) though there remains a significant learning curve that must be negotiated, ideally in the setting of dedicated fellowship training or in a mentored or proctored setting [4].

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Patient Selection and Preparation

Successful outcomes following RAPD are intimately linked to appropriate and judicious patient selection, particularly early in the learning curve. The selection process begins with a thorough assessment of the patient's medical and surgical history along with cardiopulmonary risk stratification. Predictors of mortality following open PD include age, male sex, preoperative albumin, tumor size, sepsis, and comorbidities, particularly renal insufficiency [5]. Among these factors, preoperative nutrition is the only modifiable risk factor. Therefore, particular attention to concomitant weight loss, biliary obstruction, steatorrhea, new-onset or worsening diabetes mellitus, and poor alimentation are important. Long-standing biliary obstruction with or without malnutrition is best managed with temporary biliary stenting and nutritional supplementation [6]. However, if an operation is planned within 7–10 days and biliary obstruction has been sub-acute, biliary stenting is best avoided [7].

Cross-sectional imaging with intravenous contrast should be performed for all potential candidates. Computed tomography (CT) or magnetic resonance (MR) imaging depending on institutional availability, patient factors, and preference may be used. CT and MR accurately assess the primary pathology and are highly predictive of resectability [8]. Involvement of major vascular structures (superior mesenteric vein [SMV], portal vein [PV], hepatic artery [HA], and superior mesenteric artery [SMA]) is generally a contraindication to RAPD though some expert surgeons have reported on the feasibility of vascular resection and reconstruction with minimally invasive techniques [9]. Endoscopic ultrasound (EUS) may also be utilized, particularly if tissue diagnosis is required. While assessment of large-vessel vascular invasion by EUS is very sensitive and specific for some practitioners, it is also highly operator dependent [10]. For this reason the authors rely on triphasic cross-sectional imaging interpreted by an expert pancreatic-biliary radiologist to evaluate resectability in the preoperative setting.

Prior abdominal operations and anatomic abnormalities must be noted, and while these are not absolute contraindications to RAPD, ulcer operations, large hiatal hernias, severe scoliosis, and roux en-Y gastric bypass surgery may add undue complexity to a robotic-assisted approach. The indication for operation should be considered as well. It is the opinion of the authors that early in the practitioner's RAPD experience, benign lesions or those with low malignant potential (i.e. low-grade pancreatic neuorendocrine tumors [PNET], cystic neoplasms, ampullary adenoma, etc.) are ideal due to lack of vascular involvement. Unfortunately, these 'non-PDA' cases may be associated with higher pancreatic leak rates due to a soft pancreatic gland and the presence of a non-dilated pancreatic duct. In summary, a thoughtful and exclusionary approach to patient selection maximizes the opportunity to perform RAPD safely.

Instrumentation

Our practice has led to a standardized approach to instrumentation: the dissection is carried out with a monopolar cautery hook dissector, a fenestrated bipolar cautery grasper, and a utility grasper forceps. Suturing is performed with large needle drivers

Table 22.1 Equipment for robotic-assisted pancreaticoduodenectomy (RAPD)

Robotic instruments	Laparoscopic instruments	Disposable equipment	Durable equipment	Sutures/supplies
12 mm, 30° down scope	5 mm 0° and 30° scope	GIA staplers (3.5 mm, 2.5 mm staple height)	Split-leg OR table	2-0 silk, 3-0 silk; 8″ length
Hook monopolar cautery	Graspers	5- and 7-French ERCP Stent	Carter-Thomason	3-0 V-Loc 180; 6″ length × 2
Fenestrated bipolar forceps	Scissors	Laparoscopic specimen bag (10 cm, 15 cm)	Self-retaining liver retractor	4-0 V-Loc 180; 6″ length × 2
Prograsp™ forceps	Maryland dissector	19-French Blake drain	Ultrasound	5-0 polyglactin or polydiaxonone 5″ length
Maryland dissector	5 mm trocar × 2	10 mm clip applier		¼″ Umbilical tape
Scissors (monopolar)	12 mm trocar × 2	GelPoint® Mini™		1/8″ Vessel loops
Large needle driver × 2		Vessel sealer		
8 mm trocar × 3				
Ultrasound probe				

GIA gastrointestinal anastomosis

with and without integrated cutting blades and additional tools such as scissors and Maryland dissectors are used as needed. The bedside assistant's tools consist of standard laparoscopic instruments: graspers, scissors, suction–irrigator, and a vessel sealing device such as Ligasure (Covidien-Medtronic; Minneapolis, MN). We employ a self-retaining liver retractor (Mediflex; Islandia, NY) routinely to retract segment 4B of the liver. Instruments and supplies are listed in Table 22.1. Additionally, retractors and instrument trays for an open PD, including vascular instruments, should be immediately available in case of the need to convert to laparotomy.

