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ORIGINAL ARTICLE

Vein resection without reconstruction (VROR) in pancreatoduodenectomy: expanding the surgical spectrum for locally advanced pancreatic tumours

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Abstract

Purpose Pancreatic malignancy with mesenterico-portal venous involvement can be safely managed with en bloc vein resection with comparable survival outcomes. Non-constructible venous encasement is regarded as criteria of unresectability in pancreatic cancer. In long-standing extra-hepatic venous obstruction, hepatopetal blood flow is established by collateralization in the hepatoduodenal and mesenteric region. Their importance in pancreatic malignancies is being recently acknowledged.

Methods The records of patients undergoing pancreatoduodenectomies were retrospectively evaluated from 2012 to 2019. Pre and intraoperative records of patients undergoing concomitant vein resection were evaluated for the presence of venous collaterals, and its impact on oncological management was studied.

Results Over a period of 7 years, 947 pancreatoduodenectomies were performed, of which 56 patients underwent concomitant vein resection. Among these, six patients had significant collaterals due to venous obstruction. They had pancreatic adenocarcinoma (2), neuroendocrine tumour (2) and solid pseudopapillary epithelial neoplasm (2) respectively. All these patients successfully underwent pancreatoduodenectomy with vein resection without vascular reconstruction. Superior mesenteric vein (SMV) was resected in four patients, whereas spleno-portal junction was resected in two patients. Dominant collaterals were preserved in all, without compromising oncological safety. Bowel congestion was checked by tolerability to 20-minute mesenteric venous clamping test. There was no major morbidity or hospital mortality following this surgical approach.

Conclusion We recommend vein resection without reconstruction (VROR) as a novel approach in locally advanced pancreatic tumours (due to non-constructible vein involvement) with significant venous collaterals and emphasize the need to assess venous collateralization pre and intraoperatively.

Keywords Pancreatic cancer · Portal vein involvement · Pancreatoduodenectomy · Vein resection · Collateral vessel · Portal hypertension

Introduction

Pancreatic malignancy with mesenterico-portal venous involvement can be safely managed with vein resection with comparable survival outcomes [1, 2]. Non-constructible venous involvement has been regarded as criteria of unresectability in pancreatic cancer [3]. In long-standing extra-hepatic portal venous obstruction, hepatopetal blood flow is established by formation of collaterals in the hepatoduodenal, mesenteric, mesocolic and retroperitoneal region [4]. Importance of these collateral vessels in borderline resectable and unresectable pancreatic malignancies undergoing proximal and distal pancreatectomy is recently being acknowledged [5–9]. Preservation of these collaterals can preclude portal vein-superior mesenteric vein (PV-SMV) reconstruction after resection of the main trunk, especially when reconstruction is likely to be complex or impossible. Here we present a series of patients who underwent pancreatoduodenectomy (PD) with vein resection without reconstruction (VROR).

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Materials and methods

This retrospective study was performed at a high volume tertiary teaching hospital [10] of western India over 7 years. Records of the patients who underwent PD with vein resection were collected from a prospectively maintained database from January 2012 to December 2019. During this tenure, all patients with suspected periampullary malignancy (pancreatic head cancer, distal cholangiocarcinoma, ampullary carcinoma, duodenal carcinoma, neuroendocrine tumour [NET] and solid pseudopapillary epithelial neoplasm [SPEN]) were evaluated with pancreatic protocol computed tomography (CT) scan to assess for resectability. Patients with locally advanced pancreatic lesions as per the International Study Group for Pancreatic Surgery (ISGPS) criteria [3] (PV-SMV encasement > 180° and/or superior mesenteric artery [SMA] contact ≤ 180° with non-constructible PV-SMV involvement) were subjected to biopsy for confirmation of histology. The details of these patients were discussed in a multidisciplinary team (MDT) meeting for further management. Neoadjuvant therapy was administered depending on the histology, grade, differentiation (in NET) and performance status of the individual. The response assessment CT scan (after neoadjuvant therapy) was re-discussed in the MDT meeting for further surgical management. Patients with stable or partial response to neoadjuvant therapy were evaluated for curative surgery whereas those with progressive disease were given further additional therapy depending on performance status and disease biology.

There was a subgroup of locally advanced pancreatic lesions (SPEN [11], early grade NET), in which upfront curative surgery was performed without administering neoadjuvant therapy. However, this decision was made only after discussion in the MDT meeting.

