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ORIGINAL ARTICLE – PANCREATIC TUMORS

Robotic Artery-First Approach During Pancreatoduodenectomy

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ABSTRACT

Background. Surgical resection with adjuvant or neoadjuvant chemotherapy is the only curative modality for treatment of patients with pancreatic and periampullary tumors. With the increasing use of minimally invasive techniques, laparoscopic and robotic pancreatoduodenectomy (PD) has become more common, but laparoscopic artery-first techniques have been described in few studies. The aim of this study is to describe our robotic artery-first technique.

Methods. Video clips were compiled from several robotic PDs to demonstrate the artery-first technique. This technique consists of early retroperitoneal dissection of the superior mesenteric artery from the pancreatic head.

Results. Overall, 73 patients underwent robotic PD at our center between March 2018 and August 2020. Of these, 24 patients underwent the robotic artery-first approach. Indication for its use included proximity of the tumor to the portal vein or SMV in six cases. In three cases, partial resection of the portomesenteric axis was necessary, and the artery-first approach allowed for safe venous resection and reconstruction. In three other cases, the tumor was in close contact with the vein, but it could be resected with free margins without venous resection. In the remaining 18 patients, the approach was systematically used regardless of tumor proximity to the portomesenteric axis.

Conclusions. This robotic artery-first approach is feasible and safe for PD. The approach could facilitate robotic PD, and its systematical use could provide some important advantages during the resection phase. The videos could also help oncological surgeons to perform this complex yet important maneuver.

Surgical resection with adjuvant or neoadjuvant chemotherapy is the only curative modality of treatment for patients with pancreatic and periampullary tumors. However, many patients still relapse and die within a few years, even after radical resection. Although most pancreatoduodenectomies (PDs) are considered R0, some studies have shown that they are actually R1.[1] When using standard protocols to evaluate PD specimens, the resection margin around the superior mesenteric artery (SMA) is often positive and a definite poor prognosis factor.[2]

In 1996, Leach et al. described an alternative method for exposure of retropancreatic mesenteric vessels during total pancreatectomy.[3] They advocate early separation of the SMA from the specimen in cases with large tumors that prevent mobilization of the distal pancreas in cases of total pancreatectomy. In 2001, Machado et al. described a posterior approach to the head of the pancreas during resection of pancreatic head tumors with portal involvement.[4] The main feature of this technique is that the pancreas is dissected from its posterior aspect, and the SMA is completely dissected from the head of the pancreas.

Pessaux et al. later combined these two techniques in 2006 and mentioned the concept of "SMA first" for the first time.[5] They also reinforced the usefulness of this approach for better lymphadenectomy, identification of a replaced right hepatic artery, and early identification of non-resectability. With increasing use of minimally invasive techniques, laparoscopic and robotic PD has become more common, but the artery-first technique during

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laparoscopic PD has only been described in few studies.[6–8] Thus, the aim of this study is to describe our robotic SMA-first technique.

METHODS

Video clips were compiled from several robotic PDs to demonstrate the SMA-first technique, as follows: (1) standard robotic artery-first approach, (2) the technique in a thin patient, (3) in a patient with replaced right hepatic artery, (4) in the presence of a large jejunal vein, and (5) for proximal and distal control of the portomesenteric venous confluence during venous resection. This technique consists of early retroperitoneal dissection of the SMA from the posterior part of the pancreatic head. The posterior approach is initiated by the Kocher maneuver, followed by retraction of the head of the pancreas to the left, exposing the origin of the SMA above the left renal vein. The connective tissue around the SMA and behind the pancreatic head is removed longitudinally (Fig. 1). This study was approved by the review board of the department of surgery of our institution.