Operating Room Configuration

The patient is positioned with the right arm padded and tucked and the left arm extended at the shoulder on a split-leg table that allows the bedside assistant to stand between the legs of the patient. The patient is secured to the table with straps, and foot supports are utilized to allow reverse Trendelenburg positioning. Extreme care must be taken to pad all pressure points. The robotic (da Vinci Si) patient cart is positioned over the patient's head and the robotic arms are aligned as shown in Fig. 22.1. The laparoscopic monitors are positioned to allow the bedside assistant an unobstructed view in an ergonomically neutral posture. The robotic console should be placed to allow unimpeded communication between the console surgeon and bedside assistant.

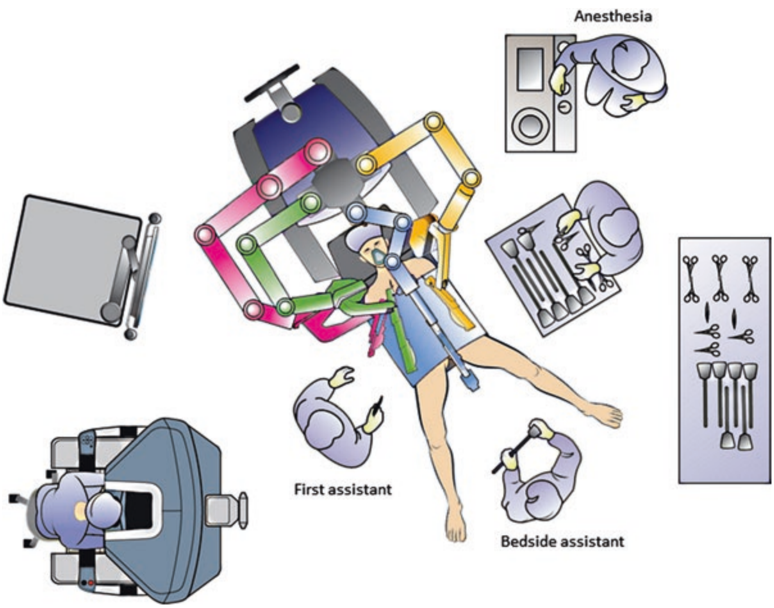

Fig. 22.1 Operating room setup

Operative Steps

The operative steps outlined in the following text represent a general flow of the operation, though specific parts may be re-arranged or modified as clinically indicated. Experienced pancreatic surgeons will quickly realize that the steps are very familiar to its open counterpart and, in fact, RAPD is essentially identical to open PD as performed by the authors with few exceptions.

Port Placement/Laparoscopy

The operation starts with the patient bed in neutral position, and a 5 mm optical trocar is placed to the left of the midline through the rectus sheath 2–3 cm above the level of the umbilicus. Upon entry into the abdomen the peritoneum is explored for evidence of metastatic disease. Barring any contraindications to resection additional laparoscopic/robotic ports are placed as shown in Fig. 22.2. Approximately 10 cm (roughly one hand-breadth) is required between robotic ports to minimize collisions between the robotic arms. The right lateral trocar is placed with the patient in reverse Trendelenburg and the right side rotated upwards to allow it to be positioned as far laterally as possible. The initial entry 5 mm trocar is changed to an 8 mm trocar for robotic instruments.

