Original Articles

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The advantages of retropancreatic vascular dissection for pancreatic head cancer with portal/ superior mesenteric vein invasion: posterior approach pancreatico-duodenectomy technique and the mesopancreas theory

S.C. Moldovan[1], A.M. Moldovan[2], T. Dumitrașcu[3], S. Andrei[3], I. Popescu[3]

[1]Department of Visceral and Digestive Surgery; [2]Department of Anaesthesiology; St. Vincent de Paul Hospital
The Catholic Institut of Lille Hospital Group, North University of France, Free Faculty of Medecine Lille, France
[3]Center of General Surgery and Liver Transplant, Fundeni Clinical Institute, Bucharest, Romania

Rezumat

Avantajele abordului vascular retropancreatic în cancerul cefalic pancreatic cu invazie de venă portă/ mezenterică superioară: duodenopancreatectomia cefalică prin abord posterior și teoria mezopancreasului

Introducere: Chirurgia reprezintă singura șansă de supraviețuire pe termen lung în cancerul cefalic pancreatic. Invazia de venă portă nu mai reprezintă actualmente o contraindicație de rezecție dar poate pune probleme tehnice deosebite. Scopul studiului este de a prezenta avantajele abordului posterior în duodenopancreatectomia cefalică cu rezecție de venă portă.
Material și metodă: Seria de față include 16 pacienți cu duodenopancreatectomie cefalică și rezectție de venă portă/ mezenterică superioară pentru neoplasm cefalic pancreatic cu invazie venoasă, pacienți operați în perioada 2004 – 2011 și care reprezintă experiența unui singur chirurg.
Rezultate: În cazul a 10 pacienți s-a practicat rezecție venoasă laterală cu sutură primară (lungimea zonei venoase rezecate sub 1,2 cm). La 6 pacienți s-a practicat rezecție segmentară venoasă (lungimea segmentului venos rezecat sub 3 cm). Zona de segment vascular rezecată a fost cu limite de siguranță oncologică în toate cazurile. O rezecție de tip R0 a fost constatată la 11 pacienți, în timp ce restul de 5 pacienți au fost considerați de tip R1 la examenul anatomo-patologic final. Complicații postoperatorii s-au constatat la 3 pacienți cu fistulă pancreatică (grad A – 2 pacienți, grad C – 1 pacient ce a necesitat re-laparotomie pentru drenajul unui abces peripancreatic) și 5 pacienți cu stază gastrică post-operatorie de grad B.
Concluzii: Rezecția de venă portă/ mezenterică superioară asociată duodenopancreatectomiei cefalice este facilitată prin tehnica abordului posterior. În plus, abordul posterior înlesnește excizia completă a mezopancreasului în cazul duodenopancreatectomiei cefalice pentru neoplasmul cefalic pancreatic, ceea ce creează premizele creșterii șanselor de a obține o rezecție cu margini negative.

Cuvinte cheie: cancer de pancreas, duodenopancreatectomie, vena portă

Corresponding author:

Irinel Popescu, MD, FACS, FEBS
Professor of Surgery
"Dan Setlacec" Center for General Surgery and Liver Transplantation
Fundeni Clinical Institute
Street no 258, 022328, Bucharest, Romania
Tel (fax): 40-213180417
E-mail: irinel.popescu220@gmail.com
traian.dumitrascu@srchirurgie.ro

Abstract

Background/Aims: Surgery remains the single hope for long-term survival long-term survival in pancreatic head carcinoma. Portal vein invasion is no longer a contraindication for resection but could be technically challenging. The aim of the present study is to emphasize the advantages of the posterior approach in duodenopancreatectomy with portal vein resection.

Methods: The present series includes 16 patients with duodenopancreatectomy and portal/superior mesenteric vein resection and reconstruction duodenopancreatectomy invading the venous axis, performed from 2004 to 2011, and representing one author's experience.
Results: A lateral resection with direct suture was performed in 10 patients and the length of the resected venous wall was less than 1.2 cm. A segmental resection was performed in six patients and the length of resected vein did not exceed 3 cm (range, 1.5 – 3 cm). All venous resection extremities were cancer-free at final pathological report. Eleven patients were considered as R0 resection while 5 patients were assessed as R1 at final pathological examination. Postoperative morbidity consisted of: 3 patients with postoperative pancreatic fistulae (grade A – 2 patients; grade C – 1 patient, requiring second look laparotomy for peri-pancreatic abscesses) and 5 patients with delayed gastric emptying grade B.
Conclusion: Portal/superior mesenteric vein resection during duodenopancreatectomy is safe and it is facilitated by the posterior approach. Moreover, the posterior approach facilitates total mesopancreas excision during duodenopancreatectomy for pancreatic head cancer, a technical feature that appears to be associated with an increased rate of negative resection margins.