Surgical Technique

Patient Positioning and Port Placement The patient was placed in supine position and 30° reverse Trendelenburg position. Robotic surgery was performed using either the da Vinci Si or Xi robotic platforms (Intuitive Surgical Inc., Sunnyvale, CA). This technique involved five trocars. Pneumoperitoneum was created using an open technique in the infraumbilical port. The pneumoperitoneum was established at 14 mmHg. The remaining trocars were inserted under direct vision. During this technique, the surgeon is seated at the robotic console, and the assistant surgeon stands on the patient's left side. The assistant surgeon performs suction, retraction, clipping, stapling, and changing of the robotic instruments.

Robotic SMA-First Technique The operation begins with division of the attachment of the transverse mesocolon down to the line of Toldt of the right colon with exposure of the right perinephric area. The next step is to perform a wide Kocher maneuver with division of retroperitoneum attachments to the pancreatic head and exposure of the left renal vein. The SMA is identified and exposed at its lateral border. Once the SMA is clearly exposed, longitudinal dissection is performed distally along its axis using robotic bipolar forceps and a cautery. Small arterial branches coming off the SMA can be isolated and controlled. Lymphovascular attachments can be easily divided with robotic bipolar forceps to better expose the SMA (Fig. 2).

Once the lateral and anterior border is clearly defined, the possibility of non-resectability due to SMA invasion is discarded, and the PD is resumed. The dissection turns to the hepatic hilum, where the common hepatic duct is

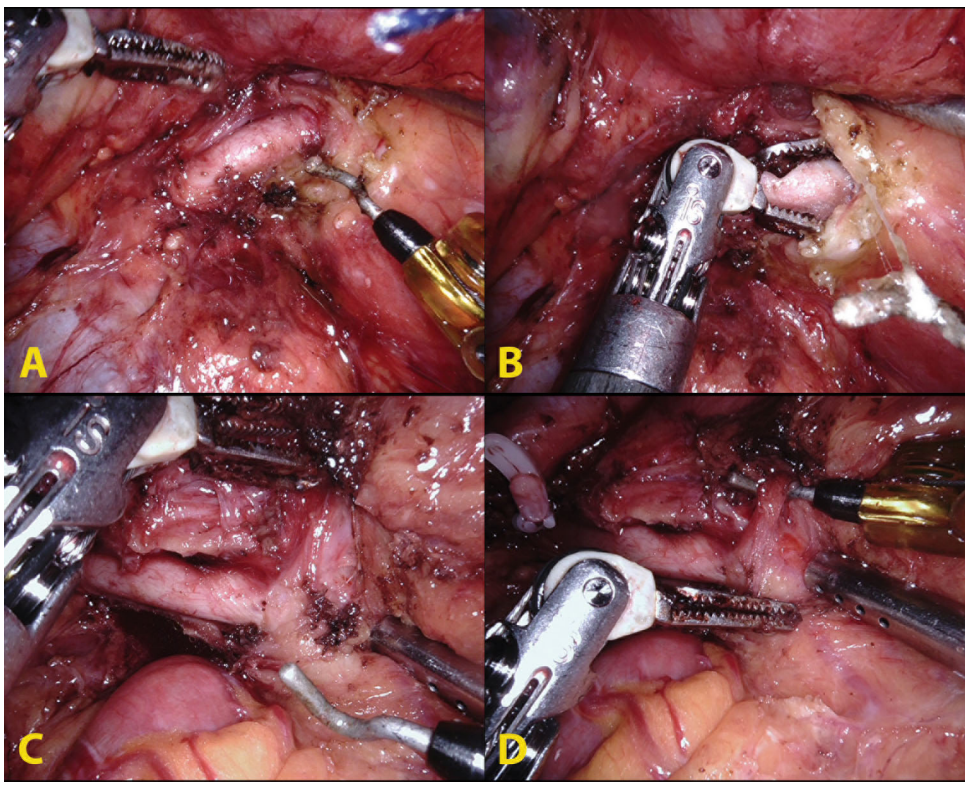

FIG. 1 Robotic superior mesenteric artery first dissection. **a** Superior mesenteric artery is identified at its origin and dissected. **b** Superior mesenteric artery is dissected towards its distal portion. **c** During dissection, inferior pancreatoduodenal artery is identified. **d** Inferior pancreatoduodenal artery is encircled