The initial dissection and exploration are performed laparoscopically. Any adhesions between the liver and stomach are divided to allow placement of the liver

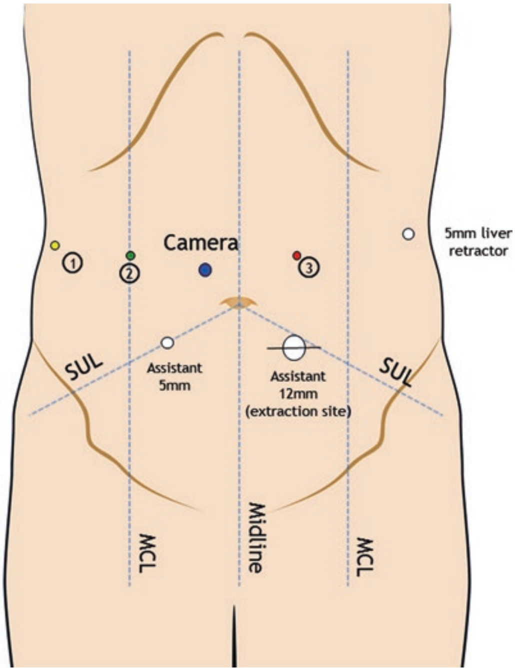

Fig. 22.2 Laparoscopic/robotic trocar positioning

retractor. The lesser sac is entered through the gastrocolic ligament below the level of the gastroepiploic arcade and opened widely. The right colon is mobilized completely to the cecum. Next, a marking stitch is placed in the jejunum 80 cm distal to the ligament of Treitz (LOT). Proximal to the marking stitch the jejunum is tacked to the greater curve of the stomach with another stitch. This maneuver facilitates identification and orientation of the jejunal loop for creation of the gastrojejunostomy (GJ).

Docking/Bedside Assisting

The robot is docked and robotic instruments are inserted: monopolar cautery hook dissector in arm 1, fenestrated bipolar cautery grasper in arm 2, and Prograsp™ forceps in arm 3. A 30°, down-angled stereoscopic laparoscope is used. The bedside assistant, standing between the legs of the patient, operates the vessel sealer and suction–irrigator or laparoscopic graspers through the right lower quadrant 5 mm trocar and the left lower quadrant 12 mm trocar. The bedside assistant is responsible for clearing the surgical field of blood/fluids, providing dynamic retraction, dividing blood vessels and achieving hemostasis with the vessel sealer, operating staplers, exchanging robotic instruments, passing sutures, and extracting the specimens. Bedside assistant requires sound surgical instinct, a thorough knowledge of surgical anatomy and the steps of the operation, as well as maneuvers to stem blood loss or manage emergencies. It is not an appropriate role for most surgical scrub technicians, physician assistant, or junior surgical residents.

Kocher Maneuver

Once the robot arms are positioned, hook cautery is used to dissect the duodenum and the head of the pancreas off of the retroperitoneum until the left renal vein is visible and the LOT is reached. The proximal jejunum is delivered into the dissection field whereupon a point 10 cm distal to the LOT can be chosen to create a mesenteric window and divide the bowel with a stapler (2.5 mm staple height). The vessel sealer is used to divide the mesentery. This linearizes the distal duodenum and facilitates the lateral SMV dissection later.

Transect Stomach/Hepatic Artery/GDA

The lesser omentum is opened in the *pars flaccida* taking care not to divide a replaced/accessory left hepatic artery (HA), if present. A stapler with 3.5 mm staples is used to divide the stomach 2–3 cm proximal to the pylorus. The antrum is retracted to expose the underlying neck of the pancreas. The hepatic artery lymph node (level VIIIa) is identified and the peritoneum is opened along its inferior border. The entire lymph node is excised exposing the [common] HA beneath it. Once the HA is identified, it is traced distally to the takeoff of the gastroduodenal artery (GDA) which is skeletonized. The HA [proper] is also traced further distally where the right gastric artery may be found and divided with a vessel sealer. The importance of using Doppler flow ultrasound to confirm flow in the HA while occluding the GDA cannot be understated. It is also the author's practice to rotate the specimen medially (to the left) and dissect the lateral border of the hepatoduodenal ligament to confirm the presence or absence of an accessory/replaced right HA *before* the GDA has been ligated. Once these steps have confirmed the arterial anatomy, a stapler with 2.5 mm staples can be used to transect the GDA. The bedside assistant applies a 10 mm vascular clip to the GDA stump.