There were no patients of distal pancreatectomy with VROR in our database, and hence, only those undergoing pancreatoduodenectomy with VROR were considered for the current study. Their clinical profile, radiological features, operative findings and clinical outcome were evaluated.

Preoperative assessment of vascular involvement and anatomy

All patients in this cohort underwent a thorough study of the spleno-portal venous axis anatomy. The salient features studied were as follows: site and length of venous and arterial involvement, degree of abutment or encasement, presence of venous thrombus, collateral vessels (their size, calibre and course in relation to the PV-SMV), first jejunal vein (its calibre in comparison to SMV) (Figs.1, 2 and 3). If the spleno-portal junction was involved, then additional features, such as the site of drainage of inferior mesenteric vein (IMV) and left gastric vein (LGV) and whether resection involves IMV, LGV, middle colic vein or colic marginal vein, were also studied.

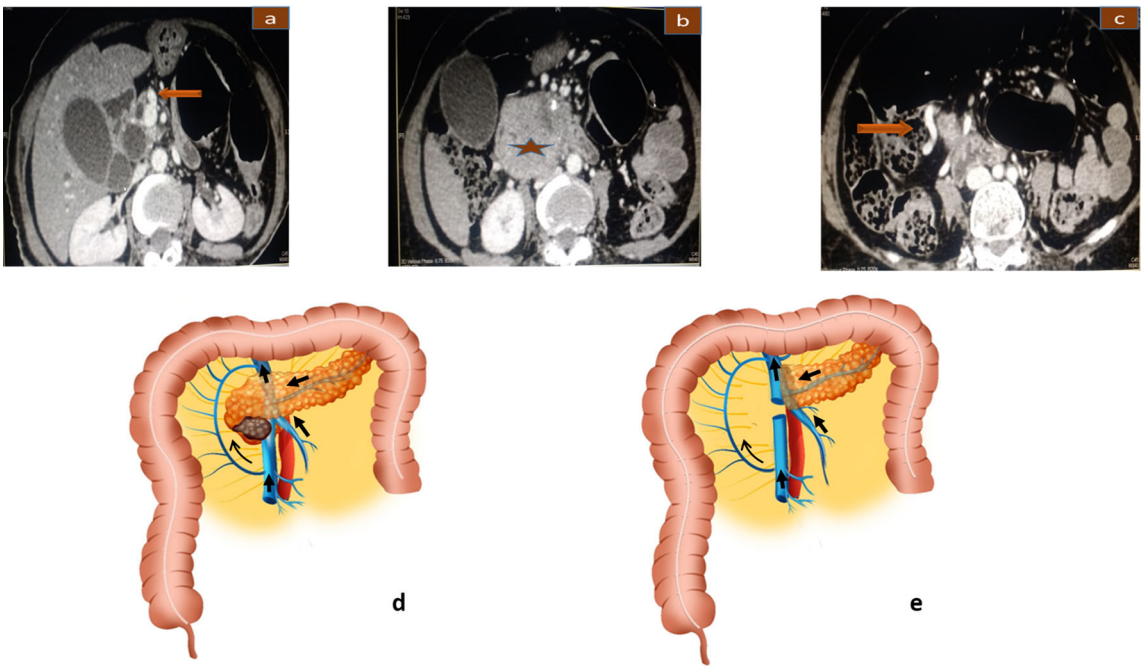

Fig. 1 Case of pancreatic head neuroendocrine tumour involving superior mesenteric vein. **a** Collateral vein (brown arrow) joining the portal vein above the tumour. **b** Neuroendocrine tumour (brown star) involving superior mesenteric vein. **c** Collateral vein (brown arrow) traversing the transverse mesocolon below the tumour. **d** Diagrammatic representation of the course and flow (black arrow) in collateral vessel in relation to the tumour. **e** Diagrammatic representation of the course and flow (black arrow) after PD with VROR

