



Follow “the superior mesenteric artery”: laparoscopic approach for total mesopancreas excision during pancreaticoduodenectomy

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Abstract

Background The prognosis of patients affected by pancreatic adenocarcinoma and periampullary tumors is dismal, mainly due to aggressive tumor biology and low rate of resectability at the diagnosis. Among resectable patients, the quality of surgical resection, with a particular focus on the complete resection of the retropancreatic tissue (the so-called “mesopancreas”) encircling the superior mesenteric artery (SMA), has a cardinal role. With this assumption, many pancreatic surgeons recommend periadventitial dissection of the SMA in order to obtain a total mesopancreas excision (TMpE), maximizing surgical margin and minimizing R1 resection rate.

Objective To introduce our approaches for periadventitial dissection of the SMA, tailored to patient and tumor characteristics and aiming at obtaining a TMpE, during laparoscopic pancreatoduodenectomy (LPD).

Methods Three different approaches for the SMA periadventitial dissection during LPD are described: the right, the right–left, and the anterior SMA-first approach. Indications, advantages, and technical aspects of each technique are reported, as well as pathologic results, particularly focusing on resection margin status and removed lymphnodes number, safety, and feasibility.

Results Overall, R0 rate and number of lymphnodes retrieved were 86% and 26, respectively, without significant differences according to the SMA approach performed. Rate of conversion to laparotomy due to intraoperative bleeding during SMA dissection step was 6% (3/48) among patients who underwent the right SMA approach and nil among remaining patients.

Conclusion During LPD, a tailored approach for periadventitial dissection of SMA makes TMpE feasible, safe, and oncologic valid, when performed by a team experienced with minimally invasive approach and pancreatic surgery.

Keywords Laparoscopic pancreaticoduodenectomy · Pancreatic cancer · Mesopancreas · Superior mesenteric artery first approach

Due to their aggressive biology, periampullary tumors and pancreatic head adenocarcinoma are usually not resectable at the time of diagnosis because of locally advanced primary disease or distant metastases. In addition, the majority of patients undergoing surgery will experience limited survivals, negatively affected by peripancreatic lymph nodes

involvement, vascular invasion, tumor size, perineural spread, and surgical margin tumor invasion [1–4].

While the majority of such factors are independent from or marginally influenced by surgical resection quality, the surgical margin status is the only one potentially modifiable by the type of resection performed. Given that the margin facing the superior mesenteric vessels, in particular the superior mesenteric artery (SMA), is the most frequently involved by the tumor at the time of pancreatoduodenectomy (PD), many pancreatic surgeons now recommend a periadventitial approach to the SMA [5], aiming at a complete removal of the retropancreatic tissue encircling the SMA, the so-called “Mesopancreas,” in order to maximize surgical margin around the SMA and to obtain a total mesopancreas excision (TMpE) [2, 4, 6–11].

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The SMA-first approach, initially designed with the aim of excluding tumor invasion of the SMA at the beginning of PD, allowing the procedure interruption before pancreatic transection, has subsequently gained increasing interest as a surgical procedure helping periadventitial dissection of the SMA during PD. While different approaches for SMA dissection have been described [12] during open PD, few studies have analyzed feasibility, safety, and indications of such approaches during LPD [13–16], with particular focus on TMpE.

The aim of the present manuscript is to report on our experience with three approaches, each specifically tailored to particular patient and tumor characteristics, for periadventitial dissection of the SMA and TMpE during LPD.

Materials and methods

Between May 2015 and May 2019, 59 consecutive patients underwent attempted LPD with TMpE for pancreatic and periampullary tumors at the Department of HBP surgery, Poliambulanza Foundation Hospital, Brescia, Italy. At least three members of the HPB surgical team (E.R., M.G., A.M., V.S., C.C., G.Z.) participated at all the procedures, the majority of which were performed by E.R. Three different approaches for periadventitial approach to SMA were adopted, according to tumor and patient characteristics, as described in detail in the following paragraphs. A standardized histopathology assessment of the specimen was performed and the “1 mm rule” for R1 resection definition was used [17]. IRB approval was not required for this research. Written consent for retrospective studies was systematically obtained for each patient.

Mesopancreas definition

In the absence of an objective and universally accepted definition of mesopancreas and of its anatomical boundaries [6–9], according to available literature, we defined mesopancreas as the tissue located around the origin of the SMA and delimited:

- Medially, by the right aspect of the SMA and of the superior mesenteric vein.
- Laterally, by the medial and posterior aspect of the pancreatic head and uncinate process.
- Posteriorly, by the left renal vein.
- Distally (caudal), by the beginning of the mesenteric root.
- Proximally (cephalic), by the origin of the celiac trunk.

