The robotic Whipple procedure is a minimally invasive option for resectable pancreatic cancer and other tumors of the pancreas head, distal common bile duct, and ampulla.

Robotic Whipple Procedure for Pancreatic Cancer: The Moffitt Cancer Center Pathway

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Background: Resection of malignancies in the head and uncinate process of the pancreas (Whipple procedure) using a robotic approach is emerging as a surgical option. Although several case series of the robotic Whipple procedure have been reported, detailed descriptions of operative techniques and a clear pathway for adopting this technology are lacking.

Methods: We present a focused review of the procedure as it applies to pancreatic cancer and describe our clinical pathway for the robotic Whipple procedure used in pancreatic cancer and review the outcomes of our early experience. A systematic review of the literature is provided, focusing on the indications, variations in surgical techniques, complications, and oncological results of the robotic Whipple procedure.

Results: A clinical pathway has been defined for preoperative training of surgeons, the requirements for hospital privileges, patient selection, and surgical techniques for the robotic Whipple procedure. The robotic technique for managing malignant lesions of the pancreas head is safe when following well-established guidelines for adopting the technology. Preliminary data demonstrate that perioperative convalescence may exceed end points when compared with the open technique.

Conclusions: The robotic Whipple procedure is a minimally invasive approach for select patients as part of multidisciplinary management of periampullary lesions in tertiary centers where clinicians have developed robotic surgical programs. Prospective trials are needed to define the short- and long-term benefits of the robotic Whipple procedure.

Introduction

Pancreatic cancer has a dismal prognosis, with annual incidence and mortality rates that are nearly equal. In 2015, nearly 49,000 Americans will be diagnosed with pancreatic cancer and 40,500 will die from the disease.1 For the minority of patients amenable to resection at diagnosis, tumor extirpation remains the single opportunity for cure. Resection for these patients is technically demanding and fraught with intraoperative and postoperative challenges. Although the mortality rate associated with the Whipple procedure is less than 2%, the morbidity rate generally approaches 40%, even in most high-volume centers.2

Much of the morbidity following the Whipple procedure is secondary to the invasive nature of the operation.2 With a large abdominal incision, patients can
have complications such as poor pulmonary function, which can lead to pneumonia. In addition, due to significant intraoperative stress, patients may experience cardiac events due to fluid shifts or adrenergic demand. In the postoperative setting, surgical site infection continues to be challenging, with up to 7% of patients having a wound complication. These complications may also induce stress in patients and clinicians at a time when the malignant diagnosis is still fresh in their minds. With this in mind, the identification of minimally invasive surgical techniques that can mitigate some of the physiological challenges — and, thus, morbidity — of this procedure has come to the forefront.

**Prior Experience**

The first report of the Whipple procedure using robotic technology was published in 2003 as part of a description about early experience with general robotic surgery by Giuliani et al. In 2011, Zureikat et al published the first article dedicated to outcomes for pancreatic resection. In that report, they described 30 pancreatic operations that took place between 2008 and 2010; of those, 24 were the Whipple procedure, 4 were central pancreatectomies, and 2 were Frey procedures. Initial mobilization was performed using laparoscopic techniques for some of the cases, but the resections and reconstructions were performed using the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, California), and the anastomotic techniques were identical to the open approach — a fact that allows for outcome comparison.

The outcomes from this early experience were encouraging. Of those undergoing the robotic Whipple procedure, the overall pancreatic leak rate was 21% (5 of 24); the majority was subclinical or grade A. The overall rate of morbidity was 25% for the robotic Whipple procedure cohort and defined by Clavien–Dindo grade 3/4 complications. The report focused on the safety of the robotic approach; therefore, direct benefits of the approach were not reported. Morbidity and mortality were confirmed as being noninferior to other reports of open pancreatic resection.