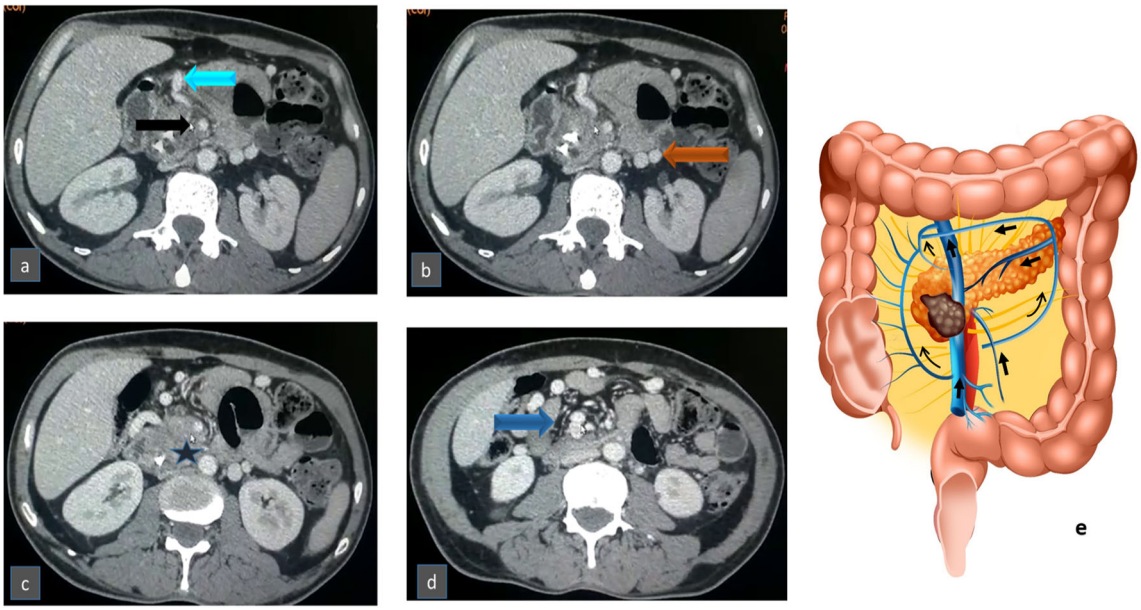

Fig. 2 Case of pancreatic uncinate adenocarcinoma involving superior mesenteric vein. **a** Collateral vein (blue arrow) arising from SMV (black arrow) just above the tumour. **b** Collateral vein (brown arrow) joining IMV on left side. **c** Pancreatic uncinate mass (black star) involving SMV and abutting SMA. **d** Collateral vein (blue arrow) traversing mesocolon and joining the SMV below the tumour. **e** Diagrammatic representation of the course and flow (black arrow) in collateral vessels in relation to the tumour