Hepatoduodenal Ligament/Bile Duct/Superior Neck

With the GDA transected the portal vein (PV) is easily identified immediately deep to the previous dissection. The hook cautery is used to dissect in the peri-adventitial plane of the vein, and soft tissue at the superior neck of the pancreas is divided. This is a convenient time to create the superior aspect of the superior mesenteric vein (SMV) tunnel as well. Next, the lateral border of the PV is dissected, freeing it from the bile duct anterio-laterally. This dissection may be difficult in patients with bile duct tumors; care must be taken not to injure the PV where it may be adherent to the common bile duct (CBD). At this point the lymph node posterior to the PV and CBD (level XI) may be dissected and retracted caudally to be taken with the specimen. Again, identification and protection of a replaced right HA are necessary and may be aided by placing vessel loop around it. If no CBD stent has been placed the bile duct is divided with a stapler with 2.5 mm staples. If a stent is present the bile duct may be transected with a stapler above the stent or with cautery. Cholecystectomy can then be performed in a standard fashion.

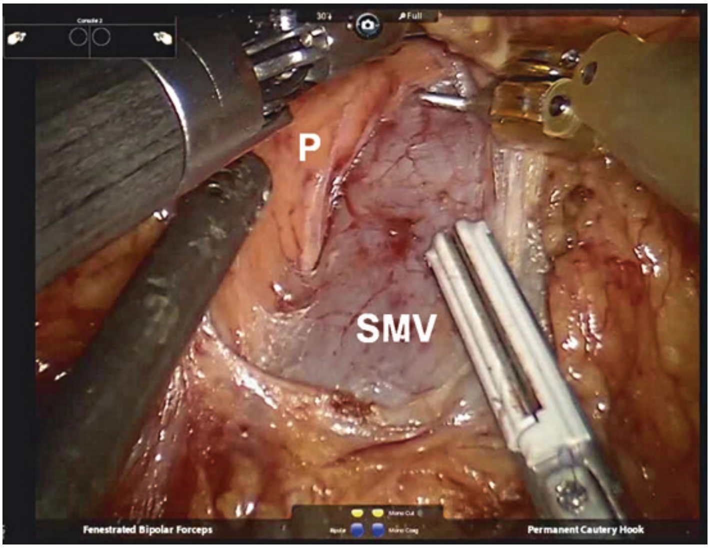

Fig. 22.3 Creating the tunnel behind the neck of the pancreas. The bedside assistant applies gentle traction downwards and uses the opposite hand to elevate the neck of the pancreas to expose the tunnel. *SMV* superior mesenteric vein, *P* neck of pancreas

Inferior Neck/Tunnel

Next, with the third arm retracting the specimen cephalad the inferior neck of the pancreas is exposed. The peritoneum at the inferior border of the pancreas is opened until the SMV is identified, allowing creation of the pancreatic neck tunnel. This is accomplished by using a grasper to gently lift the pancreas while the hook cautery bluntly develops the avascular plane anterior to the SMV using gentle downward movements progressively more proximal on the vein wall (Fig. 22.3). Several maneuvers assist in making the tunnel dissection safer and easier: create a wide window in the peritoneum at the inferior border of the pancreas—this will open the dissection to allow greater access to the tunnel and effectively make the tunnel shorter. Also, use the vessel sealer or bipolar cautery to divide the soft tissue at the inferior neck of the pancreas medial to tunnel. There are typically several small vessels here which bleed profusely if divided with monopolar cautery. Finally, pan outwards with the camera to identify the PV at the superior neck of the gland, as this will establish the trajectory of the SMV and help to avoid creating a tunnel that does not connect to the superior dissection. The superior and inferior tunnels are joined and the bedside assistant places a laparoscopic grasper through the tunnel so an umbilical tape may be passed through.

Transection of Pancreas/PV: SMV Dissection

The neck of the pancreas is transected with the robotic scissors using monopolar cautery. The umbilical tape suspends the pancreas to avoid injuring the SMV/

PV. When approaching the main pancreatic duct (MPD) the scissors are used without energy to avoid cauterizing the duct itself. Once transection of the pancreas is complete, an *en face* margin from the specimen side may be obtained for frozen section analysis, if indicated.