An early report on outcome comparisons between the robotic Whipple procedure and the open Whipple procedure was published in 2012 from Lai et al. Between the years 2000 and 2012, a total of 20 study patients underwent the robotic Whipple procedure and 67 underwent the open Whipple procedure. End points for the comparison between groups included operative time, hospital length of stay, estimated blood loss (EBL), complication rate, perioperative mortality rate, R0 resection rate, and lymph-node harvest. The group found that the study patients had decreased length of stay and EBL, but these came at the cost of increased operative time. No quality-of-life end points were used, and no conclusions could be drawn about direct patient benefits from the robotic approach.

Several other experiences with pancreatic resection have since been reported, but, to date, Zureikat et al from the University of Pittsburgh has published the most recent and largest report. Of the 250 pancreatic resections completed, the authors described the outcomes for 132 robotic pancreaticoduodenectomies. They found that the procedure was safe with a 30-day mortality rate of 0.8%, and 21% of their study patients experienced a Clavien–Dindo grade 3/4 complication. In terms of pancreatic leak, the authors reported a total incidence of 22%, with the majority (53%) described as grade A. The most common complication was fluid collection (38%), of which one-half was the result of a pancreatic leak. Zureikat et al also focused on feasibility in terms of conversion rate and readmission for groups seeking to expand the use of the robotic platform for the Whipple procedure. Their conversion rate was noted to be 8% and their readmission rate was 28%. Both of these values suggest that the platform could be adopted at other institutions.

**Benefits**

Surgeons have sought to mitigate some of the complications related to pancreaticoduodenectomies through rapid advances in the field of minimally invasive surgery. Many benefits of minimally invasive surgery have been attributed to smaller incisions compared with open tumor resection. Although some of these benefits are directly related to the wounds (ie, decreased incidence of wound infection and postoperative hernia formation), many are related to the decreased intraoperative stress response. Intuitively, these benefits are greatest for resections with significant open morbidity, such as the Whipple procedure, and, for this reason, many high-volume centers have turned toward minimally invasive approaches for this operation.

The initial experience with a minimally invasive approach to the Whipple procedure was primarily focused on the laparoscopic approach. One early international report demonstrated acceptable rates of morbidity (31%) and mortality (2%). It is unclear where the cases described fell on the learning curve of the operation because there were no conversions to open resection. A domestic cohort study reported favorable outcomes such as decreased length of stay and intraoperative transfusions associated with the laparoscopic approach. However, these benefits were mitigated by increased operative time.

Although many benefits have been ascribed to the minimally invasive surgical approach, the technical difficulties of this operation have been highlighted by the adoption of the laparoscopic approach that has, in turn, prevented the wide-
spread adoption of this technique. The ideal minimally invasive approach to the Whipple procedure must be easily reproduced and adopted by surgeons who currently perform open resections. However, the laparoscopic approach did not meet this criterion and, thus, adoption has been generally poor.17,18

The robotic Whipple procedure has many benefits for both the patient and the surgeon. For the patient, the benefits previously discussed are all relevant. During resection, there is less insensible loss of fluid and manipulation of viscera through retraction, thus leading to less stress to the patient with fluid shifts and amount of medications to maintain general anesthesia. The use of smaller incisions means that patients have decreased incision-related morbidity, and, with less pain, postoperative pulmonary complications.

The benefits to the surgeon are equally demonstrable. The robotic platform is an advanced device and, like any other surgical instrument, increases the natural human ability of manual tasks in a way that no other device has achieved to this point. Performing fine dissection of crucial planes during oncological resections is fundamental to an open operation and the ease with which this can be accomplished on the robotic platform is beneficial to both the surgeon and the patient. Another benefit is the general ergonomics to the surgeon that an open resection cannot provide.

It is also worth noting that patients seek innovators, so the ability to utilize the newest technology drives referrals for resection. As multidisciplinary robotic programs are developed in tertiary centers the complication rates for these procedures should decrease over time.