Key words: pancreatic cancer, duodenopancreatectomy, portal vein

Introduction

The adenocarcinoma of the pancreatic head remains a disease with a dismal prognosis because most of the patients have locally or systemically advanced disease at the time of the diagnosis (1). Thus, the resectability rate at the time of presentation is less than 20% (2). Chemotherapy for pancreatic head cancer has been demonstrated to slightly increase survival only in an adjuvant setting, after duodenopancreatectomy (3).

Although the main purpose of curative-intent surgery for pancreatic head adenocarcinoma is to achieve negative resection margins (4), this is not possible in an important proportion of the resected patients (5), even in the most experienced centers (6). Negative resection margins represent the most important prognostic factor after resection for pancreatic head cancer (7,8).

Vascular resections in pancreatic head adenocarcinoma were introduced with the aim to increase the resectability rate and to potentially reduce the percentages of positive margins of duodenopancreatectomy (9,10).

Arterial resections during duodenopancreatectomy are associated with increased morbidity and poor survival rates and they are indicated only in highly selected patients (11). Conversely, resection of the portal/superior mesenteric vein is feasible and justified because it does not impair the postoperative morbidity and mortality and it is considered to have a long-term survival quite similar to patients without venous resection (12-14).

Although modern imaging techniques might underestimate the extension of the disease, especially for small liver or peritoneal metastases (15), venous invasion can be accurately assessed preoperatively in most of the cases (16). Nevertheless, the pancreatic surgeon should be aware and trained for portal-mesenteric resection and reconstruction techniques.

The aim of the present study is to emphasize a preliminary experience with duodenopancreatectomy and portal / superior mesenteric vein resection and reconstruction, using the posterior approach technique.

Patients and methods

Patients

The present series includes 16 patients with duodenopancreatectomy and portal/superior mesenteric vein resection and reconstruction for pancreatic head cancer invading the venous axis, performed from 2004 to 2011, and representing one author's experience (SCM). Three patients of the present series had previous surgical biliary derivations performed in other hospitals and underwent neoadjuvant chemotherapy.

Operative technique

The posterior approach for duodenopancreatectomy was used in the present series of patients, in a similar manner as it was previously described (17).

After laparotomy the resectability was assessed (absence of metastases to the liver or peritoneum, invasion to the superior mesenteric artery, celiac trunk or hepatic artery). Suspected areas of invasion into the portal or superior mesenteric vein were checked with intraoperative ultrasound examination.

The procedure of duodenopancreatectomy started with an extensive Kocher maneuver. The superior mesenteric artery was identified and looped at its origin from the aorta, in the angle formed by the inferior vena cava and the left renal vein. Thus, invasion of the superior mesenteric artery could be identified in an early setting, precluding a useless macroscopic positive (R2) resection. Moreover, this approach allowed an easier identification and sparing of anatomical variants of the hepatic artery (replaced / accessory right hepatic artery or common hepatic artery originating from the superior mesenteric artery) (*Fig. 1, 2*).

Although the complete removal of the interaorto-caval lymph nodes was not performed in the present series of patients, sample lymph nodes were routinely sent for frozen section assessment.