Retracting the specimen laterally, the robotic scissors are used with the tips opened 3–5 mm to bluntly ‘roll’ the vein off of the pancreas. The bedside assistant applies gentle retraction on the vein medially allowing progressive dissection towards the uncinate process. Inferiorly, this dissection will expose the middle colic and gastroepiploic veins as they drain into the SMV. Next, the entire specimen is rotated medially and the lateral wall of the SMV is identified and skeletonized. This maneuver is important to avoid mistaking the first jejunal vein for the SMV which can set the stage for ligating the true SMV under the assumption that it is an expendable mesocolic tributary. Once the SMV is positively identified the specimen is rotated laterally again and the middle colic and gastroepiploic veins may be ligated.

Cephalad, if a replaced right (or common) HA is present, it will be encountered as it passes lateral to the PV and continues posteriorly towards the SMA. Arterial branches in this location should not be ligated unless involved by tumor *and* alternate arterial inflow to the liver is confirmed.

Uncinate Dissection/SMA

The uncinate process is typically the most challenging portion of the dissection. The bedside assistant plays an active role in retracting the SMV/PV medially and maintaining a bloodless field, while the third robotic arm retracts the specimen laterally ‘up and out’ (analogous to the surgeons left hand during open PD). The console surgeon applies liberal use of bipolar cautery both for obtaining hemostasis and to ‘pre-coagulate’ visible uncinate vessels prior to dividing them. Fortunately, the visualization of the SMA is unparalleled in comparison to the traditional open technique where these steps are performed with a combination of ‘feel’ and blind dissection. This enhanced visualization allows the dissection to follow a plane immediately adjacent to the artery, which enables maximize the retroperitoneal surgical margin. While most bleeding can be avoided with careful use of cautery, there is usually some level of ‘oozing’ that may persist until the specimen is completely freed. As a result, overzealous attempts to achieve a bloodless field may unnecessarily prolong this step and paradoxically result in more blood loss.

Removal of Specimen

Completion of the uncinate dissection marks the end of what is typically the most challenging portion of the operation. Most major blood loss, physiologic perturbation, and operative risk are incurred up to this point. The continued strain of operating on the robotic console may contribute to some level of ‘robot fatigue’. This phenomenon is quite reproducible though not measured formally and is based on our own observations after cooperating on many cases. Typical signs are missed cues and 'unforced errors' that are uncharacteristic for the skill of the operating surgeon. In our experience, the best strategy to mitigate the effects of robot fatigue is to switch the roles of the bedside assistant and console surgeon at this point in the operation.

The specimens are placed in retrieval bags, and the incision around the left lower quadrant 12 mm trocar is enlarged transversely to allow removal. A gel port with an airtight lid (GelPoint™ Applied Medical; Rancho Santa Margarita, CA) may be used to seal the incision and allow re-insufflation of the abdomen. The 12 mm assistant trocar is placed through the gel port.

Pancreaticojejunostomy

Many methods of pancreatic-enteric anastomosis have been described and there remain numerous variations. We have standardized our approach using a modified Blumgart two-layer PJ technique.

The jejunal limb is oriented so the antimesenteric border lies next to the pancreatic duct and loops gradually and without kinking past the bile duct. Two to four centimeters of the pancreatic stump is dissected from surrounding tissues. Interrupted horizontal mattress sutures of 3-0 silk are placed using trans-pancreatic bites of pancreas and seromuscular bites of jejunum. A 5-French Hobbs ERCP stent (Hobbs Medical; Stafford Springs, CT) is placed in the main pancreatic duct (MPD) to help prevent inadvertent occlusion. The sutures are tied so that the bowel wall is directly opposed to the posterior pancreas without any dead space. The best way to ensure this is to lift both tails of the sutures prior to securing the first knot (Fig. 22.4). The needles are left