**Approach at the Moffitt Cancer Center**

The pathway for patients with pancreatic cancer at our institution, the H. Lee Moffitt Cancer Center & Research Institute (Tampa, Florida), follows 6 key steps: (1) diagnosis, (2) staging, (3) fitness for surgery, (4) resection, (5) adjuvant therapy, and (6) surveillance. At each point along this course, the decision to proceed is predicated by the performance status and disease burden of the patient (Appendix A).19 With this methodical approach to care, all patients have multiple points of evaluation for resection during their course of treatment.

As a referral center, most patients present to Moffitt Cancer Center with a diagnosis of pancreatic cancer. Following a review of the patient’s external medical records, a medical oncologist or surgical oncologist, depending on the presumed extent of disease, sees the patient. All patients presumed to be candidates for resection are seen by a surgeon. After the patient’s initial visit with a Moffitt Cancer Center physician, the pathological diagnosis is reviewed and confirmed from the original slides. Discussion of all patients then takes place during the multidisciplinary tumor board, which is composed of medical oncologists, radiation oncologists, radiologists, pathologists, gastroenterologists, and surgeons, at which point the patients are subdivided into 4 categories: (1) resectable disease, (2) borderline resectable disease, (3) unresectable disease, or (4) further evaluation needed. This classification is based on guidelines from the National Comprehensive Cancer Network and from consensus opinion of all faculty members present.19,20

Patients with resectable disease fit for an operation proceed to the required surgical procedure after preoperative cardiopulmonary evaluation (Appendix B). Those who have borderline resectable disease are treated with neoadjuvant chemoradiation, which includes initially gemcitabine, docetaxel, and capecitabine and then either stereotactic body radiation therapy or intensity-modulated radiation therapy with concomitant fluorouracil.20 Following chemoradiation, patients are restaged with positron emission tomography and pancreas-protocol computed tomography. If the disease is resectable, then the patients proceed to the required surgical procedure. Those with progression or response not amenable to resection receive further systemic chemotherapy. Patients with locally advanced disease are recommended a systemic chemotherapy regimen according to performance status. The initial radiographic findings are reviewed.

**Patient Selection**

Appropriate patient selection for the robotic Whipple procedure is based on the characteristics of the patient and of the tumor. For patients, the most important characteristic is their fitness for general anesthesia. All patients undergoing the Whipple procedure for pancreatic cancer at Moffitt Cancer Center undergo preoperative cardiopulmonary evaluation, which is particularly important for the robotic approach because of the increased operative time — much of it spent in the reverse Trendelenburg position. Relative exclusion criteria for the robotic approach include prior intra-abdominal surgery, major abdominal wall reconstruction surgery, and a body mass index (BMI) greater than 30 kg/m². At this point prior chemoradiation directed to the pancreas remains a strong contraindication for the robotic approach.

Patients with a low volume of disease and no evidence of borderline characteristics, as defined by National Comprehensive Cancer Network criteria, are offered the option of robotic surgery.19,20 Dilated biliary and pancreatic ducts facilitate the technical aspects of the ablative and reconstructive steps of the procedure and minimize the risk of complications. Specific diagnoses for which we offer the robotic Whipple proce-
procedure at Moffitt Cancer Center include adenocarcinoma, pancreatic neuroendocrine tumors, duodenal cancers, bile duct cancers, periamplullary cancers, cystic neoplasms of the pancreas, periamplullary adenoma, and islet cell neoplasms.

**Initial Operative Principles**

Robotic assistance during surgery for the management of pancreatic cancer at Moffitt Cancer Center is based on the fundamental principles of surgical practice and ethics. The perioperative management involves a team of surgeons, nurses, nurse practitioners, and training staff dedicated to this procedure. During the operation, 2 surgeons are involved, along with either a complex general surgical oncology fellow or a general surgery resident. All patients receive mechanical bowel preparation with oral antibiotics and are offered an epidural catheter for pain control.

The robotic procedure is performed with the same sequence of technical maneuvers as are utilized in the open procedure. This is important for several reasons. Doing so helps us understand and compare the outcomes between both modalities. In addition, it allows the surgical team to troubleshoot, understand, and further improve the flow of the procedure. The surgeon is able to offer the open or robotic Whipple procedure to the patient while explaining that both procedures are performed in the same fashion.