The vascular dissection started on the right side of the superior mesenteric artery from its root toward the mesentery, inside the sheath of the artery and, if the case, of the anomalous replaced or accessory right hepatic artery. Thus, the complete removal of the retroportal lamina (inserted upon the superior mesenteric artery) was achieved (*Fig. 3 A, B*). At the

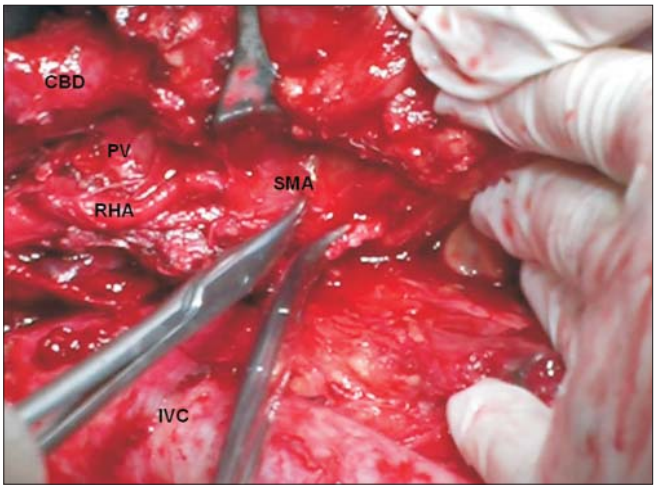

Figure 1. *Early identification of a replaced right hepatic artery (RHA) originating from the superior mesenteric artery (SMA)(intraoperative aspects) during the posterior approach in duodenopancreatectomy (PV – portal vein, IVC – inferior vena cava, CBD – common bile duct)*

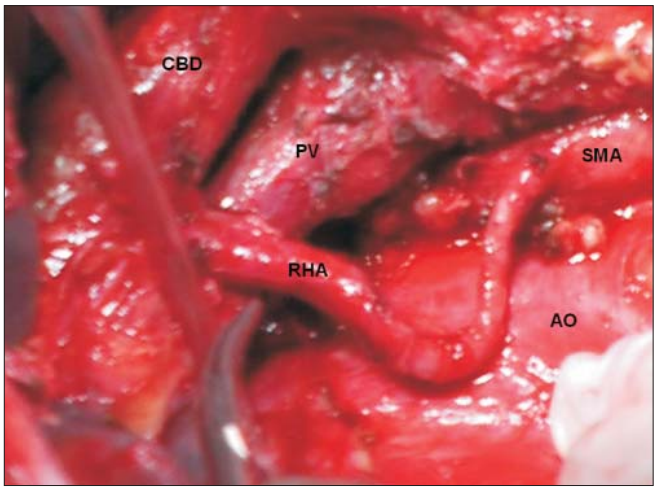

Figure 2. *The right side of the superior mesenteric artery (SMA) is completely freed and a replaced right hepatic artery (RHA) is spared prior to pancreatic transection (intra-operative aspects) (PV – portal vein, IVC – inferior vena cava, CBD – common bile duct, AO - aorta)*