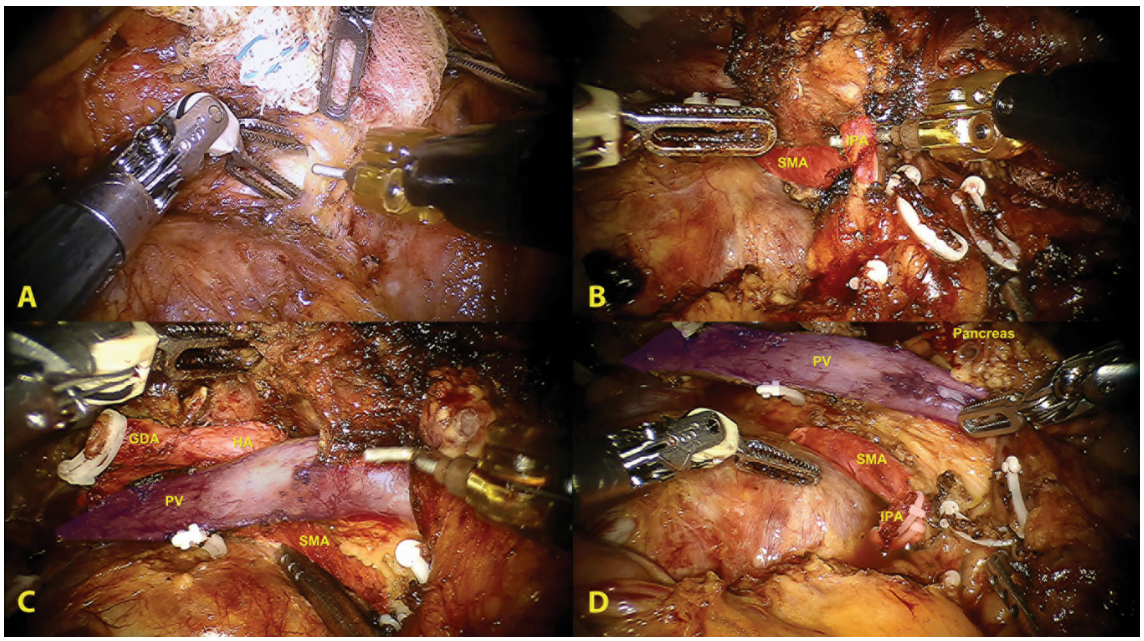

FIG. 2 Robotic superior mesenteric artery first dissection. **a** Superior mesenteric artery (SMA) is identified and dissected towards its distal portion. **b** During dissection, the inferior pancreatoduodenal artery (IPA) is identified and encircled. **c** After completion of SMA dissection, the surgical specimen is only attached to the portomesenteric venous axis. GDA, gastroduodenal artery; HA, common hepatic artery. PV, portal vein. **d** Final view after surgical specimen removal

