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ORIGINAL ARTICLE – PANCREATIC TUMORS

Mesopancreas Excision and Triangle Operation During Robotic Pancreatoduodenectomy

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ABSTRACT

Background. The retropancreatic space between the superior mesenteric artery, celiac axis, and portal vein is called the mesopancreas. Total mesopancreas excision and skeletonization of both celiac axis and superior mesenteric artery are used to reduce R1 resection in high-risk patients and in those with locally advanced cases. The aim of this study is to present a series of videoclips from several patients showing the mesopancreas excision and the triangle operation with detailed technical description of both techniques with different approaches.

Methods. Video clips were compiled from several robotic pancreatoduodenectomies to demonstrate the total mesopancreas excision and triangle operation technique, as follows: (1) main steps for mesopancreas excision and tringle operation, (2) anterior approach for mesopancreas excision and (3) triangle operation.

Results. A total of 87 patients underwent robotic PD at our center between March 2018 and March 2021. Of these, 22 patients underwent robotic mesopancreas excision. This technique was used for patients at high-risk for R1 resection in 18 patients and triangle operation in four patients. Partial portal vein resection was necessary in 6 cases. One patient had R1 resection and was treated with adjuvant therapy. The remaining patients presented free surgical margins. The mean number of harvest lymph nodes was 40 (range:27-77). Median interval between the operation and chemotherapy was 23 days.

Conclusions. The robotic total mesopancreas excision and the Triangle operation are feasible and safe for selected patients. The indication for this radical operation is the presence of a high risk for R1 resection and for those with locally advanced disease. The presented video may help oncological surgeons to perform these techniques.

Pancreatoduodenectomy (PD) is the procedure of choice for tumors located in the head of the pancreas. It has been demonstrated that lymph node invasion and non-R0 resection are associated with worse survival after PD.[1] However, extended lymphadenectomy fails to improve survival.[2] Therefore, a technique that may improve the rate of R0 may increase the chance of survival. R1 resection is associated with inadequate posterior clearance, which is one of the main reasons for local recurrence.[3] The relevant anatomical space is usually called the mesopancreas.[4]

In 2012, Adham and Singhirunnusorn described a standardized technique for total mesopancreas excision.[5] They performed a clearance of the retropancreatic retroportal space by resecting the triangular tissue between the superior mesenteric artery (SMA), celiac axis (CA), and portal vein/superior mesenteric vein (PV/SMV). According to the authors, their technique was inspired by previous reports of early retropancreatic approaches.[6,7]

In 2017, Hackert et al. described the removal of the mesopancreas in a more radical operation for patients with

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local advanced tumors after neoadjuvant treatment.[8] The technique consists of the removal of all tissue around the SMA and CA. In some cases, this can result in complete skeletonization of both arteries until their origin in the aorta, including the neural and lymphatic plexus. The typical triangular aspect after completion of this artery-sparing procedure inspired its name as the "Triangle" operation.[8].

METHODS

Video clips were compiled from several robotic pancreatoduodenectomies to demonstrate the total mesopancreas excision and triangle operation technique, as follows: (1) main steps for mesopancreas excision and tringle operation, (2) anterior approach for mesopancreas excision, (3) triangle operation. These two techniques are complementary. The total mesopancreas excision consists in the removal of all tissue behind the pancreatic head on the right side of the SMA and CA. According to Adham et al, the mesopancreas consists of a triangular flap of tissues that extend from the posterior surface of the head of the pancreas behind the SMV/PV axis. It forms an inverted triangle between CA and SMA and covering their right semi-circumference. The triangle operation is the removal of the same tissue, but the SMA and the CA are completely skeletonized, so the left semi-circumference of these structures is also dissected. 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 mesopancreas excision and triangle operation
The first step is to perform a wide Kocher maneuver with division of the retroperitoneum attachments to the pancreatic head, followed by exposure of the inferior vena cava, and the left renal vein. The next step is to perform superior mesenteric artery first approach, which lies above the left renal vein. SMA is identified and exposed at its origin. Mesopancreas dissection is defined by the dissection along the right side of the SMA, with excision of lymph nodes and nerve plexus. Hepatic hilum is then dissected with division of the common bile duct, followed by hilar lymphadenectomy and skeletonization of the hepatic artery, portal vein and division of the gastroduodenal 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 two centimeters below the pylorus. After creation of a tunnel at the level of the pancreatic neck, pancreas is divided. SMA is then identified behind the portal vein and skeletonized towards its origin. Periadventitial dissection of the right semi-circumference of the SMA leaves the mesopancreas to the right of the SMA. Surgical specimen is then detached from the portal vein, and we can see the triangle formed by these three structures, CA, SMA and portal vein (Fig. 1)

FIG. 1 Robotic mesopancreas excision and Triangle operation. a Intraoperative view before completion of operation: mesopancreas is highlighted. HA, hepatic artery, PV, portal vein.b Intraoperative view after resection of the pancreatic head: HA, hepatic artery, PV, portal vein, SMA, superior mesenteric artery. c Intraoperative view after Triangle operation: portal vein (PV) and superior mesenteric vein (SMV) are completely dissected. Hepatic artery (HA), celiac axis, and superior mesenteric artery (SMA) are skeletonized. SV, splenic vein. d Intraoperative view after Triangle operation: Portal vein and superior mesenteric vein (PV/SMV) are pulled upwards to expose the area of mesopancreas excision. Hepatic artery (HA), celiac axis (CA), superior mesenteric artery (SMA), and PV/SMV formed a triangle, for which the technique is named.