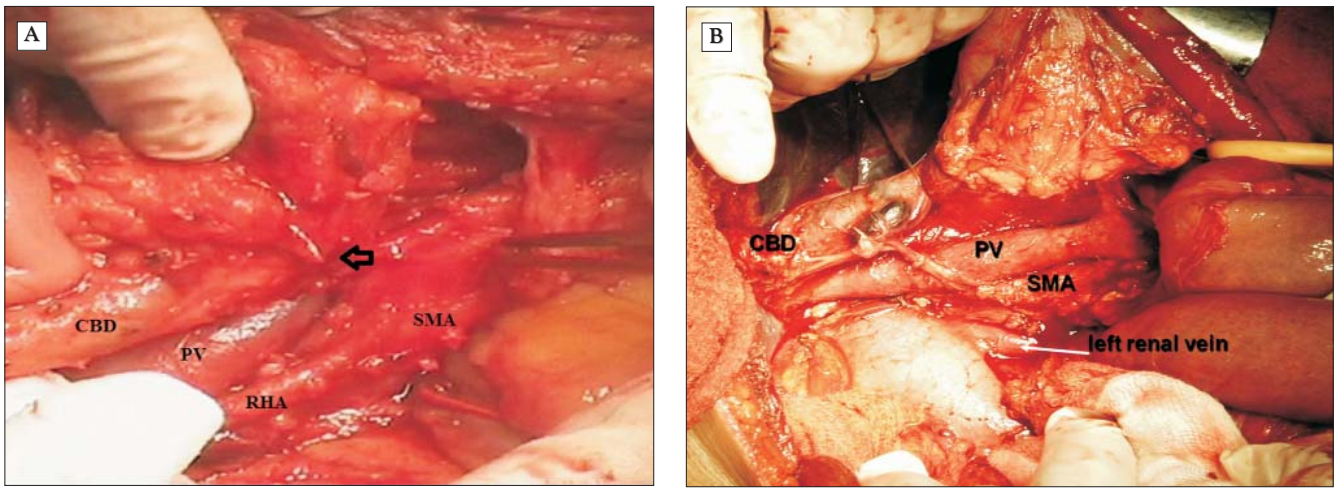

Figure 3. ***(A)*** *Invasion of the pancreatic head cancer into the portal vein (arrow), after complete removal of the retroportal lamina from the right side of the superior mesenteric artery (SMA) (intraoperative aspects) (PV – portal vein, RHA – replaced right hepatic artery).* ***(B)*** *Complete removal of the mesopancreas (PV – portal vein, SMA – superior mesenteric artery; CBD – common bile duct)*

same time, the right half of the superior mesenteric artery nervous plexus was removed. The dissection was performed inside the sheath of the venous axis, by dividing a cuff of connective tissue surrounding the vein. The dissection was performed only in the areas without a suspected invasion on intraoperative ultrasound. When the dissection was finished, the invasion area was approached, without any risk of tumor efraction.

Afterwards, the infrapancreatic superior mesenteric vein was dissected and looped. The elements of the hepatic hillum were dissected and looped, after the colecystectomy was performed. Thus, both portal and superior mesenteric veins were looped caudal and cranial to the tumor invasion. The common bile duct was not divided from its origin, traction upon it allowing a better venous sheath exposure on its axis and dissection without any angulations. In this way, the risk of inadvertent portal vein laceration was prevented (*Fig. 3 A*).

The gastro-duodenal artery was clamped and divided after the hepatic artery pulsations were assessed. The pancreatic isthmus section was safely performed at this point. Thus, the operative specimen remained attached only to the venous axis. No venous clamping was required until this moment. En bloc removal of the operative specimen was now performed (duodenopancreatectomy with portal/superior mesenteric vein segmental resection).

In cases with invasion of the right side of the portal vein at the level of the spleno-mesenteric confluence, the preservation of the latter was possible only in patients with small invasion. Thus, a lateral venous resection with suture

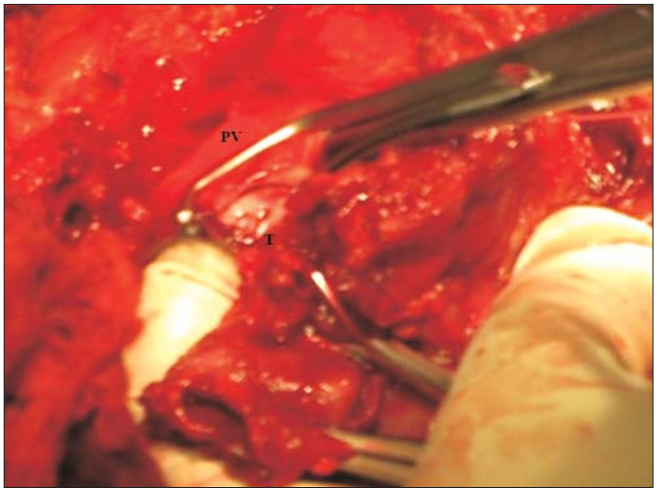

Figure 4. *Lateral resection of the portal vein (PV) in a pancreatic head cancer tumor (T) with limited invasion of the portal vein (intraoperative aspects). Of notice, the portal flow is not completely obstructed*

