Vascular Resections in Association With Pancreatic Resections for Locally Advanced Pancreatic Cancer

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Abstract. *Background/Aim:* Locally advanced pancreatic cancer has been considered for a long period of time as an unresectable lesion and therefore, all patients have been traditionally addressed to the oncological services for palliative purposes. However, due to the wide usage of newer oncological agents in association with improved surgical techniques, radical surgical procedures became feasible. The aim of this study was to present the different surgical procedures that were performed in locally advanced pancreatic cancer patients in order to achieve radical resections. *Patients and Methods:* Between 2019 and 2020, six cases were submitted to pancreatic and vascular resections in Fundeni Clinical Hospital. *Results:* In all cases, surgery with curative intent was attempted; portal vein resection was performed in five cases, whereas arterial

resection was performed in three cases. Reconstruction was performed by direct re-anastomosis, by placing cadaveric or synthetic grafts. The postoperative outcomes were favourable in all cases. *Conclusion:* Vascular resections can be safely associated with pancreatic resections in cases presenting locally advanced pancreatic lesions, with acceptable morbidity rates.

Although the procedure of pancreatic head resection en bloc with duodenal resection has been suggested early during the nineteenth century, being proposed by Trendelenburg in 1882, Codvilla in 1898, Kausch in 1909, Hirschel in 1914 and Tenani in 1922, it has been standardised and defined by Allan Whipple in 1935 (1, 2). At that moment, the rates of intraoperative and postoperative complications were significant and therefore, certain surgeons considered that these procedures should be rather abandoned because the risks were higher than the benefits (3-5). During the following decades, improvement in the field of surgery and perioperative care led to a significant improvement in the long-term outcomes and encouraged surgeons worldwide to continue performing this procedure (6, 7). When it comes to vascular resections as part of the oncological abdominal surgical procedures, the first such resection was imagined by Appleby in 1953 and consisted of celiac axis resection in

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Table I. Intraoperative details of the patients submitted to *en bloc* pancreatic and vascular resections.

Case	Age	CA15-3 levels	Preoperative biopsy	Vascular anatomical particularities	Type of resection	Type of reconstruction
1	53	1,250	Well differentiated pancreatic adenocarcinoma	Right hepatic artery originating from the superior mesenteric artery. Local invasion of the mesenterico-portal confluent	Total pancreatoduodenectomy <i>en bloc</i> with splenectomy and segmental resection of the mesenterico-portal confluent (Figure 1)	Termino-terminal anastomosis between the portal vein and the superior mesenteric vein
2	57	580	Moderately differentiated pancreatic adenocarcinoma	Local invasion of the portal vein	Pancreatoduodenectomy <i>en bloc</i> with the invaded segment of the portal vein	The portal vein was reconstructed by local interposition of a cadaveric venous graft (Figure 2 and Figure 3)
3	59	960	Well differentiated pancreatic adenocarcinoma	Local invasion of the portal confluent and of the superior mesenteric vein	Pancreatoduodenectomy <i>en bloc</i> with the portal confluent and superior mesenteric vein	Synthetic Goretex graft between the remaining superior mesenteric vein and the remaining portal vein (Figure 4)
4	45	1,100	Poorly differentiated pancreatic adenocarcinoma	Local invasion of the right hepatic artery. Right hepatic artery originates from the superior mesenteric artery	Pancreatoduodenectomy <i>en bloc</i> segmentary resection of the right hepatic artery	Termino-terminal arterial anastomosis (Figure 5)
5	52	760	Poorly differentiated pancreatic adenocarcinoma	Local invasion of the portal vein and superior mesenteric artery	Pancreatoduodenectomy <i>en bloc</i> with portal vein and superior mesenteric artery resection	Termino-terminal porto-portal anastomosis, reimplantation of the superior mesenteric artery in the abdominal aorta (Figure 6 and Figure 7)
6	67	2,100	Poorly differentiated pancreatic adenocarcinoma	Local invasion of the portal vein and of the common hepatic artery	Pancreatoduodenectomy <i>en bloc</i> with common hepatic artery and portal vein resection	The portal vein was reconstructed by placing a cadaveric graft while the common hepatic artery was replaced by placing an arterial cadaveric graft which was anastomosed between the remaining hepatic artery and the celiac trunk (Figure 8)