Surgical technique for laparoscopic pancreaticoduodenectomy

Until September 2015, a high-definition display was used while, starting from October 2015, 3D flexible laparoscope has been used in the majority of cases. The patient is placed in supine position with legs in abduction. The pneumoperitoneum is induced at a pressure of 12 mmHg using an open laparoscopy technique in supra-umbilical area and the remaining trocars are inserted under direct vision, two 12-mm trocars in perirectal right and left, slightly above the previous one, additional two 12 mm on both flanks, a 5-mm trocar lateral to the right flank and one 12-mm trocar for the smoke-suction system (AirSeal®) in subxiphoid area after tackling the falciform ligament with a stay suture.

Following exploration of the abdominal cavity, after excluding peritoneal carcinosis and metastases at the liver surface, the gastrocolic ligament is opened and the right colonic flexure mobilized. At this point, an extensive Kocher maneuver is performed in order to expose the anterior wall of the confluence of left renal vein in the inferior vein cava. Such maneuver is followed by SMA identification and dissection, according to the SMA approach used. The stomach is transected at the antrum, the lymphadenectomy of the hepatic pedicle is extended to the hepatic artery and coeliac trunk, the retropancreatic tunnel is identified and the gastro-duodenal artery is ligated and divided.

At this point, the operation moves below the mesocolon, where the Treitz ligament is dissected, the first jejunal loop is divided, devascularized, and moved supramesocolic, through the treitz space. Following duodeno-jejunal de-rotation behind the mesenteric root, the operation continues with the division of the common bile duct, the division of the pancreas, and the excision of the mesopancreas along the adventitial plane of the SMA (see chapter “mesopancreas resection”), until complete detachment of the specimen. The reconstruction is achieved through laparoscopic termino-lateral hepatico-jejunal anastomosis with 5/0 reabsorbable monofilament, double purse-string pancreaticogastrostomy (through a supraumbilical minilaparotomy until September 2015 and fully laparoscopic starting from October 2015), latero-lateral linear stapled gastro-jejuno-stomy (on a single jejunal loop until September 2015 and on an Y-en-Roux jejunal loop starting from October 2015), and finally a latero-lateral linear stapled jejuno-jejuno-stomy.

Superior mesenteric artery approach for total mesopancreas excision

We standardized three different techniques to achieve TMpE, based on the principle of following the SMA periaortical plane, customizing the SMA approach according to the characteristics of the patient and of the tumor as following:

- Right SMA approach: for patients with BMI < 25, tumor not in contact with the venous axis, without infiltration of the mesopancreas or with mesopancreas infiltration limited to the right aspect of the SMA.
- Right–Left SMA approach: for patients with any BMI, tumor not in contact with the venous axis, and mesopancreas infiltration extending to the left of the SMA.
- Anterior SMA approach: for patient with any BMI and tumor in contact with or infiltrating the venous axis.

Right SMA approach (video no 1)

Indication

We recommend the right SMA approach in the most favorable cases, with slim patients affected by small tumors not extending beyond the right side of the SMA. Indeed, while on one side, a low BMI is associated with thin mesenteric root, which facilitates duodeno-jejunal de-rotation after Treitz and first jejunal loop transection, allowing a safer dissection of the uncinata process and a easier dissection and separation of the inferior pancreaticoduodenal artery, on the other one a small tumor located on the right side of the SMA uniquely requires a dissection on the vessel side.

Technical steps

Following a wide Kocher maneuver, the SMA origin can be identified above the left renal vein. Herein, the SMA is surrounded by neurovascular-lymphatic tissue and can only be initially identified as a pulsating bulge. The dissection of the overmentioned tissue leads to the SMA adventitial plane, which is dissected both circumferentially around and longitudinally along the vessel adventitia, toward the mesenteric root, as far as possible. Moving the dissection distal the SMA origin, the origin of an inferior pancreaticoduodenal artery may be identified.

During this final step, the specimen is still connected only by the mesopancreas: the SMA can be identified

posterior right to the portal vein and can be followed toward its origin, while safely dividing the inferior pancreaticoduodenal artery at its origin on SMA.

Technical pearls

- (i) At the beginning of the operation, following a wide Kocher maneuver, it is pivotal that the assistant surgeon, using the xyphoid trocar, lifts the duodenopancreatic block up and pulls it to the left of the patient, in order to straighten up as much as possible the SMA, which now has an horizontal orientation, its origin being at the right of the screen: such maneuver allows a safer dissection of the mesopancreas on the posterior-right wall of the SMA, which can be better identified and dissected free from encircling tissue.
- (ii) We usually do not dissect nor encircle or divide the inferior pancreaticoduodenal artery identified during the right SMA approach: such attitude depends on our previous experience with the right SMA approach during open PD, when a considerable risk of bleeding from the inferior pancreaticoduodenal artery was seen when such vessel was approached from the right-posterior wall. In addition, at the beginning of our LPD experience, a bleeding during inferior pancreaticoduodenal artery dissection occurred during right SMA approach, bringing to convert the procedure to laparotomy in order to perform a correct hemostasis. Consequently, we suggest to dissect and divide the inferior pancreaticoduodenal artery during the retroportal lamina dissection at the end of the resection phase of the operation.