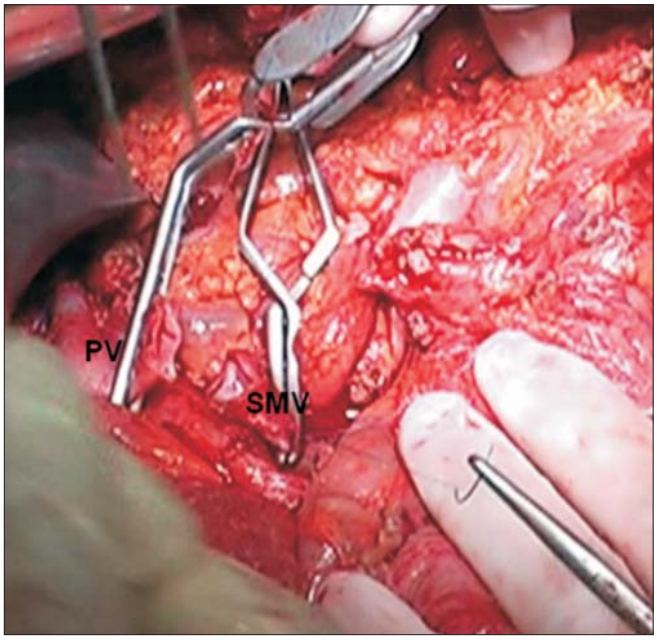

Figure 5. *Portal vein (PV) and superior mesenteric vein (SMV) clamped after en bloc removal of the operative specimen (pancreatico-duodenectomy with segmental venous resection) (intraoperative aspects)*

could be performed without jeopardizing the oncological safety. There was no need for a total venous clamping in these cases (*Fig. 4*). Where the lateral resection was not oncologically safe, a short length segmental resection of the portal/superior mesenteric vein was performed, never exceeding 3 cm (*Fig. 5*). This allowed a rapid, direct, end-to-end anastomosis, avoiding intestinal congestion. In our experience there was no need for venous shunting or reconstruction using venous or prosthesis grafts. In the present series, in cases requiring a wide lateral resection with patch plasty reconstruction, a segmental resection was performed, avoiding vein harvesting or synthetic grafts.

In cases with spleno-mesenteric confluence resection following termino-terminal portal anastomosis, a spleno-portal termino-lateral anastomosis was performed, without total clamping of the portal flow (*Fig. 6*). The left gastric vein could not be preserved in these patients with splenic intraoperative swelling due to venous congestion, immediately resolving after the spleno-portal anastomosis.

After the removal of the operative specimen and vascular reconstruction, the gastrointestinal anastomoses were performed, drains were left in situ and the abdominal closure ended the operation. In all cases, a standard but not extended lymphadenectomy was performed.

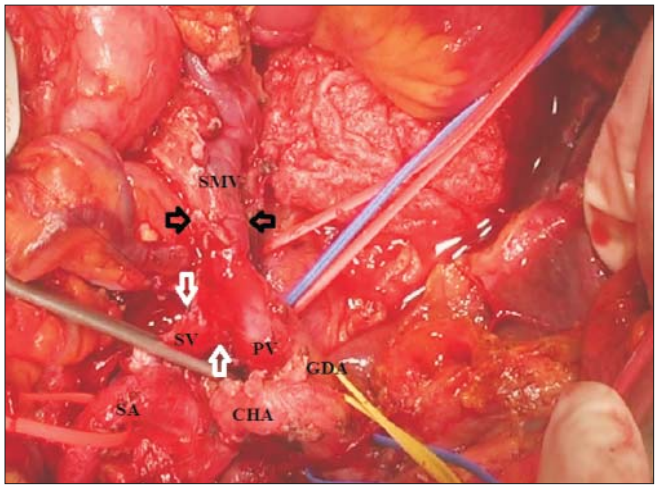

Figure 6. *Vascular reconstruction after pancreatico-duodenectomy with porto-mesenteric confluence resection: end-to-end anastomosis of the superior mesenteric vein (SMV) with portal vein (PV) (black arrows) and re-implantation of the splenic vein (SV) into the portal vein in an end-to-side manner (white arrows) (intraoperative aspects) (SA – splenic artery, CHA – common hepatic artery, GDA – gastro-duodenal artery stump)*

Results

A lateral resection with direct suture was performed in 10 patients and the length of the resected venous wall was less than 1.2 cm. A segmental resection was performed in six patients and the length of the resected vein did not exceed 3 cm (range, 1.5 – 3 cm). In the six patients undergoing segmental resection, the clamping time did not exceed 20 minutes. Two patients required resection of the spleno-mesenteric confluence and re-implantation of the splenic vein.

All venous resection extremities were cancer-free at the final pathological examination. Eleven patients were considered as R0 resection while 5 patients were assessed as R1 at the final pathological examination. Two patients were classified as V1 with transmural venous invasion, 6 patients as V1 with vein invasion, but not transmurally, and the rest of 8 patients were V0.

One patient died because of myocardial infarction on day

5 after surgery. Postoperative morbidity consisted of: 3 patients with postoperative pancreatic fistulae (grade A – 2 patients; grade C – 1 patient, requiring second look laparotomy for peri-pancreatic abscesses) and 5 patients with delayed gastric emptying grade B.