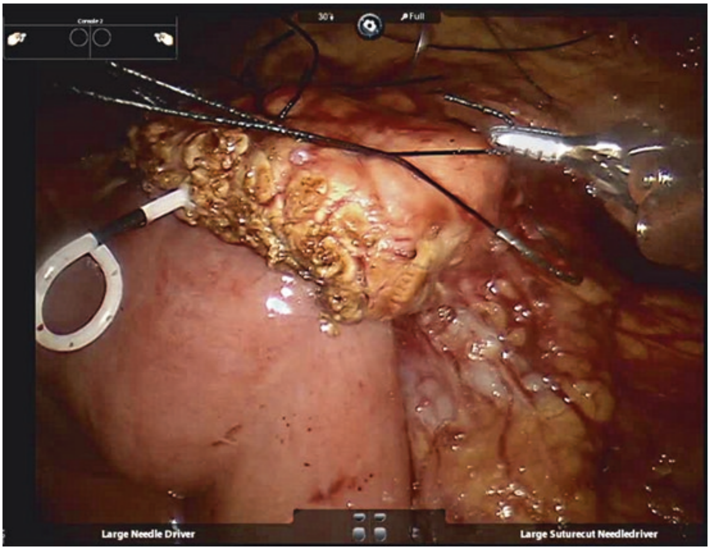

Fig. 22.4 Placement of buttressing sutures of 3-0 silk. Note how the surgeon lifts the ends of the suture prior to tying the first knot to close any dead space between the serosa of the jejunum and pancreas posteriorly. The pancreatic duct stent prevents occlusion of the main pancreatic duct

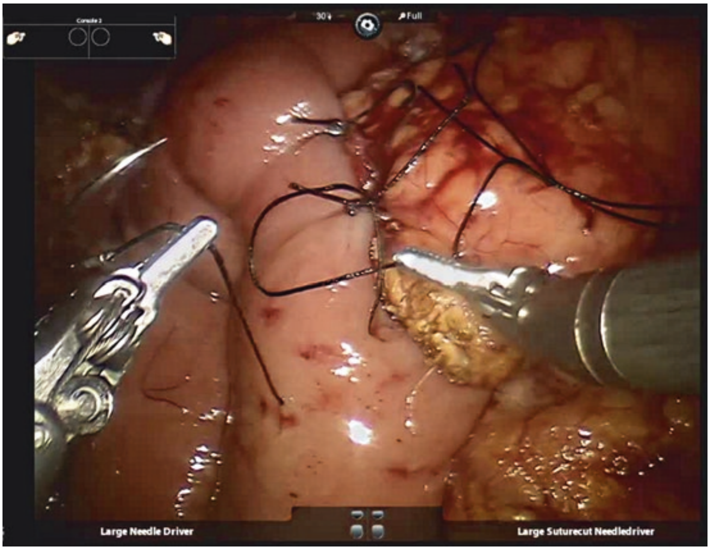

Fig. 22.5 Seromuscular bites of jejunum are used to imbricate the bowel wall over the anterior surface of the pancreas

on these sutures and used for the anterior seromuscular layer later. Three sutures are placed in the posterior row with the middle stitch straddling the MPD.

Next, a 2–3 mm enterotomy is made in the jejunum using monopolar cautery. The inner suture line is constructed with interrupted 5-0 polydiaxonone or polyglactin sutures incorporating the pancreatic duct and full-thickness jejunum. The choice of suture material is based on surgeon preference with each offering some minor advantages and disadvantages. Both have been used extensively in our experience with good results. It is usually possible to place three to five sutures in the posterior row. After the posterior suture line is complete the Hobbs stent is inserted with the curved end in the jejunum. Another three or four 5-0 sutures anteriorly complete the inner layer. These are placed without tying until all sutures have been placed. Then, the sutures at the superior and inferior aspect of the duct are tied followed by the middle sutures, which are tied last. It may be helpful for the bedside assistant to gently push the bowel medially to remove any tension while the sutures are being tied. Finally, the anterior row mattress sutures are created using the previously placed posterior row needles (Fig. 22.5).

Hepaticojejunostomy

The biliary anastomosis is constructed in one layer and may be interrupted or continuous depending on the diameter of the bile duct. For large ducts, we perform a running hepaticojejunostomy (HJ). We prefer using absorbable 4-0 V-Loc 180 sutures (Covidien-Medtronic; Minneapolis, MN) as the barbed monofilament

Fig. 22.6 Single-layer continuous hepaticojejunostomy anastomosis

obviates the need for maintaining continuous traction on the suture as it is sewn (Fig. 22.6). Smaller ducts should be reconstructed with interrupted 5-0 polydiaxonone. Our practice has been to place the biliary anastomosis at least 10–15 cm downstream of the PJ anastomosis. Although not classically described in the literature, in the opinion of the authors, this space between the two anastomoses helps to prevent reflux of biliary fluid into the pancreatic anastomosis. Little clinical evidence exists to support this practice, but it is an important anecdotal observation that may decrease the incidence of massive pancreatic anastomotic disruption.