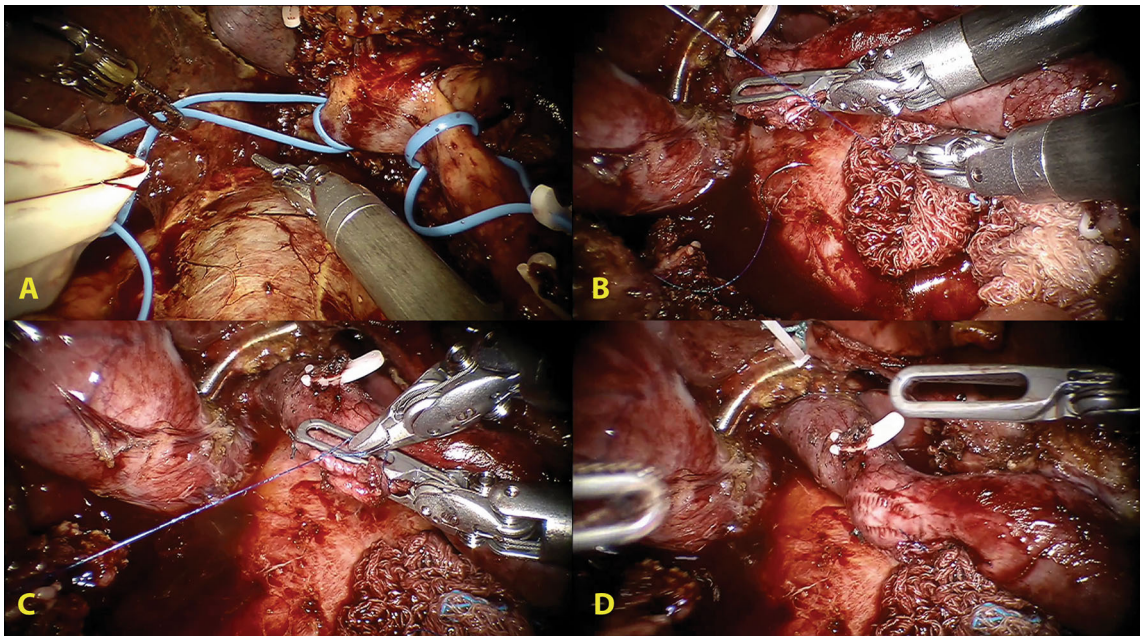

FIG. 3 Robotic superior mesenteric artery-first dissection in a patient with partial involvement of the portal vein. **a** After the robotic artery-first approach, the surgical specimen is attached to the portal vein. The portal vein is encircled with a vessel loop proximally and distally. **b** After lateral transection of the portal vein, a vascular clamp is inserted to allow portal vein flow during venorrhaphy. **c** Running 4-0 Prolene suture is performed. **d** Final view after portal vein lateral suture

isolated, ligated, and divided between Hem-o-locks. The gastroduodenal artery is now dissected, isolated, and divided between Hem-o-locks. As a result, the portal vein superior is now exposed to the pancreatic neck, and the maneuver is completed with removal of hilar lymph nodes until complete skeletonization of the portal vein and hepatic artery.

The ligament of Treitz is mobilized, and the jejunum is passed behind the root of the mesentery and divided with stapler, followed by the division of its mesentery with a harmonic scalpel. The duodenum is divided with a stapler 2 cm below the pylorus. The next step is to create a tunnel behind the pancreatic neck at the level of the portal vein. Umbilical tape is passed around the pancreatic neck, and the superior mesenteric vein (SMV) is exposed. The pancreas is then divided with harmonic shears using an active blade until identification of the pancreatic duct, which is divided with scissors while leaving an adequate stump for further anastomosis. With lateral traction on the jejunum, the most caudal and inferior attachment of the uncinate to the SMV and SMA is exposed and divided with bipolar energy or between Hem-o-locks.

This maneuver allows for a full visceral rotation of the pancreatic head and facilitates further exposure of the lateral and anterior border of the SMA. Once the border is clearly defined, larger vessels such as the inferior pancreato-duodenal artery are identified and controlled. At this point, the surgical specimen is completely separated from the SMA, and the pancreatic head is only attached via the portal and SMV veins. Whenever the portal or SMV is invaded by the tumor, the maneuver greatly facilitates and simplifies venous resection and reconstruction when necessary (Fig. 3). If there is no invasion, the maneuver allows en bloc resection of the head of the pancreas along the retroperitoneal lymph nodes. If a replaced right hepatic artery is present, this technique allows for easier and safer identification.