locally advanced gastric cancer (8). Similar to the Whipple's procedure, the Appleby procedure was also deemed initially, as it was considered to have an unacceptable rate of perioperative complications (9). However, in time, due to the improvement of surgical techniques and of postoperative care, vascular resections have been widely associated as part of pancreatic resections in order to maximize the rates of radical resections (10-12). Moreover, in the last decade, these procedures have been also performed in a minimally invasive manner, increasing even more their efficacy (13-16).

Patients and Methods

After receiving the approval of the Ethical Committee from "Dan Setlacec" Center of Gastrointestinal Diseases and Liver Transplantation, Fundeni Clinical Institute no. 426/11.10.2021 data of patients submitted to synchronous pancreatic and vascular resections between 2019 and 2020 were reviewed and introduced in the current study. Six such cases were identified and their intraoperative and early postoperative outcomes are presented.

Results

The age of the patients included in the present study ranged between 45 and 67 years, the mean age being 55,5 years. The mean preoperative value of CA19-9 was 1,125 U/ml (ranging between 580 and 2,100 U/ml). All patients underwent preoperative computed tomography in order to exclude the presence of distant metastases, magnetic resonance imaging in order to assess the local extension of the lesion, as well as endoscopic ultrasound and biopsy. In all cases per primam surgical procedure was attempted; details regarding the presence of an arterial invasion were observed at the preoperative investigations in case 5, whereas in the remaining cases arterial involvement was observed intraoperatively. However, the decision to perform per primam resection in case 5 was taken after discussing the possible risks and benefits with the patient due to the overall good clinical and biological status. The intraoperative details are presented in Table I.

Figure 1. Total pancreatoduodenectomy en bloc with splenectomy and segmentary resection of the mesenterico-portal confluent. Direct anastomosis between the portal vein (PV) and superior mesenteric vein was performed. Right hepatic artery (RHA) originating from the superior mesenteric artery (SMA). ICV: Inferior cava vein.

Figure 3. The specimen of pancreatoduodenectomy en bloc with the invaded segment of the portal vein.

Figure 2. Pancreatoduodenectomy en bloc with the invaded segment of the portal vein. The portal vein was reconstructed by local interposition of a cadaveric venous graft.

Figure 4. Pancreatoduodenectomy en bloc with the portal confluent and superior mesenteric vein. Synthetic Goretex graft between the remaining superior mesenteric vein and the remaining portal vein.

In all cases radical resection was achieved, negative resection margins being achieved. Meanwhile, in all cases invasion of the resected vascular segments were demonstrated and the mean operative time was 420 min (range=320-540 min). The estimated blood loss ranged between 600 ml and 1,500 ml, while the mean number of transfused units of erythrocytes was 3. Postoperatively, all patients were submitted to adjuvant chemotherapy. Computed tomography was performed in all cases in order to assess the functionality and patency of the vascular reconstructions and demonstrated the absence of local signs of vascular complications such as graft thrombosis. Intraoperative aspects are shown in Figure 1, Figure 2, Figure 3, Figure 4, Figure 5, Figure 6, Figure 7 and Figure 8.

Discussion

The definition of unresectable pancreatic cancer has changed during the last decades. The initial step forward consisted of extending the limits of the definition of resectable pancreatic

Figure 5. *Pancreatoduodenectomy en bloc with segmentary resection of the right hepatic artery. The arterial continuity was re-established through a termino-terminal anastomosis.*

Figure 7. *The specimen of pancreatoduodenectomy invading the portal vein and the superior mesenteric artery.*

Figure 6. *Termino-terminal porto-porta anastomosis and reimplantation of the superior mesenteric artery at the level of the abdominal aorta – the final intraoperative aspect.*