Gastrojejunostomy

The jejunum that had been tacked to the greater curve of the stomach is freed, and the marking stitch position is noted to identify the efferent end of the jejunal loop, so it may be placed downstream of the planned gastrojejunostomy. A posterior row of 3-0 silk seromuscular sutures are placed along the length of the planned anastomosis (Fig. 22.7). Once the posterior row is complete (typically five sutures) the gastric staple line is removed with monopolar cautery. A corresponding longitudinal enterotomy is created on the jejunum.

Two 3-0 V-Loc 180 sutures are placed to complete the corner of the anastomosis using full-thickness jejunum and stomach. These stitches are placed close together, and the suture is pulled taught after each throw to eliminate any gaps. The posterior row stitch is sewn continuously to the opposite corner and around to the anterior part of the anastomosis. At this point the suture is set aside and the anterior row

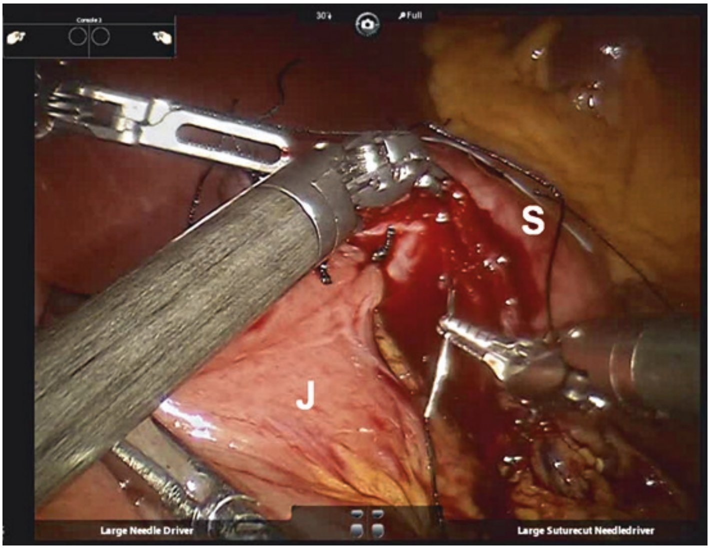

Fig. 22.7 Gastrojejunostomy posterior-row sutures of 3-0 silk. Note this row of sutures is placed near the mesenteric border of the jejunum to avoid narrowing the anastomosis. *J* jejunum, *S* stomach

suture is used to perform a Connell stitch to complete the inner layer of the anastomosis. Finally, 3-0 silk Lembert sutures are used to complete the anterior row taking care not to narrow the anastomosis.

Falciform Flap/Drain Placement/Closure

We routinely create a vascularized tissue flap from the falciform ligament to exclude the GDA stump from potential PJ anastomotic leakage. Several 3-0 silk sutures may be used to secure the flap to the retroperitoneum as needed. Given routine drain placement has been associated with a decrease in severe complications following PD [11], we place a 19-French Blake channel drain (Ethicon; Sommerville, NJ) through the right flank robotic port directed under the right lobe of the liver, anteriorly past the HJ and anterior to the PJ. The end of the drain is tucked behind the gastrojejunostomy to hold it in place. A Carter-Thomason device is used to re-approximate the fascia of the 12 mm camera incision, and the left lower quadrant extraction incision is closed with appropriate fascial sutures in an open fashion.

Post-operative Care

Post-operative care is similar to that of open PD patients. Routine intensive care unit admission is generally unnecessary, and we find post-operative regional analgesia to be useful (paravertebral catheters placed preoperatively). As much of the post-operative care is standardized as this has been shown to improve care and facilitate timely discharge [12]. Prophylactic low molecular–weight heparin is routinely administered.

Surgical drain management is standardized as well: a serum and drain fluid amylase activity are assayed on the morning of post-operative day 3, and if the drain fluid amylase activity is ≤3 times the serum value and the patient is improving clinically, the drain is removed on post-operative day 4, regardless of the volume of its output. This protocol has been adapted and modified from a protocol published by Bassi et al. [13, 14].