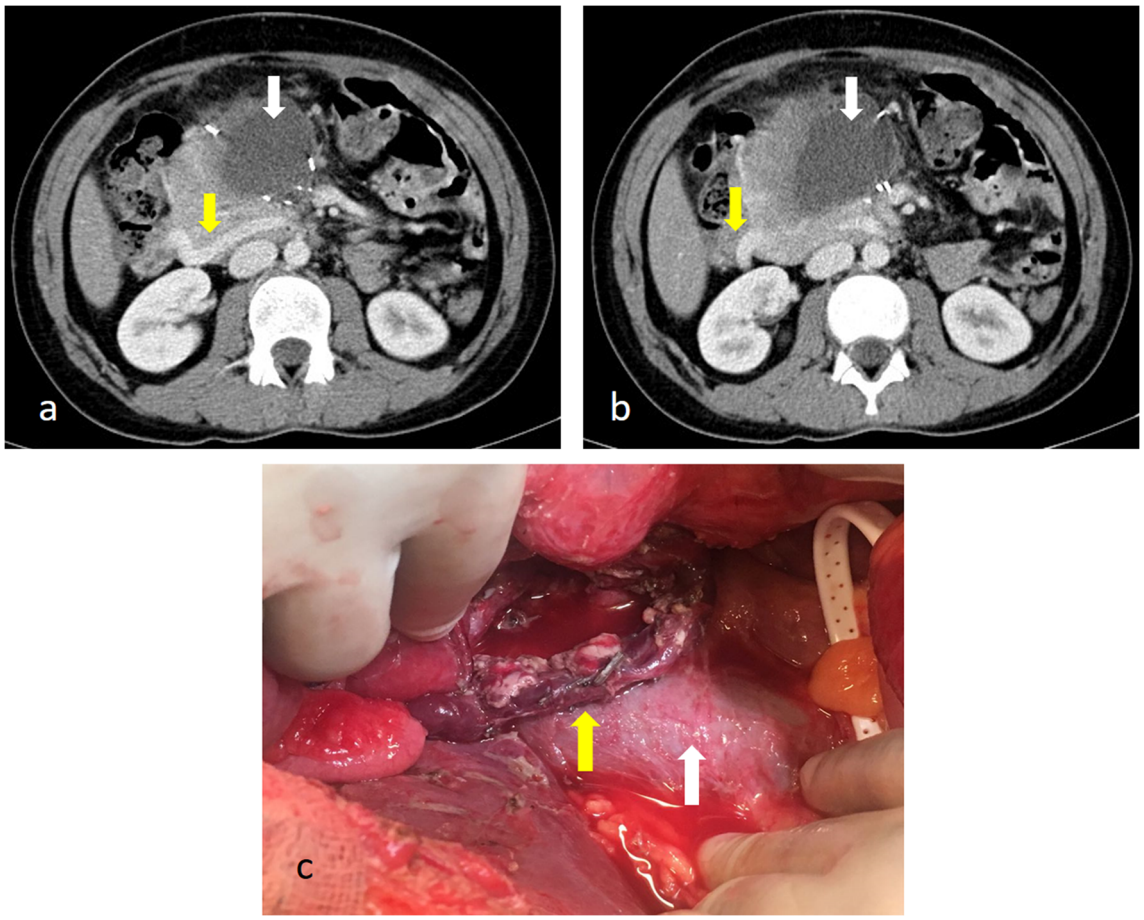

Fig. 3 Case of pancreatic head solid pseudopapillary epithelial neoplasm involving portal vein. **a** and **b** Preoperative CT scan showing tumour (white arrow) involving SMV with dominant collateral vein (yellow arrow). **c** Intraoperative field after PD with VROR, showing the preserved collateral vessel (yellow arrow). Inferior vena cava (white arrow)

Intraoperative assessment

After a thorough exploration to rule out metastatic disease, standard steps of PD were undertaken. Artery-first approaches were used in all these cases, and in some scenarios, initial steps were modified according to the site of the tumour and degree of venous involvement [12]. In patients requiring isolated SMV resection for wider surgical margins, the spleno-portal venous junction was preserved to ensure adequate hepatopetal portal venous blood flow via splenic vein. Few patients had large lesions involving long SMV segment extending up to the splenic vein–portal vein junction. In these patients, the LGV was preserved (if oncologically and technically feasible) during the initial dissection, to avoid congestion of the stomach. Dominant collateral vessels were preserved in all these patients to ensure adequate mesenteric decompression (ensuring intact colic marginal vein) (Figs. 1 and 2). Before division of the PV-SMV during en bloc resection, a 20-minute mesenteric venous clamping test (clamping the SMV below the site of resection with a vascular clamp) was performed and tolerability of the small bowel to this test was assessed [13]. Tolerability was ascertained if the small bowel or the mesentery did not show any signs of venous congestion, bowel oedema, punctate haemorrhagic spots or hematoma after 20-minute of venous clamping. An intraoperative Doppler ultrasound was performed after mesenteric clamping, before vein resection to ensure adequate hepatopetal portal venous blood flow. After that, en bloc resection of the SMV or the spleno-portal junction was undertaken without venous reconstruction. Standard reconstructive techniques of pancreaticojejunostomy [14], hepaticojejunostomy and duodenojejunostomy were performed to complete the procedure. Doppler ultrasound was again performed before abdominal closure to confirm adequate hepatopetal blood flow. The clinical and radiological eligibility criteria for PD with VROR have been described in Table 1.

Postoperative assessment

All these patients followed the institutional enhanced recovery after surgery (ERAS) protocol following the pancreatic surgery [16]. Therapeutic anticoagulation was not routinely administered as vascular reconstruction was not performed. These patients were monitored closely for acidosis, liver decompensation, gastrointestinal bleeding and ascites. A Doppler ultrasound was routinely performed at 6 and 12 hours after surgery to assess for portal vein blood flow. The evaluation and management for other post pancreatectomy complications (postoperative pancreatic fistula, delayed gastric emptying, bleeding, bile leak and chyle leak) were carried out as per our institutional protocols, which were standardized after service reconfiguration [17]. After recovery and discharge, adjuvant treatment was administered according to the pathological stage followed by oncologic surveillance with CT scan and tumour marker levels, at periodic intervals. During these visits, portal venous flow was evaluated by Doppler ultrasound, and if required, an upper gastrointestinal endoscopy was performed to look for features of portal hypertension.