Discussion

The duodenopancreatectomy is nowadays performed in high-volume centers with low mortality and reduced severe morbidity (18). It has been proven to be a safe operation not only for elective indications but also in an emergency setting (19,20). Pancreatic fistula remains the main cause for postoperative morbidity and mortality (21,22).

Pancreatic head cancer represents an important indication for duodenopancreatectomy (23) and this remains the single hope for long-term survival in pancreatic head adenocarcinoma (24).

A recent consensus statement (25) defined resectable and borderline resectable pancreatic head cancers. Thus, a pancreatic head tumor is considered as localized and resectable when there is no evidence for any of the following: distant metastases, "abnormal" appearances of the portal/superior mesenteric vein (i.e., abutment, distortion, thrombus or encasement), absence of a clear fat plane around major arteries (celiac trunk, hepatic artery and superior mesenteric artery) (25). Borderline resectable are considered pancreatic head cancers without distant metastases but with venous involvement of the portal/superior mesenteric vein (tumor abutment with or without impingement, narrowing of the lumen, encasement) and no encasement of the neighboring major arteries. The obstruction of the vein due to either encasement or thrombus should be with patent venous lumen caudal and cranial to the involved area and should allow a safe resection and reconstruction. If not, the cases are considered as unresectable (25).

Duodenopancreatectomy with portal/superior mesenteric vein resection is considered to be the standard practice for pancreatic head cancers with venous invasion when a safe vascular reconstruction can be achieved, there is no invasion into the major arteries (hepatic artery, celiac trunk or superior mesenteric artery) and an R0/R1 resection is expected (5).

The portal vein resection during duodenopancreatectomy was first promoted by Fortner and co-workers, as part of "regional pancreatectomy," with the aim to increase the resectability rate and negative resection margins (9). Afterwards, portal vein resection techniques started to expand resectability and allowed a higher proportion of cancer-free margins. The survival is similar to patients without venous resections (26).

The preoperative assessment of the venous invasion in pancreatic head cancer has been proven to be highly accurate. Moreover, the type of portal vein invasion of pancreatic head cancer at computer tomography was recently found to be correlated with the pathological invasion of the vein. Bilateral narrowing of the portal vein or complete obstruction with collateral veins assessed at computer tomography were found to be associated with a worse outcome (27). Previous studies showed that the depth of venous wall invasion is strongly correlated with a poor outcome (28,29).

The percentages of portal/superior mesenteric vein resections during duodenopancreatectomy recognized a large range. There are surgical teams, especially from Japan, in which the percentages of portal vein resections during duodenopancreatectomy for malignancies are very high (30,31).

In order to prevent the portal congestion at the time of venous reconstruction, some surgical teams use a by-pass catheter that re-directs the mesenteric flow into the systemic circulation (10). Although an excellent method, it did not gained widely acceptance in other parts of the world. Our clinical practice demonstrated that the time of venous reconstruction was very rarely prolonged in order to require a venous by-pass, especially when a posterior approach duodenopancreatectomy was performed (17).

Although the aim of an en bloc duodenopancreatectomy with venous resection is to obtain an operative specimen with negative resection margin, data from the literature showed that even the patients with an R1 resection have a better prognosis compared to patients with portal/superior mesenteric vein invasion which was not resected (32,33).

Reconstruction techniques after porto-mesenteric venous resection include:

- For marginal resection:
  - Direct suture;
  - Patch plasty.
- For segmental resection:
  - Direct anastomosis;
  - Graft interposition:
    - Homograft (left renal vein or internal jugular vein);
    - Prosthesis.

Prosthetic reconstruction of the portal/superior mesenteric vein can be accomplished with no significant complications (34), but reconstruction without graft interposition is preferable and feasible in most of the cases, as it was shown in the present series. Although the use of the left renal vein for reconstruction after portal/superior mesenteric vein resection during hepato-bilio-pancreatic malignancies has been proven to be safe and without added morbidity (35), in clinical practice the length of the resected vein is rarely so long in order to preclude an end-to-end venous reconstruction, without graft interposition.