A preliminary timeout is performed prior to the induction of general anesthesia and the patient is then positioned as illustrated in Fig 1. Patient positioning is performed in collaboration with the anesthesia team, with an emphasis on safety of pressure points. Special care is taken to ensure that the face, eyes, and airway are protected to prevent injury, focusing on any potential dislodgment of the endotracheal tube when docking the robot. The right arm is tucked and the left arm is left abducted for access by the anesthesia team. Once the patient is draped and all instruments are counted, a second timeout is performed with the surgeon. At that time, the team discusses the operative plan, thus following the World Health Organization timeout protocol. Special emphasis is placed on the importance of communication during the procedure. The risk of bleeding during the dissection of the pancreatic head and uncinate process from the vessels is underscored. The surgeon also reviews the steps required to expeditiously convert to an open procedure in the event of uncontrolled blood loss. All instruments required for the open resection are confirmed to be available in the room during the timeout.

Initial entry to the peritoneal cavity depends on the dimensions of the patient's abdomen. The characteristics of the patient and location of the tumor allow for appropriate modification to safely and efficiently achieve the goals of the procedure (Fig 2). The procedure begins with a 3-cm midline incision in the infraumbilical position. A Veress needle is used to enter the peritoneal cavity and is confirmed by aspiration and the saline drop test in patients with no prior abdominal operations. The open Hasson technique is used for patients with prior abdominal operations. Insufflation is then initiated at low flow and an initial pressure below 10 mm Hg is targeted. After obtaining pneumoperitoneum, a 12-mm port is then placed into this incision through which an 8-mm robotic port is placed. The remaining ports include a 12-mm port for the camera to
the right of the umbilicus in the midclavicular line, an 8-mm port lateral and superior to that camera port at the right anterior axillary line, an 8-mm port superior to the umbilicus at the left anterior axillary line, and a 12-mm port to the right of and inferior to the umbilicus, approximately 8 cm between the camera and periumbilical port (see Fig 2). The surgeon explores the abdomen with the camera before docking the robot to determine if any obvious evidence of metastatic disease is present. At this time, the patient is placed in a reverse Trendelenburg position, the robot is brought into position, all arms are docked, and the instruments are inserted. Positioning precautions in collaboration with anesthesia are confirmed after the robot has been docked.

Ablative Steps
The ablative steps in the robotic Whipple procedure follow the same principles as the open procedure. The falciform ligament is divided from the anterior abdominal wall using the robotic vessel sealer. The gallbladder fundus is then sutured to the anterior abdominal wall (Fig 3). The second surgeon utilizes the assistant port to provide gentle, deliberate traction as needed, utilizing the suction irrigator and is in constant communication with the surgeon at the console. The gastrocolic ligament is incised with the vessel sealer to gain access to the lesser sac proximal to the planned point of gastric transection, with care not to injure the gastroepiploic vessels, short gastric, or transverse colon mesentery (Fig 4).

The dissection is then proximally carried along the transverse colon to complete a Cattell–Braasch maneuver. Attention is then turned to an extended Kocher maneuver that ends with division of the ligament of Treitz from the right side (Fig 5). Doing so results in the delivery of the proximal jejunum to the right upper quadrant — colloquially called the “ah-ha moment” (Figs 6–8). Potential pitfalls at this point include injury to the gastroepiploic vessels, colonic mesenteric vessels, duodenum, inferior vena cava, or the inferior mesenteric vein. The proximal and distal ends of the jejunum are marked with silk suture in preparation for future gastrojejunostomy. The proximal jejunum 10 cm from ligament of Trietz is divided with a stapler (see Fig 8), and the mesentery is divided proximally along the bowel wall, avoiding injuries to the superior mesenteric vein.

Attention is then turned to the safe transection and dissection of the pancreas from the surrounding ves-

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Fig 3. — Exposure is achieved by taking down the falciform ligament, placing a liver retractor under the left lobe, and tacking the gallbladder to the abdominal wall.