Table 1 Clinical and radiological eligibility criteria for patients undergoing pancreatoduodenectomy with VROR [a]

	Clinical criteria	Radiological criteria
Inclusion criteria for VROR[a]		
Superior mesenteric VROR[a]	a. Preservation of spleno-portal venous junction for adequate hepatopetal flow and, b. Preservation of dominant collateral vessels (if oncologically feasible) for adequate mesenteric decompression and, c. Negative mesenteric venous clamping test [13]	a. PV[e]-SMV[f] contact > 180° and/or SMA[d] contact ≤ 180° with non-constructible PV[e]-SMV[f] involvement b. Adequate preoperative evaluation of the pattern of LGV[b], SV[g], PV[e], SMV[f], IMV[c] drainage and determining the need for venous reconstruction
Spleno-portal junction VROR[a]	a. Preservation/reconstruction of LGV[b] to maintain gastro-splenic outflow and, b. Preservation/reconstruction of IMV[c] or good calibre collateral vessel, with intact colonic marginal vein to maintain mesenteric outflow and, c. Negative mesenteric venous clamping test [13]	c. Presence of dominant collateral veins after comparing its size to that of SMA[d] [15] d. Adequate hepatopetal portal venous flow, after mesenteric venous clamping as evaluated by intraoperative ultrasound
Exclusion criteria for VROR[a]		
	a. Locally advanced pancreatic lesions (> 180° SMA[d] involvement) with no or minimal response to neoadjuvant therapy b. Patients requiring total pancreatectomy c. Small calibre collateral veins resulting in inadequate mesenteric decompression d. Positive mesenteric venous clamping test [13]: bowel congestion, oedema, mesenteric hematoma, punctate haemorrhages	a. Portal cavernoma without dominant collateral veins b. Poor hepatopetal portal venous flow after mesenteric venous clamping, as evaluated by intraoperative ultrasound

[a] vein resection without reconstruction, [b] left gastric vein, [c] inferior mesenteric vein, [d] superior mesenteric artery, [e] portal vein, [f] superior mesenteric vein, [g] splenic vein

Table 2 Demographic profile of PD[a] patients undergoing VROR[b]

S. no	Age (years)/gender	Histopathology	Collaterals on radiology	Neoadjuvant therapy	Time to surgery (days)	Blood loss (ml)	Postoperative morbidity (CD grade)[f]	Follow-up duration (months)	Recurrence	Delayed portal hypertension
1	65/M	NET[c] (grade 1, well-differentiated)	No	No	56	1600	SSI[g], nausea, blood transfusion (CD grade: 2)[f]	48	No	No
2	34/F	NET[c] (grade 1, well-differentiated)	Yes	No	62	1200	Diarrhoea, chyle leak (CD grade: 3A)[f]	24	Yes	No
3	71/M	Adenocarcinoma (pancreatic head)	Yes	Yes (mFOLFIRINOX)[e]	84	1500	DGE[h], blood transfusion (CD grade: 2)[f]	24	No	No
4	15/F	SPEN[d] of pancreas	No	No	42	1900	Dyselectrolytemia, blood transfusion (CD grade: 2)[f]	8	No	No
5	66/F	Adenocarcinoma (pancreatic head)	Yes	Yes (mFOLFIRINOX)[e]	96	2000	SSI[g], blood transfusion (CD grade: 2)[f]	12	Yes (peritoneum)	No
6	11/M	SPEN[d] of pancreas	Yes	No	36	1700	N/A[i]	20	No	No

[a] pancreatoduodenectomy, [b] venous resection without reconstruction, [c] neuroendocrine tumour, [d] solid pseudopapillary epithelial neoplasm, [e] modified FOLFIRINOX regimen, [f] Clavien-Dindo grade, [g] surgical site infection, [h] delayed gastric emptying, [i] data not available

Ethical standards

The study data was collected retrospectively in the course of common clinical practice, and accordingly, written informed consent was obtained from the patients before the surgical procedure. All procedures were in accordance with the institutional ethical standards. The protocol conformed to the "World Medical Association Declaration of Helsinki—Ethical Principles for Medical Research Involving Human subjects" adopted by the 18th WMA General Assembly, Helsinki, Finland, June 1964, as revised in Brazil 2013. HIPAA (Health Insurance Portability and Accountability Act) compliance was also ensured to protect the patient information, throughout the study.