Learning Curve

Numerous studies have investigated and defined the number of cases that are needed to be performed before proficiency may be attained for complex procedures. Open PD has been reported to require between 30 and 60 procedures [15–18] and RAPD may add as many as 80 more cases to a surgeon's cumulative experience before mastery is attained [3, 4]. However, cautious interpretation of these numbers is warranted given evidence showing that much of the improvement in perioperative outcomes seen with increased experience has to do with the overall volume of the hospital and the quality of its ancillary services (advanced endoscopy, interventional radiology, critical care medicine, etc.) [19, 20]. Furthermore, our experience with RAPD was reported in the absence of formal training and curricula, and without the aid of mentorship in robotic-assisted surgery. In the current era, surgical trainees have the advantage of greater exposure to the robotic platform as well as the opportunity for apprenticeship with experienced surgeons. As a result the number of cases needed to graduate from the learning curve is expected to fall significantly. Nonetheless, it is important for surgeons who intend to start practicing robotic-assisted pancreatic surgery to seek and attain appropriate mentorship from experienced pancreatic and minimally invasive surgeons.

Drawbacks/Limitations

The most frequently cited limitation of RAPD (and robotic-assisted surgery, in general) is the significant cost associated with purchase of the console ($1.2 million) and maintenance/equipment costs ($100,000–150,000 per year) above and beyond expenditures for operating room time and other supplies and equipment. These costs are magnified in the early phase of the adoption of RAPD given the longer operative times. However, robotic-assisted surgery has been shown to be profitable, particularly when operative efficiency has been optimized [21], and the institutional investment required for starting an RAPD program can be balanced by cost savings associated with shorter length of stay [22].

The complexity of RAPD represents another hurdle in the widespread adoption of robotic-assisted approaches. As with laparoscopic PD, there are currently only selected centers performing RAPD regularly. As residency training programs implement standardized robotics training curricula and trainee exposure to robotic-assisted techniques grows, we expect there will be an increased comfort with the robotic interface that will allow greater dissemination of RAPD in the future. Evidence to support the role of resident/fellow training as well as institutional implementation of robotics in the growth of robotic-assisted surgery is accumulating [23, 24].

Outcomes

The primary goal in developing RAPD is to improve patient outcomes. To date the largest series reporting outcomes following RAPD have shown that open and robotic-assisted techniques are largely equivalent [3, 25]. However, it is important to note that endpoints such as operative times and blood loss as well as perioperative complications such as pancreatic fistula and even mortality as reported in these series represent the learning curve phase of their experience. This is illustrated by operative times that averaged 529 ± 103 min for the entire cohort of 132 RAPD but decreased to about 400 min after the learning curve of 80 cases was surpassed at the University of Pittsburgh [3]. Mature data to compare RAPD and open PD is still forthcoming and no direct comparisons of open PD and RAPD have been completed. A recently published systematic review of robotic and laparoscopic approaches to pancreatic surgery shows RAPD is associated with longer operative time with no associated increase in perioperative morbidity or mortality. Hospital length of stay has been observed to be decreased in some, but not all series [26]. Oncologic outcomes such as margin positivity and lymph node harvest also appear to be similar among RAPD and open PD series, though direct comparative data are lacking.

Long-term survival following PD is the most important outcome to measure, particularly for cancer patients. The receipt of adjuvant chemotherapy has implications on cancer-specific survival, and the morbidity associated with PD delays or prevents the administration of chemotherapy in a significant proportion of patients. There is evidence that laparoscopic PD is associated with fewer delays in the initiation of adjuvant therapy, and this may prove to be true for RAPD as well, though data is lacking at this time [27].

Conclusions

Though technically challenging, RAPD represents a step forward in the management of pancreatic disease. In appropriately selected patients, RAPD may be performed safely and cost-effectively. We predict greater cumulative clinical experience will be required to realize the full potential of RAPD as the techniques and technology are still in their relative infancy. With continued dissemination of RAPD, there will be an opportunity for direct comparison of outcomes to open and laparoscopic approaches, which will help to define the role of robotic-assisted approaches to PD.

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