Fig 4. — The lesser sac is entered by incising the gastrocolic ligament in the avascular plane, the dissection is carried to the planned resection plane on the stomach, and then distally toward the duodenum.

Fig 5. — The Kocher maneuver is performed by an extended mobilization of the duodenum from its retroperitoneal attachment to the ligament of Treitz, with care not to injure the duodenum or retroperitoneal structures.

Fig 6. — The ligament of Treitz is transected with care not to injure the inferior mesenteric vein. At this point, the “ah ha” moment is reached when the proximal jejunum begins to fall into the field through the defect.

Fig 7. — The proximal jejunum is brought into the field retrograde through the transected ligament of Treitz defect.

Fig 8. — The jejunum is transected with the robotic stapler and the bowel is marked with a silk suture.
sels. First, the stomach is transected between the body and the antrum using the robotic stapler (Fig 9), and then the right gastroepiploic vessels and right gastric vascular pedicle are transected (Fig 10). Next, the dissection of the porta hepatis superior to the neck of the pancreas begins; the hepatic artery lymph node is removed and sent to pathology for a permanent section (Fig 11). The portal vein, hepatic artery, and gastroduodenal artery are identified after meticulous dissection (Figs 12 and 13). Intra-abdominal ultrasonography helps to confirm the location and trajectory of the portal vein posterior to the pancreatic neck, which is critical for a safe and subsequent dissection (Figs 14 and 15). The superior mesenteric vein is identified inferior the pancreas, and a tunnel is then developed posterior to the neck of the pancreas, thereby connecting the previous porta hepatis dissection (Fig 16).

Extreme caution is taken because bleeding caused by an injury to the portal vein or avulsion of a portal venous branch can be life threatening. Communication between the surgical and anesthesia teams is critical prior to initiating this dissection so as to ensure that preparations are made for an expedient conversion to laparotomy if necessary. The surgical assistant is critical to the dissection because he or she uses the laparoscopic suction irrigator to assist with exposure and the application of direct pressure to control bleeding. Should bleeding occur during the vascular dissection, the surgeon can return to the sterile field from the console while the instruments control the hemorrhage. This effectively locks the instrument in a hemostatic position and allows time to prepare for definitive repair. Hemostatic clips may also be used for quick, temporary control with subsequent suture repair after hemostasis is obtained.

After the tunnel is created anterior to the portal vein, the neck of the pancreas is transected with the robotic scissors attached to the monopolar cautery. The gastroduodenal artery is then transected with a vascular stapler after confirming pulsatile in the proper hepatic artery (Fig 17). The dissection is then carried laterally to include the porta hepatis and mobilize the bile duct. The remainder of the pancreatic head and uncinate process are then mobilized from the portal vein and superior mesenteric vein by ligating the venous branches, followed by dissection of the superior mesenteric artery and dissection of the arterial branches (Figs 18 and 19). The final retroperitoneal attachments are transected and the distal common bile duct is transected (Figs 20–22). The gallbladder is dissected from the liver bed and the cystic duct and artery are transected with robotic staplers (Fig 23). Hemostasis is confirmed and the specimen is removed from the periumbilical incision using the EndoCatch (Covidien,
New Haven, New Jersey) device. It is marked for frozen section analysis of the margins and final pathology. Sutures are placed that will ultimately close the fascia; however, the sutures are not tied so as to allow for the continued use of the port for future reconstruction.