Results

A total of 947 pancreatoduodenectomies were performed over 7 years (2012–2019). Among them, 56 patients underwent concomitant PV-SMV resection. There were six patients who underwent en bloc vein resection without reconstruction (Table 2). The median age of this cohort was 49.5 years (range: 11–71 years). All these patients had locally advanced pancreatic lesions on CT scan as per the ISGPS criteria (non-constructible vein involvement). On preoperative biopsy, they had pancreatic adenocarcinoma (PDAC) ($n = 2$), early grade pancreatic NET ($n = 2$) and SPEN ($n = 2$). After MDT discussion, neoadjuvant chemotherapy (modified FOLFIRINOX regimen) was given in patients with PDAC, whereas patients with pancreatic NET and SPEN were planned for upfront surgery. Response assessment CT scan after neoadjuvant therapy showed stable disease in one and partial response in the other patient with PDAC. The median time to surgery, i.e. the time interval between the first hospital visit to the date of surgery, was 59 days (range: 36–96 days) for the entire cohort, whereas it was 90 days for patients with PDAC (including duration of neoadjuvant therapy). Large calibre 'dominant' venous collaterals were visualized on preoperative CT scan in four patients (Figs. 1, 2 and 3) whereas in two other patients, they were noticed intraoperatively. All six patients tolerated the intraoperative 20-minute venous clamping test and had adequate hepatopetal portal venous flow on Doppler after mesenteric clamping. En bloc vein resection was then successfully performed in all, without any venous reconstruction (Figs. 1 and 3). Four patients underwent isolated SMV resection whereas two patients required resection of the splenoportal venous junction. Splenic vein continuity with portal vein was thus preserved in four, whereas in two patients, it was ligated, with preservation of LGV (draining into PV). Dominant collateral vessels were preserved intraoperatively in all of them (Table 3). The median blood loss was 1650 ml (range: 1200–2000 ml) and the median length of stay was

Table 3 Eligibility profile of patients undergoing PD[a] with VROR[b]

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Age (years)/gender	65/M	34/F	71/M	15/F	66/F	11/M
Diagnosis	NET[c]	NET[c]	PDAC[d]	SPEN[e]	PDAC[d]	SPEN[e]
Dominant collateral veins on radiology	No	Yes	Yes	No	Yes	Yes
Dominant collateral veins intraoperatively	Yes	Yes	Yes	Yes	Yes	Yes
Portal cavernoma	No	No	No	No	No	No
Preservation of dominant collateral veins	Yes	Yes	Yes	Yes	Yes	Yes
Preservation of spleno-portal venous junction	Yes	Yes	Yes	No	Yes	No
Preservation of LGV [f]	Yes	Yes	Yes	Yes	Yes	Yes
Intact colonic marginal veins	Yes	Yes	Yes	Yes	Yes	Yes
20 minute mesenteric venous clamping test	Negative	Negative	Negative	Negative	Negative	Negative
Adequate hepatopetal portal venous flow on intraoperative ultrasound after mesenteric venous clamping	Yes	Yes	Yes	Yes	Yes	Yes

[a] pancreatoduodenectomy, [b] vein resection without reconstruction, [c] neuroendocrine tumour, [d] pancreatic ductal adenocarcinoma, [e] solid pseudopapillary epithelial neoplasm, [f] left gastric vein

13 days (range: 11–19 days). One patient had grade B ISGPS chyle leak requiring pigtail placement (Clavien–Dindo grade 3a) whereas in others, there were no major postoperative complications. The data on the postoperative morbidity were not available for one patient (Table 2). None of these patients had any sequelae of liver decompensation/failure in immediate postoperative period. At follow-up visits, all patients were evaluated with an oncological surveillance CT scan and Doppler ultrasound to assess for portal venous flow. There were no features of portal vein obstruction and/or portal hypertension at a median follow-up of 22 months (range: 8–48 months). There was no mortality reported, until the last follow-up visit. On final histology, R0 resection was achieved in four out six patients (2 SPEN, 1 NET and 1 PDAC). One patient with PDAC (as shown in Fig. 2) had R1 resection at the SMA margin and developed recurrence 1 year after surgery.

Discussion

Mesenteric venous resection with reconstruction has been accepted as a standard practice for pancreatic cancer as studies have shown equivalent survival of patients undergoing margin-negative venous resection compared with patients undergoing standard PD [1, 2]. Sometimes, vein reconstruction is not possible because of oncologic or technical reasons, and in these scenarios, pancreatic malignancy is considered locally advanced and treated with palliative intent.

In long-standing portal venous obstruction, venous collaterals develop to bypass the obstructed segment in order to maintain hepatopetal blood flow [4]. Such collateral vessels have also been shown in pancreatic cancer encasing portal vein [18]. Oehme and colleagues [19] have reported construction of spleno-renal or mesocaval shunt or both during extended pancreatectomy for adequate gastrosplenic and mesenteric decompression respectively. While in our series, we focused on the collateral-based venous outflow without vascular reconstruction for adequate mesenteric decompression.