Figure 8. *Pancreatoduodenectomy en bloc with portal vein and hepatic artery resection. Vascular reconstruction was performed by placing venous and respectively arterial cadaveric grafts.*

cancer to lesions presenting venous invasion. Therefore, at this moment it is strongly recognised that these lesions are considered as borderline resectable and therefore, cases presenting a good clinical and biological status are successfully submitted to venous resections en bloc with pancreatoduodenectomy (17-19). This was the first paradigm, which has been widely accepted in the last decades and the results in terms of survival did not fail to demonstrate the

effectiveness of these procedures; similar rates of long-term survival being reported in such cases when compared to cases submitted to standard pancreatoduodenectomy (17).

Once this fact was widely demonstrated and recognised, tertiary, high volume centres went further and tried to demonstrate whether cases presenting both arterial and venous invasion could also benefit from surgery as a first intention procedure (18). While in cases presenting exclusively venous invasion per primam resection is widely accepted nowadays, in cases presenting both arterial and venous invasions things are far from being well standardised (18, 19). Therefore, such cases presenting are currently classified as having locally advanced lesions and the therapeutic strategy differs depending on the

general status of the patient and on the local conditions. Furthermore, in such cases, neoadjuvant chemotherapy could be proposed as first intention treatment, followed by re-evaluation through imaging, and in cases in which tumor regression is encountered, resection could be attempted (19-21). When talking about the type of pancreatic resection which should be performed in such cases, different opinions have been stated so far; while certain authors propose both cephalic pancreatoduodenectomy and total pancreatoduodenectomy, other tertiary centres propose routinely performing total pancreatoduodenectomy in order to diminish the risks of haemorrhagic, fatal complications. Therefore, in cases in which arterial resection is performed, leaving in place a pancreatic stump increases the risks of developing a postoperative pancreatic leak (22-26). In such cases, association between a pancreatic leak and an arterial anastomosis might induce the development of a fulminant arterial haemorrhage, which is fatal in most cases (27-29).

As for the types of vascular reconstructions, it has been widely demonstrated that depending on the local conditions, multiple types of reconstructions could be considered. Therefore, while in cases presenting limited invasion a paracelar resection followed by direct suturing or termino-terminal anastomosis could be performed, excluding in this way the possibility of placing a graft, in cases presenting more extended vascular invasion a graft is mandatory (30). While initially synthetic grafts such as Dacron or Goretex grafts have been proposed, nowadays cadaveric grafts represent the option of choice (31). In time, cadaveric grafts proved to be more efficient when compared to synthetic grafts due to the lower risks of thrombotic and infectious complications and therefore, there is a trend to replace them. However, it should not be omitted that cadaveric grafts or even autologous grafts are not always available, especially if cadaveric tissue banks are not available (32). Another interesting option that is associated with lower rates of postoperative complications is represented by animal grafts such as bovine pericardium. Similar to cadaveric or autologous grafts, bovine pericardium is associated with lower rates of postoperative complications such as thrombosis, but it is also more difficult to be obtained, prepared, and preserved and therefore, is not always available (33, 34).

Conclusion

Although initially the presence of vascular invasion has been considered for a long period of time as a sign of unresectable disease, and patients were submitted to palliative therapy, the therapeutic strategy has changed due to improvements in the field of perioperative and postoperative management. Therefore, both arterial and venous resections have been successfully performed as part of the therapeutic armamentarium of such cases. However, these procedures should be performed in tertiary centres, where the volumes of such cases are sufficiently larger, and thus significant experience has been obtained.

Conflicts of Interest

There are no conflicts of interest to declare regarding this study.

Authors' Contributions

VB, IoB, NB, OS, SP: performed the surgical procedures; NB, CS, IrB, OS, AAA, LP reviewed literature data; IoB, BU: preoperative investigation of the patient; IoB, NB, CS: prepared the draft of the manuscript; VB: was advisor of the surgical procedures; VB, NB: reviewed the final version of the manuscript. The Authors read and approved the final version of the manuscript.

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