Right–left SMA approach (video no 2)

Indications

The Right–Left SMA approach has been developed for patient with high BMI and tumor extension to the mesopancreas at the left side of the SMA. In such patients, while the identification and dissection of the origin of the SMA using the right SMA approach are usually not more challenging compared to lean patients, achieving a TMpE uniquely with a right approach can be difficult and risky. Indeed, high BMI is frequently associated with thick mesenteric root, which makes the dissection of the mesopancreas from the SMA more difficult after de-rotation of the duodeno-jejunal axis, mainly due to mesenteric root and uncinata process steric hindrance. In addition, a tumor infiltrating the mesopancreas at the left of the SMA requires a dissection of at least $\frac{3}{4}$ of the SMA circumference, more easier to perform through a right and left SMA dissection approach.

Technical steps

The right approach to the SMA is performed as previously described: the SMA is identified at its origin above the left kidney vein and dissected free from the mesopancreas, moving distal, toward the mesenteric root. The SMA is then encircled with an elastic tape.

The dissection of the SMA is then continued on its left margin as follows: after placing the patient in slight Trendelenburg, the mesocolon being lifted up, the Treitz ligament is divided. Treitz dissection allows for the identification of the previously placed elastic tape encircling the SMA at its origin. The vessel loop can be pulled to left allowing SMA dissection on its periadventitial plane on the anterior-left margin and its separation from the mesopancreas. Such additional dissection makes safer and easier the final separation of the mesopancreas from the SMA: indeed, after the duodeno-jejunal axis de-rotation below the mesenteric root, as a consequence of the previous left dissection, the uncinata process is already partially detached from the SMA, making the inferior pancreaticoduodenal artery dissection and separation easier and safer.

Technical pearls

It is of critical importance to encircle the SMA with an elastic tape during the right step of this approach: such maneuver subsequently facilitates SMA mobilization during the left approach, creating different angles of dissection and reducing the risk of arterial injury.

Anterior SMA approach (video no 3)

Indications

The anterior SMA approach can be indicated in case of tumoral contact/invasion of the mesenterico-portal axis. In such case, it can be difficult to identify the right margin of the SMA, “covered” by the tumor attached to the portal/superior mesenteric vein. Such approach, through the anterior dissection of the mesenteric root, allows to achieve a complete dissection of the mesopancreas, independently of the site and length of venous contact/invasion, approaching the SMA from the anterior wall and allowing a complete circumferential dissection of the vessel, finally leaving the specimen “suspended” on the vein uniquely at the tumor contact/infiltration point, facilitating the subsequent tumor dissection or venous resection/reconstruction.

Technical steps

The superior mesenteric vessels are approached through the mesenteric root, at the inferior margin of the pancreatic neck whose anterior wall is gradually dissected. The superior mesenteric, portal, and splenic vein (and eventually their branches) are encircled with elastic tapes. The left anterior margin of the SMA can be identified behind-left to the vein axis and longitudinally dissected free upwards, toward the SMA origin. Subsequent circumferential dissection of the SMA allows identification of the inferior pancreaticoduodenal artery, which can be divided at its origin from the SMA. The specimen is finally suspended exclusively on the venous axis, making easier an attempt of tumor detachment from the vein or vein clamping, resection, and reconstruction.

Technical pearls

It is pivotal to achieve an extensive dissection and taping of the mesenteric vein and splenic vein, such maneuvers allow to identify and dissect, layer by layer, the SMA located behind the veins, deep in the mesenteric root. In case of tumoral invasion of the spleno-mesenteric-portal confluence, it is necessary to divide the splenic vein at its insertion on the portal vein, in order to gain the necessary access to the retroportal tissue anterior to the SMA.

Results

In the present series, among the 59 patients who underwent attempted LPD with TMpE, the right SMA approach was adopted in 81% of cases (48/59 patients), right–left SMA approach in 9% of cases (5/59 patients), and anterior SMA approach in 10% of cases (6/59 patients). The R0 resection rate and the mean (range) number of retrieved lymphnodes were 86% (51/59 patients) and 26 (12–93) overall; 96% and 32 (12–93) among patients undergoing the right SMA approach; 60% and 26 (14–46) among the patients undergoing right–left SMA approach; and 83% and 52 (27–82) among the patients undergoing the anterior SMA approach.

Among patients undergoing the right SMA approach, in one case a laparotomic conversion was necessary to control a bleeding occurred during the dissection of the inferior pancreaticoduodenal artery origin from the SMA. Two additional patients undergoing right SMA approach experienced a bleeding during the final step of resection, after duodeno-jejunal de-rotation behind the mesenteric root, the bleeding originating from a jejunal branch of the superior mesenteric vein and from the inferior pancreaticoduodenal

artery, respectively. No intraoperative complications related to the right–left and to the anterior SMA approach occurred.