A careful study of the spleno-mesenterico-portal venous axis, dominant collateral vessels and intraoperative assessment, allows resection of SMV without any reconstruction, provided adequate hepatopetal flow and mesenteric decompression is ensured. It is important to assess if these collaterals are efficient in decompressing the mesenteric system, and for this, radiological criteria such as diameter of the collateral vein with respect to that of SMA can be used, as was used by Katz et al. for jejunal or ileal trunk (SMV) ligation without reconstruction [19]. Also intraoperatively, tolerability of the small bowel to venous occlusion can be tested by 20-minute clamping test, as was used in our series [13].

In our series, patients with PDAC received neoadjuvant chemotherapy because of locally advanced status (non-constructible vein involvement), whereas patients with SPEN or NET were considered for upfront surgery. Four patients underwent SMV resection whereas spleno-portal junction was resected in two others. Table 4 shows various published series on the surgical approach of VROR until date. In this literature review, all the patients underwent SMV resection without reconstruction, with preservation of collaterals and the spleno-portal venous junction. There was no major morbidity or hospital mortality in these reports, as well as in our series. Overall, 12 patients with PDAC got operated using this surgical approach, including 2 of our cases, until date. R0 resection was achieved in five, R1 resection in three, and there were incomplete data on resection margins in four other patients with PDAC. The overall survival in this collective cohort ranged from 6 to 48 months, based on the available data

Table 4 Review of studies reporting vein resection without reconstruction

Study	N[a]	Diagnosis	Neoadjuvant therapy	Preoperative collaterals on imaging	VROR[e], type of vein resected	Preservation of collaterals	Preservation of SV[h] flow to PV[i]	Morbidity	Mortality (in-hospital)	Follow-up (months)	**R-status**
Gage et al. 2018 [5]	5	PDAC[b] (5)	Yes (5)	Yes (5)	Yes (5), SMV[f] (5)	Yes (5)	Yes (5)	1:GI bleed, POPF[j] 4: none	No	32, 26, > 19, > 17, > 32 (after diagnosis)	R0: 3 R1: 2
Jouffret et al. 2018 [6]	1	PDAC[b]	Yes	Yes	Yes, SMV[f]	Yes	Yes	Chyle leak	No	15 (after surgery)	R0
Maley et al. 2017 [7]	2	PDAC[b] (2)	Yes (2)	Yes (2)	Yes (2), SMV[f] (2)	Yes	Yes	N/A[m]	No	1: > 48 1: 6 (after surgery)	N/A [m]
Hashimoto et al. 2010 [8]	2	PDAC[b] (2)	N/A[m]	N/A[m]	Yes (2), SMV[f] (2)	N/A[m]	N/A[m]	N/A[m]	N/A[m]	N/A[m]	N/A [m]
Our series	6	PDAC[b] (2) SPEN[c] (2) NET[d] (2)	Yes (PDAC[b])	Yes (4), PDAC[b] (2) SPEN[c] (1) NET[d] (1)	Yes (6), SMV[f] (4) PV-SV[g] junction (2)	Yes (6)	Yes (4) No (2)	1: Nausea, SSI[l] 1:diarrhoea, chyle leak 1: DGE[k] 1:Dyselectrolytemia 1: SSI[l] 1: N/A[m]	No	8, *12*, 20, 24, *24*, 48, (after surgery)	R0: 4 R1: 2

Italicized numbers represent survival of PDAC[b] patients in our series

[a] number of cases, [b] pancreatic ductal adenocarcinoma, [c] solid pseudopapillary epithelial neoplasm, [d] neuroendocrine tumour, [e] vein resection without reconstruction, [f] superior mesenteric vein, [g] portal vein–splenic vein junction, [h] splenic vein, [i] portal vein, [j] postoperative pancreatic fistula, [k] delayed gastric emptying, [l] surgical site infection, [m] data not available

of 10 patients. It is thus difficult to comment on the oncologic safety of this approach. However, it is worth mentioning that all these reports are from high-volume centres, given the complexity of the surgical procedure. It is also difficult to perform controlled studies, considering the rarity of occurrence of such situations in clinical practice even at high-volume centres.

Two of our patients underwent en bloc spleno-portal junction resection to achieve wide surgical margins. However, these patients with SPEN had a very indolent presentation with extensive intra-abdominal collateralization. The large LGV was preserved (for gastrosplenic decompression) and the mesenteric system was entirely decompressed by collateral-based flow which was confirmed on the venous clamping test.