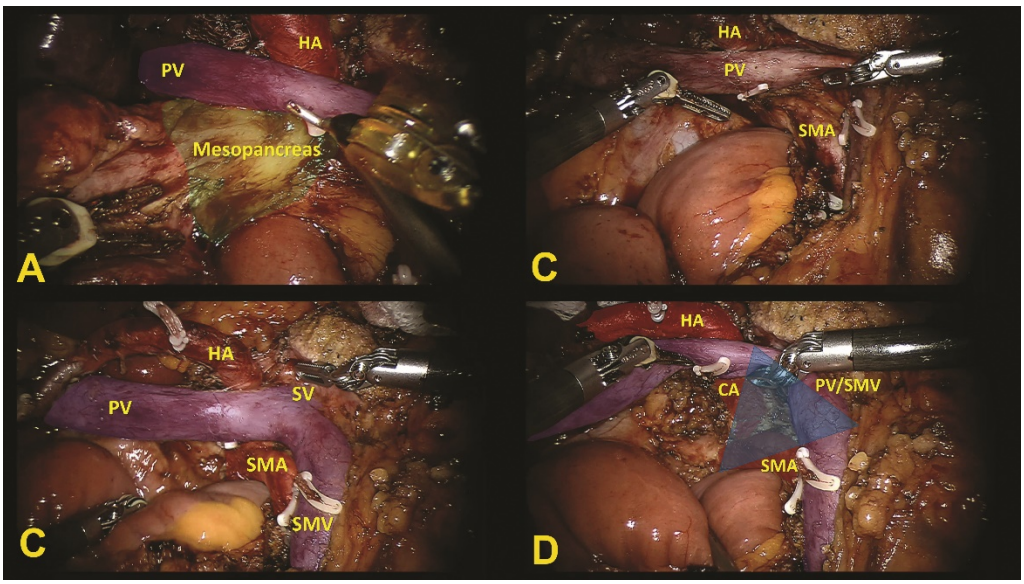
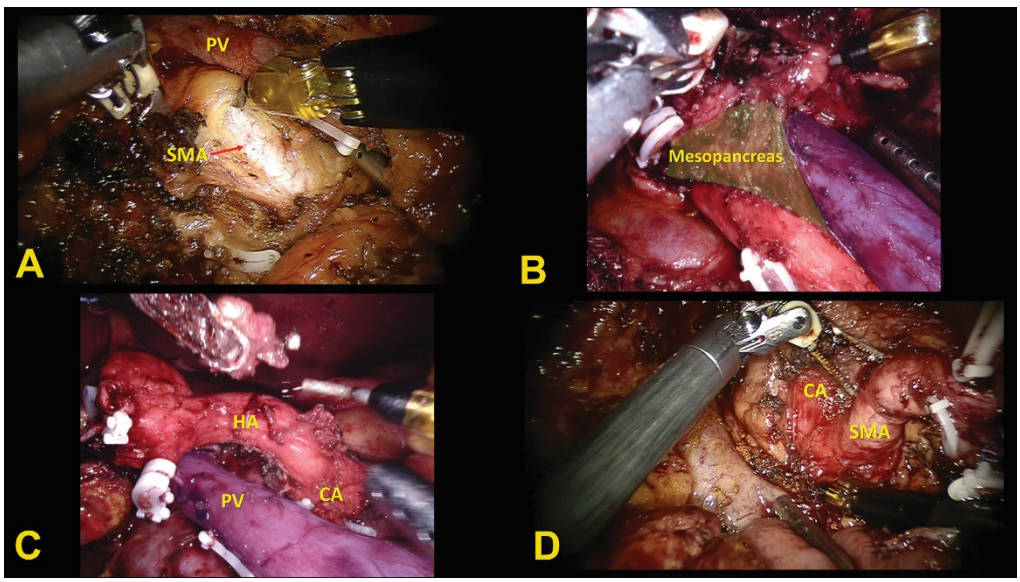


FIG. 2 Robotic mesopancreas excision and Triangle operation. a Intraoperative view of anterior approach mesopancreas excision. Superior mesenteric artery (SMA) is identified behind the portal vein (PV) and exposed towards its origin.. b Intraoperative view of anterior approach. SMA and portal vein are dissected and mesopancreas is highlighted. c Intraoperative view of triangle operation. Hepatic artery (HA) is dissected towards its origin, exposing the celiac axis (CA). PV, portal vein. d Intraoperative view: Celiac axis (CA) and SMA are dissected towards their origin in Aorta