Discussion

Minimally invasive techniques have revolutionized the surgical practice and are now applied to almost every field of abdominal surgery. Concerning pancreatic surgery, a minimally invasive approach is now recognized as the standard of care for resection of benign or border-line tumors of the left pancreas. However, despite almost 25 years have passed since the first report on LPD [18], minimally invasive surgery for periampullary tumors and pancreatic head adenocarcinoma is still considered a challenging procedure, uniquely performed at specialized Pancreatobiliary Units with large experience in minimally invasive approach [19]. The slow diffusion of LPD is related to intrinsic difficulty of laparoscopically reproducing PD, a surgical procedure per se characterized by high rate of postoperative morbidity, dissection close to major vessels, and a complex reconstruction with at least three anastomoses.

An additional critical point of LPD is represented by oncologic safety of the procedure, mainly related to the ability of achieving negative surgical margin, through performing a TMpE. In this context, a periadventitial approach to the SMA seems the only way to remove the mesopancreas and maximize the surgical margin. In this manuscript, we describe three optional approaches for periadventitial dissection of the SMA, which represents a critical step for achieving a TMpE during LPD for pancreatic head adenocarcinoma or periampullary tumor. These three approaches represent the result of a stepwise technical evolution revolving around the concept of SMA periadventitial dissection.

Based on our previous experience with SMA-first approach during open PD [14, 20–22] and on the reported evidence of reduced bleeding and better mesopancreas clearance [23] related to its use, we decided to apply such approach from the beginning of our LPD program. At the beginning of our experience with LPD, we only performed the right SMA approach, directly derived from the open approach, and such approach revealed adequate, feasible, and safe for the majority of patients. However, as the selection criteria extended to include patients with high BMI and larger tumors, the Right SMA approach revealed some limitations: two patients underwent conversion laparotomy due to bleeding (venous in one case and arterial in the other one) occurring at the end of the resection phase, when the specimen has been de-rotated behind the mesenteric root and is dissected free from the SMA.

The venous bleeding, from a jejunal branch of the superior mesenteric vein, occurred in a patient with a BMI = 28 and was mainly due to an excessive stretching to left of

the superior mesenteric vein, during the dissection of the mesopancreas from the right margin of the SMA after duodeno-jejunal de-rotation behind the mesenteric root. Such complication was partially due to the thickness of the uncinate process and of the mesenteric root, which made SMA dissection particularly challenging. In contrast, the arterial bleeding from the origin of the inferior pancreaticoduodenal artery occurred in a slim patient (BMI = 22), with preoperative imaging indicating pathologic tissue extending at the anterior and left side of the SMA, and was related to an excessive stretching of the specimen to right, in the attempt of dissecting the mesopancreas from the anterior-left wall of the SMA.

Such events led us to develop additional approaches for SMA dissection, customized on patient BMI and extension of mesopancreas tumoral invasion at the preoperative CT scan [24]. The right–left approach to SMA was designed for patients needing for a mesopancreas dissection extended to the left side of the SMA or with a thick mesenteric root, both conditions potentially endangering the final step of mesopancreas dissection from the SMA. As the inclusion criteria for LPD were further extended to patient with contact/infiltration of the portal/superior mesenteric vein, a third approach to the SMA was designed, aiming at dissecting the SMA while the specimen is still attached at the venous axis in contact with the tumor. This represents a great advantage, because a complete mobilization of the mesopancreas from the SMA before to perform the venous resection is associated with shorter venous clamping/anastomosis duration.

The techniques described in the current manuscript represent a minimally invasive translation of our standardized approaches to open PD, therefore our learning curve was speeded by our previous experience. Concerning the adoption of such techniques in the own practise, we suggest first of all to gain experience with SMA-first approach during open PD, trying to dissect the SMA on its periadventitial plane, which is safer and almost bloodless, while having at least two experienced HPB surgeons at the table. In addition, only HPB teams with advanced laparoscopy skills and experience with pancreatic surgery should attempt LPD with such approach.

Conclusion

A tailored approach for periadventitial dissection of SMA makes TMpE feasible, safe, and oncologically valid, not only in patients with low BMI and small tumors included in the pancreas, but also in patients with high BMI or with mesopancreas or venous axis tumor infiltration, assuming that it is performed by a team experienced with minimally invasive approach and pancreatic surgery.

Compliance with ethical standards

Disclosures Edouardo Morales, Giuseppe Zimmiti, Claudio Codignola, Alberto Manzoni, Marco Garatti, Valentina Segà, and Edoardo Rosso have no conflicts of interest or financial ties to disclose.

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