RESULTS

A total of 73 patients underwent robotic PD at our center between March 2018 and August 2020. Of these, 24 patients underwent the robotic SMA-first approach. Indication for its use was tumor proximity to the portal vein or SMV in six cases. In the last 18 patients, this approach was used systematically. In three cases, partial resection of the portal vein/SMV was necessary, and the artery-first approach allowed for safe venous resection and reconstruction. In three cases, the tumor was in close contact with the vein but could be resected with free margins without venous resection. In patients where this approach was used systematically, it was useful to achieve free posterior margins once the posterior limit could be easily defined after identification of the SMA.

DISCUSSION

PD is the method of choice for treatment of pancreatic head tumors. With the advent of new and more efficient chemotherapeutic agents and technical improvements, there has been an increase in the indications for PD, as well as the complexity of these operations. Vascular resection and neoadjuvant therapy are becoming more and more common, so the resection stage of PD has become more difficult and attracted more attention.

In 2001, we described a posterior approach to the head of the pancreas during the resection of pancreatic head tumors with portal involvement.[4] The main feature of this technique is that the pancreas is dissected from its posterior aspect, and the SMA is completely dissected from the head of the pancreas. Later, Pessaux et al. reinforced the usefulness of this approach for better lymphadenectomy, identification of a replaced right hepatic artery, and early identification of non-resectability.[5] Since their description, this technique has come to be called the SMA-first approach, or simply, "artery first."

With the increasing use of minimally invasive techniques in abdominal surgery, laparoscopic PD was described in 1994.[9] However, due to the complexity and technical challenges in the resection and reconstruction process, laparoscopic PD has not yet become a standard procedure.[10] The robotic approach, with the added freedom and stability of the robotic platform, may offer options for the performance of a complex reconstruction that can overcome some of the limitations of laparoscopic PD.

The da Vinci robot provides 3D vision with 20 × magnification, which improves the precision of pancreatic dissection and allows for anastomosis sutures at difficult angles with the non-dominant hand when necessary. The notable dexterity of robotic instruments, stable high-definition 3D vision, and tremor filtering technology provided by the robotic platform can overcome some of the limitations of laparoscopic PD, especially during the reconstruction process.[11] Since 2018, all of our minimally invasive pancreas surgeries have been performed using the robotic platform.[12] Our experience with this new system has developed, and so have the indications for more complex cases using a robotic approach.[12–14]

R0 resection is an important factor for long-term survival after PD. Pessaux et al. reported that, whenever the SMA is dissected early during the PD, they could identify SMA invasion before any irreversible maneuver, avoiding incomplete or R1/R2 resection.[5] They also pointed out that this maneuver could be useful to obtain better lymph node clearance and perhaps a higher proportion of patients with R0 resection. This point is still controversial in the literature, however Jiangh et al. compared artery-first PD with the standard technique in a meta-analysis including 1483

participants from 18 studies. They showed the superiority of the artery-first PD, which had a significantly lower overall complication rate, less blood loss, increased R0 resection rate, and better 3-year overall survival.[15] However, in a multicenter, randomized, controlled trial, Sabater et al. showed no difference in the rates of R0 resection and postoperative complications.[2] These results raised an important question of whether the artery-first approach should be used routinely or selectively.[16]

Our initial opinion was that the artery-first approach could be reserved for cases in which a venous resection is required. Interestingly, after using it selectively in our robotic cases, we observed that the portal/SMV detachment was greatly facilitated by this approach, and so was lymph node resection. Therefore, we started to use it systematically in all our robotic PD cases. However, surgical planes showed in these selected videoclips may not appear as clear in all cases, depending on presence of neoadjuvant chemotherapy, radiotherapy, and previous history of acute pancreatitis, or in morbidly obese patients. Once the SMA is completely dissected from the posterior aspect of the pancreatic head, venous branches to the SMV and portal vein are more easily controlled.

CONCLUSIONS

The robotic artery-first approach is feasible and safe in PD. This approach may facilitate robotic PD, and its systematic use could provide some important advantages during the resection phase. Furthermore, the video provided may help oncological surgeons to perform this complex yet important maneuver.

DISCLOSURES The authors declare no conflicts of interest.

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