Anterior Approach for mesopancreas excision and triangle operation

Mesopancreas can be excised without the use of SMA artery first technique. SMA is identified behind the superior mesenteric vein and dissected from this point towards its origin in the Aorta. Periadventitial dissection results in skeletonization of the anterior and right-lateral aspect of the SMA. During this dissection inferior pancreatoduodenal artery (IPA) will be encountered and ligated. At the same time the hepatic artery is dissected towards its origin in the celiac axis. The tissue flap that lies between these two structures is the mesopancreas and is removed *en bloc* with the surgical specimen (Fig. 2).

The triangle operation

The triangle operation consists in a complement of the mesopancreas excision. It is usually necessary in cases with locally advanced disease after neoadjuvant treatment. For those patients, generally the SMA and/or celiac axis is close to the tumor and complete skeletonization of these two structures is necessary to obtain free margins. The steps are essential the same but there is a need for circumferential dissection of the SMA and CA to avoid R1 resection. The mesopancreas is identified and removed as described above (Figures 1 and 2).

RESULTS

A total of 87 patients underwent robotic PD at our center between March 2018 and March 2021. Of these, 22 patients underwent robotic mesopancreas excision. This technique was used for patients at high-risk for R1 resection in 18 patients and triangle operation in four patients. Partial portal vein resection was necessary in 6 cases. One patient presented chyle leak that was conservatively treated and another one with persistent diarrhea with normalization 3 months after operation. No mortality was observed in this cohort of patients. One patient had R1 resection and was treated with adjuvant therapy. The remaining patients presented free surgical margins. The mean number of harvest lymph nodes was 40 (range:27-77). Median interval between the operation and chemotherapy was 23 days.

DISCUSSION

Minimally pancreaticoduodenectomy is a viable, safe, and effective procedure in the hands of an experienced surgeon. However, the applicability of the minimally invasive technique on a large scale is still restricted to large-volume centers, and so are the best results.[9] The minimally invasive approach may decrease the interval between the operation and chemotherapy, as with our patients, who initiate systemic therapy about three weeks after the procedure.[13].

Since 2018, all of our minimally invasive pancreatic surgeries have been performed using the robotic platform. With its added degrees of freedom and the stability of the robotic platform, the robotic approach is useful for minimally invasive performance of a complex pancreatic head dissection and reestablishment of the alimentary tract. The da Vinci robot provides 3D vision with 20x magnification, thus improving the precision of pancreas dissection and allowing for anastomosis sutures to be applied at difficult angles with the non-dominant hand when necessary. As our experience with this new system has increased, so have the indications for more complex cases using the robotic approach.[12, 14-16] With the increase in complexity in our PDs, an increase in R1 resection rate was to be expected.

R0 resection is the most important factor for long-term survival. The most frequent site of R1 resection after PD is within the retropancreatic and retroportal space.[4] Some changes in our technique were necessary to obtain R0 resection in patients at high risk for R1 resection during minimally invasive PD. The first change was the routine use of the robotic platform followed by the systematic use of an artery-first approach and total mesopancreas excision. Although the extension of lymphadenectomy is not related to better survival, the lymph node yield may give an idea of the adequacy of the lymphadenectomy. In the present report, a mean of 40 lymph nodes were harvested.

The Triangle operation consists of *en bloc* removal of the mesopancreas from the triangular space delimited by the superior mesenteric artery, celiac axis, hepatic artery, and PV/SMV. This operation may be associated with margin-free resection in selected patients with borderline pancreatic cancer after neoadjuvant treatment.[8] The original description includes complete removal of lymphatic and perineural extension along the SMA and CA structures without arterial resection and reconstruction.[8] In that report, a high rate of total pancreatectomy was needed, and some patients presented relevant diarrhea. In PD, autonomous denervation may not be clinically relevant as the neural structures along the left circumference are preserved, as in our patient.

The Triangle operation is a radical operation and only indicated for extreme cases. Therefore, a minimally invasive approach for this technique has only been reported once.[17] Rosso et al.[17] recently reported a laparoscopic pancreaticoduodenectomy with portal vein resection and complete clearing of the superior mesenteric artery and the right side of the celiac trunk. The present report confirms the feasibility of such a complex procedure using minimally invasive approach. In our opinion, the use of the robotic platform was essential to complete the Triangle operation and total mesopancreas excision in a minimally invasive setting.

CONCLUSIONS

The robotic total mesopancreas excision and the Triangle operation are feasible and safe for selected patients. The indication for this radical operation is the presence of a high risk for R1 resection and for those with locally advanced disease. The presented video may help oncological surgeons to perform these two important and complementary techniques.

DISCLOSURES The authors declare no conflicts of interest.

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