Reconstructive Steps
The techniques used for pancreaticobiliary anastomoses are the same for both the open and robotic Whipple procedure. The extended umbilical incision is reduced with a small wound protector and the 12-mm port is secured in place and pneumoperitoneum is achieved. The ports are placed in the same configuration for the reconstruction. The jejunum, which was previously marked with a suture, is inspected to confirm visibility, orientation, or undue tension. A 2-layer, end-to-side pancreatic jejunostomy is created in the classically described duct-to-mucosa fashion. The running imbricating posterior outer layer is carefully placed so as to avoid injuring the portal vein and the main pancreatic duct (Fig 24). The duct-to-mucosa is fashioned using interrupted 4-0 dyed and undyed polyglactin 910 suture (Fig 25). Alternating dyed and undyed sutures helps orientate the surgeon. The first suture is placed in the 12-o’clock position into the pancreatic parenchyma, which is then anteriorly retracted to help with orientation and identification of the duct.
An enterotomy is created so as to avoid creating a jejunal opening concordant in size with the main pancreatic duct. The 9- and 3-o'clock sutures are then placed through the bowel, taking large serosa and small mucosal bites through the pancreatic duct; a small and large bite are made through the pancreatic parenchyma. The 6-o’clock suture is first placed through the pancreatic duct and then out of the bowel. This suture is carefully tied to place tension along the length of the pancreatic neck so that the knots lie flat (Fig 26). It is important to master intracorporeal knot tying and be facile with the visual cues of tension, utilizing the bounce technique so that adequate tension is applied without damaging tissue. In a similar fashion, the 9- and 3-o’clock sutures are tied down and are followed by the 12-o’clock suture. The anterior-running imbricating outer layer is then fashioned with a 3-0 V-loc (Covidien, Mansfield, Massachusetts) suture and tied to the posterior layer (Figs 27 and 28).

Hepaticojejunostomy is performed using 2 running 3-0 V-loc sutures. First, a site in the jejunum is identified that most naturally appears to approximate the bile duct without any tension on the pancreaticojejunostomy. Anastomosis is planned so that the surgeon would sew to himself or herself by sewing the posterior layer first. Thus, the initial suture is placed on the duct first, outside in, just on the anterior side of the 3-o’clock position so that the posterior wall is fashioned and the corner is included when the suture is cinched. Care is taken to create a jejunal defect that matches the bile duct in diameter and that the bites include a small amount of mucosa, while also avoiding surrounding structures (Figs 29 and 30). As mentioned above, familiarity with the V-loc is important, including the need to cinch between throws. After creation of the posterior layer, the anterior layer is fashioned with a second 3-0 V-loc suture so that the surgeon is sewing toward himself or herself — this time, he or she is starting on the bowel. Great caution must be taken to avoid catching the back wall with the suture. The anterior and posterior sutures are then tied to each other.

The gastrojejunostomy is created in an isoperistaltic fashion along the posterior wall of the stomach, using the jejunum approximately 20 cm from the ligament of Treitz (Fig 31). Choice of an antecolic versus retrocolic orientation depends on redundancy of the transverse colon. In cases in which retrocolic anastomosis is fashioned, a defect is made in an avascular portion of the transverse mesocolon and the stomach is tacked to the peritoneal lining of that defect to prevent herniation or twisting. The anastomosis is fashioned with the stapler after the small bowel has been marked with a suture to confirm its orientation and lack of twisting. The common channel of the gastrojejunostomy is closed with a 3-0, V-loc running suture in the Connell fashion. This completes the resection and reconstruction (Figs 32 and 33).

At this point, the health care team confirms that
the nasogastric tube has been correctly placed and inspects the abdomen again for hemothysis. A total of 9 L warm saline is used to irrigate the abdomen. A flat 15FR Jackson–Pratt drain is placed through the right lower quadrant to track behind the choledochojejunostomy and pancreaticojejunostomy and then curve anterior to the pancreaticojejunostomy. The ports are inspected for bleeding, the fascial defects of the 12-mm ports are closed, the 4-cm middline wound is closed with interrupted 0 Vicryl (Ethicon, Somerville, New Jersey) sutures, and the skin is closed.