The length of the resected venous segment is not exceeding 3.5 cm (13) and the need for a graft is for length of over 4 cm (33). Patients with segmental venous resections exceeding 3 cm in length were associated with a poor survival rate (36). Nevertheless, portal/superior mesenteric vein and reconstruction without graft interposition was proven to be feasible and safe even for segments longer than 5 cm (37).

Duodenopancreatectomy techniques have evolved in recent years, and several modifications of the resection technique were introduced (24,38). Thus, the posterior approach (17,39,40) and "artery first" duodenopancreatectomy (41) appear to bring a benefit for patients compared to standard technique (42-46).

Technical considerations and potential advantages for posterior approach in duodenopancreatectomy *(17,40,47)*

The procedure starts with an extensive Kocher maneuver along with right colon and mesenteric root mobilization, beyond the left aortic margin. Superior mesenteric artery is identified above the left renal vein and entirely dissected inside its arterial sheath prior to pancreatic isthmus division. An abnormal variant of hepatic artery originating from the superior mesenteric artery can be easily identified and spared (*Fig. 7*).

The retropancreatic vascular dissection inside the sheath of the superior mesenteric artery is considered as appropriate for anterior and lateral venous invasion (*Fig. 8*). An additional dissection inside the sheath of the portal-mesenteric vein is performed after the superior mesenteric arterial sheath dissection (*Fig. 9*). This provides the possibility of complete removal of the mesopancreas. In cases with portal/superior mesenteric vein invasion, after transaction of the pancreatic isthmus, the pancreatic head and tumor remains attached only to the venous axis. Thus, a rapid and safe resection and venous reconstruction can be accomplished.

The main advantages of the posterior approach in duodenopancreatectomy are:

- Early assessment of the superior mesenteric artery invasion (17,40), thus avoiding useless R2 resections (38).
- Easy identification and sparing of an abnormal replaced/accessory right/common hepatic artery (39, 48-50).
- Reduced venous clamping duration for venous resection and reconstruction after en bloc resection (51-54).
- Reduced need for graft substitutions (51).
- Reduced need for splenic vein reconstruction in cases with spleno-mesenteric confluence resection (51).
- Complete resection of the retropancreatic lamina/mesopancreas and better retroportal lymph

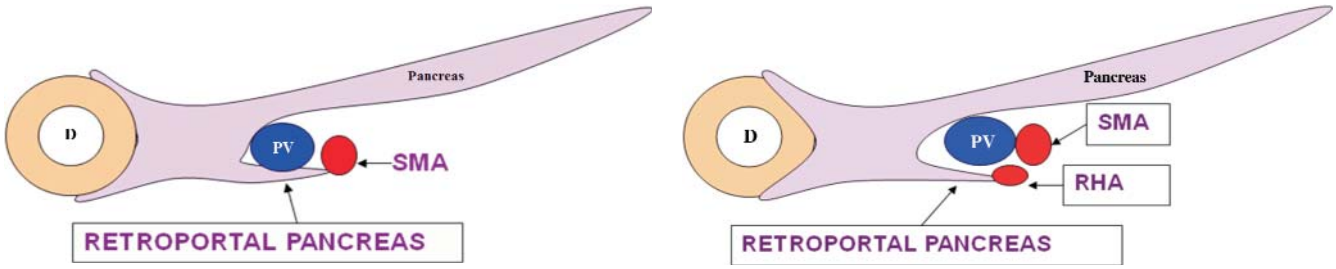

Figure 7. *Schematic transversal section of the duodeno-pancreatic complex (SMA – superior mesenteric artery; RHA – replaced / accessory right hepatic artery; D – duodenum; PV – portal vein)*