It is yet unknown if the time required for completion of neoadjuvant treatment (usually approximately 60–70 days) in pancreatic cancer with vein involvement helps in evolution of surgically favourable collaterals. If that is so, then it might be an additional rationale for giving neoadjuvant chemotherapy in patients with PDAC with non-constructible SMV involvement. In our series, the average time to surgery in patients with PDAC ($n = 2$) was approximately 13 weeks (90 days).

Nakao et al. [18] demonstrated the occurrence of venous collaterals in advanced pancreatic cancer and its significance during surgery has been reported only recently [5–9]. The current ISGPS [3] and NCCN [20] classifications also do not mention about the surgical importance of these venous collaterals. This novel approach will broaden the scope of surgery in advanced pancreatic cancer and lessen the cases labelled as locally advanced unresectable lesions.

This paper however has few limitations. It is a retrospective study of an extreme surgical approach in a highly selected group of locally advanced pancreatic tumours where there was no suitable calibre distal venous end available for vascular reconstruction. The long-term survival benefit (overall survival, disease-free survival) after VROR is unknown, given the limited number of published reports until date. In our experience, there were few cases where mesenteric venous clamping test was negative and VROR was feasible, but still, we performed an end-to-end vein reconstruction as there was an adequate calibre of proximal and distal venous end available. This was done to offer an additional safety so as to prevent any mesenteric congestion in postoperative period and prevent future risk (if any), of delayed portal hypertension. Unfortunately, we do not have the data on these patients to include in this manuscript.

Conclusion

In locally advanced pancreatic lesions (due to non-constructible vein involvement), thorough knowledge of the mesentericoportal venous anatomy, collateral vessels, their branching pattern, and flow adequacy is mandatory. This will help in achieving curative resection where vascular reconstruction is technically difficult or impossible. However, if there is a situation where VROR and vein reconstruction is feasible, then vascular reconstruction should be preferred to be on a safer side.

Authors' contributions Acquisition, analysis and interpretation of data, drafting of the article, critical revision for the intellectual content and final approval of the version to be submitted: RVK and VP. (both are shared first authors). Analysis and interpretation of data, drafting and revision of the article, critical revision for the intellectual content and final approval of the version to be submitted: MSB and VAC. Conception and design of the study, drafting and revision of the article, critical revision for intellectual content and final approval of the version to be submitted: SVS.

Data availability The data is represented in the manuscript in tables.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical standards The study data was collected in the course of common clinical practice, and accordingly, written informed consent was obtained from the patients before the surgical procedure. All procedures performed in the study were in accordance with the ethical standards of the institutional research committee. The protocol conformed to the "World Medical Association Declaration of Helsinki—Ethical Principles for Medical Research Involving Human subjects" adopted by the 18th WMA General Assembly, Helsinki, Finland, June 1964, as revised in Brazil 2013. In order to protect the patient information, HIPAA (Health Insurance Portability and Accountability Act) compliance was also ensured throughout the study. There was no requirement of any formal ethical approval as the data was collected in the course of common clinical practice, in retrospective manner.

Consent to participate Written informed consent was obtained from all the individual participants included in the study.

Consent for publication All the individual participants signed an informed consent regarding publishing their clinical details and/or clinical images in research study.

Submission declaration The research was presented as Poster in the Indian Chapter of International Hepato-Pancreato-Biliary Association conference held at Jaipur, India, on February 15–17, 2019. This manuscript has not been published previously and is not under consideration for publication elsewhere. It has been approved by all the authors listed and by authorities where this work was carried out. This manuscript will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder.

Abbreviations CD grade, Clavien-Dindo grade; CT, Computed tomography; DGE, Delayed gastric emptying; ERAS, Enhanced recovery after surgery; IMV, Inferior mesenteric vein; ISGPS, International Study Group for Pancreatic Surgery; LGV, Left gastric vein.; MDT, Multidisciplinary team; mFOLFIRINOX, Modified FOLFIRINOX regimen; NET, Neuroendocrine tumour; PDAC, Pancreatic ductal adenocarcinoma; NCCN, National Comprehensive Cancer Network; PD, Pancreatoduodenectomy; POPF, Post-operative pancreatic fistula; PV, Portal vein; SMA, Superior mesenteric artery; SMV, Superior mesenteric

vein; SPEN, Solid pseudopapillary epithelial neoplasm; SSI, Surgical site infection; SV, Splenic vein; VROR, Vein resection without reconstruction; N, Number of cases; N/A, Data not available

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