The immediate postoperative care of the patient focuses on pain control, monitoring urine output, observation for signs of pancreatic leak, and waiting for a return of bowel function. After the patient recovers and meets the discharge criteria, he or she returns to the clinic 10 to 14 days after discharge. The staff members at the Gastrointestinal Oncology Program at the Moffitt Cancer Center communicate with all patients within 48 hours of discharge to identify any potential complications early and to address any questions or concerns. Based on the final pathological diagnosis, the patient will be offered adjuvant therapy and a surveillance regimen according to the corresponding multidisciplinary clinical pathway.

**Outcomes**

Our early experience with robotic Whipple procedure demonstrated comparable morbidity and perioperative outcomes to the open experience. A total of 21 patients underwent pancreatic resection in the first year (February 2012 to March 2013) using the robotic approach. Most patients were men (76.2%) with a median age of 69 years (range, 46–85 years) and a median BMI of 29.1 kg/m² (range, 24.3–39.2 kg/m²), whereas 23.8% of patients were women and had a median age of 74 years (range, 24–76 years) and a BMI of 23.9 kg/m² (range, 20.4–26.5 kg/m²). In terms of intraoperative end points, the median operative time was 621 minutes (range, 229–880 minutes), the median EBL was 200 mL (range, 25–800 mL), and the conversion rate was 9.5%.

The oncological principles were maintained and all resections were R0 on final pathology. The final diagnosis was adenocarcinoma in 52.4%, the median tumor size was 2.3 cm (range, 1–5 cm), and a median of 16 nodes (range, 2–23 nodes) was resected. The other diagnoses included intraductal papillary mucinous neoplasm in 19.1%, neuroendocrine tumor in 19.1%, and pseudopapillary and adenoma (both 4.7%). Postoperatively, the median length of stay was 8 days (range, 4–34 days), the overall morbidity rate was 28.5%, and the pancreatic leak rate was 14.3%.

Of the entire group of patients in our early experience, 14 underwent the Whipple procedure. For this cohort, the median operative time was 681 minutes (range, 326–880 minutes), the median EBL was 200 mL (range, 25–800 mL), and the median length of stay was 8 days (range, 4–34 days). For this group of patients, the final diagnosis was adenocarcinoma in 66.7%, the median tumor size was 2.3 cm (range, 1–4 cm), and a median of 17 nodes (range, 11–23 nodes) was resected. Postoperatively, the median length of stay was 12 days (range, 6–34 days), the overall morbidity rate was 42.8%, and the pancreatic leak rate was 21.4%. No deaths occurred perioperatively. These outcomes are similar to prior published reports.

**Future Directions**

Safety in the operating room and the optimization of perioperative outcomes are of paramount importance as robotic surgery becomes more accessible for patients and surgeons. Training is the only way to ensure...
that surgeons can provide this service in a manner that is safe and without increased risk to the patient.

At the time of publication, training protocols still vary by institution, but nearly all are based on the Intuitive Surgical (Sunnyvale, California) pathway, which involves 4 general phases: (1) introduction to da Vinci-assisted surgery, (2) da Vinci technology training, (3) initial case series plan, and (4) continuing development. This pathway focuses on the surgeon and the operating room team during each step. The final phase is purposefully open-ended to allow for more specialized training in a particular field.

At the Moffitt Cancer Center, we have an institutional pathway for surgeons who have completed formal surgical training but seek robotic surgical privileges to treat patients with hepatobiliary malignancy. Proficiency with open complex hepatobiliary cases is required prior to training for robotic hepatobiliary surgery. Following their completion of the initial certificate training provided by Intuitive Surgical, surgeons can begin operating using the da Vinci Surgical System with a proctor, cosurgeon, or both for a continuous series of cases. At this point, the surgeon can schedule his or her own cases of escalating complexity, generally starting with distal pancreatectomy and progressing to operations required resection and reconstruction. We favor using a cosurgeon approach to complex resections requiring reconstruction as described above.