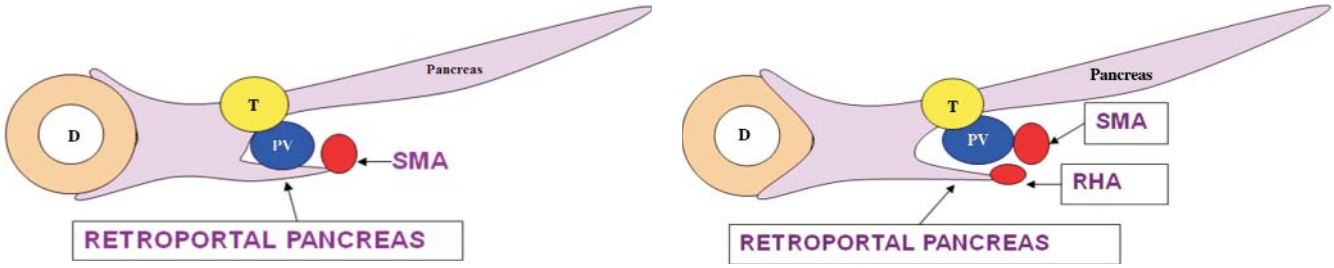

Figure 8. *Schematic transversal section of the duodeno-pancreatic complex with tumor (T – tumor; D – duodenum; PV – portal vein; SMA – superior mesenteric artery; RHA – replaced / accessory right hepatic artery)*

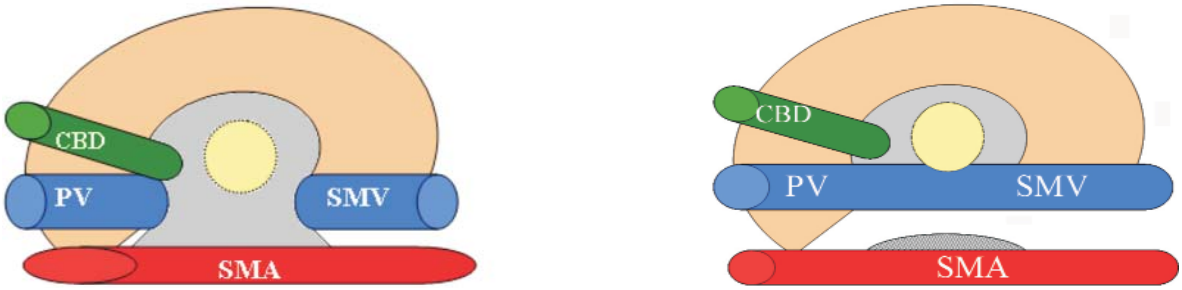

Figure 9. *Schematic view of the posterior aspect of the mobilized duodeno-pancreatic complex with tumor (in yellow) before (left side) and after (right side) complete removal of the mesopancreas*

node clearance (39,43,50).
- Facilitate right side superior mesenteric artery nervous plexus dissection and resection (50).
- Reduced operative time and blood loss, probably due to an early ligation of the vessels to the pancreatic head (43,51).

In terms of oncological radicality, the posterior approach in duodenopancreatectomy perfectly superposes the mesopancreas theory based on several embryological and anatomical grounds (55,56). Actually, the terms "retroportal lamina" or "retroportal pancreas" bear the same meaning, as the term "mesopancreas". The mesopancreas is defined as the soft tissue between the pancreatic head and superior mesenteric artery and it includes nerves, vessels, lymphatics and lymph nodes (24).

Total mesopancreas excision was recently highlighted as a key point in curative-intent surgery for pancreatic head adenocarcinoma (24) and it was confirmed by further studies that have shown a significantly increased rate of R0 resections (42,44).

Total mesopancreas excision in pancreatic head cancer has been proved to be facilitated by the posterior approach in duodenopancreatectomy (42), but should be considered as mandatory no matter what type of approach is used (24). It is not confirmed yet that total mesopancreas excision for pancreatic head cancer is as valuable as total mesorectal excision in rectal cancer (57), however it appears to be a promising field for further research.

Regarding the impact of the posterior approach technique on long-term outcome of patients with pancreatic head cancer, a recent study has shown a significant improvement of the survival as compared to the standard duodenopancreatectomy (45). However, it is not clear yet how to explain these survival benefits (58) since there were no differences of R0 resections (the most important determinant of survival in pancreatic head cancer) between the posterior approach and the standard duodenopancreatectomy groups (45).

Conclusion

Portal/superior mesenteric vein resection during duodenopancreatectomy is a safe procedure and it is facilitated by the posterior approach. Thus, the posterior approach allows an oncologically safe en bloc resection of the operative specimen and a reduced time for venous reconstruction, avoiding congestion of the mesentery. Grafts are rarely needed for venous reconstruction in this approach. Nevertheless, the posterior approach facilitates total excision of the mesopancreas during duodenopancreatectomy for pancreatic head cancer, a technical feature that appears to be associated with an increased rate of negative resection margins.

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