The training of future surgeons to use robotic surgical systems is also of paramount importance. At this time, most general surgery residency programs or surgical oncology and hepatobiliary fellowship programs use objective data for fine and dexterous skills and proctored through a pathway to proficiency. Skills Simulator (Intuitive Surgical), trainees are evaluated and proctored by advanced hepatobiliary malignancy — in particular, those with pancreatic cancer. Given the known morbidity and recovery rates from the open Whipple operation, the benefits of the robotic approach are proportionally greater than for other operations. The primary focus of this method must be on perioperative safety and quality outcomes for these patients.

We have demonstrated a method for safely performing the operation and for training future surgeons to do the same. By adhering to rigorous academic principles and the liberal proctoring of colleagues, the benefits of this approach can be expanded to more patients with pancreatic cancer.

**References**


Appendix A. — Moffitt Cancer Center Clinical Pathway for Pancreatic Adenocarcinoma (Initial Care)

1. Pancreas-protocol CT (preferred) or MRI of pancreas
2. CT of chest/pelvis
3. CA 19-9
4. PET/CT (if no obvious stage IV disease)
5. CBC and CMP
6. Screen for Total Cancer Care consent

Metastatic Lesion(s) by Imaging?

- Yes
  - Metastatic Work-Up and Palliation Measures

- No
  - EUS Staging and FNA

Multidisciplinary Tumor Board Review for Resection Status

Resectable Pathway

- Resectable per NCCN PANC-B Guidelines
  - Limited Vessel Involvement
    - R0 Likely Without Vessel Resection
      - Pancreatic Surgeon Consult

- Medically Fit for Surgery?
  - Yes
    - Surgical Procedures

- No
  - Borderline Resectable Pathway

Locally Advanced Unresectable

CA = cancer antigen, CBC = complete blood count, CMP = comprehensive metabolic panel, CT = computed tomography, EUS = endoscopic ultrasonography, FNA = fine needle aspiration, MRI = magnetic resonance imaging, NCCN = National Comprehensive Cancer Network, PET = positron emission tomography.

Developed by Springett, Malafa, Hoffe, and Gatewood on April 29, 2015.

Moffitt Clinical Pathways are intended to provide general guidance, options, considerations, and alternatives to assist medical professionals in the clinical decision-making process. They do not constitute standard of care or practice and do not substitute for either the medical professional’s clinical judgment or the patient’s individual needs and preferences. Those using Moffitt’s Clinical Pathways must agree that they are not to be substituted for sound professional judgment or the patient’s prerogative to control his or her medical care.

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Appendix B. — Moffitt Cancer Center Clinical Pathway for Pancreatic Adenocarcinoma (Resectable)

Surgical Procedures

High-Volume Center Referral for Pancreatic Resection Candidates

Patient–Physician Decision

Evidence of Pancreatitis?

Yes

Allow Time for Resolution

No

High Risk for Unresectability or Carcinomatosis?

Yes

Symptoms Appropriate for Palliative Surgery?

Yes

Cachectic Appearance or Demeanor With BMI < 19 kg/m²?

Yes

TPN Until Nutritionally Appropriate

No

Preoperative Preparation

Cachectic Appearance or Demeanor With BMI < 19 kg/m²?

No

Carcinomatosis or Unresectable?

Yes

Palliative Surgeries

No

First-Line Metastatic Chemotherapy

Staging Laparoscopy + Biopsy of Carcinomatosis (if Present)

Is Patient Candidate for Robotic Surgery?

Yes

Use Robotics for the Following Operations

No

Involvement Near Pylorus

Standard Whipple Procedure

For Involvement of the Pancreatic Head and/or Uncinate Process

Patient–Physician Decision

Involvement More Distal

Pylorus-Sparing Whipple Procedure

For Involvement of the Body or Tail Alone

Distal Pancreatectomy ± Splenectomy

For Involvement of the Neck and Body/Tail Alone

Subtotal Pancreatectomy ± Splenectomy

For Involvement of the Pancreatic Neck Only

Central Pancreatectomy

For Broad Involvement of Both the Pancreatic Head and Neck ± Body/Tail

Total Pancreatectomy ± Splenectomy

BMI = body mass index, TPN = total parenteral nutrition.

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