

Pancreaticoduodenectomy and portal-superior mesenteric vein reconstruction using autologous grafts in patients with periampullary cancer: Preliminary experience at Bach Mai Hospital

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Abstract:

Portal vein/superior mesenteric vein (PV/SMV) resection and reconstruction during pancreaticoduodenectomy (PD) represent one of the most complex procedures in digestive system surgery. Each technique for portal vein reconstruction has distinct advantages and disadvantages, making the optimal approach a subject of ongoing debate. From October 2020 to October 2024, patients with periampullary cancer who underwent PD with PV/SMV resection and reconstruction using autologous grafts were documented. The data collected included basic information, clinical characteristics, surgical details, and post-operative graft conditions. Results indicated that during the study period, eight cases of vein reconstruction using autologous grafts (falciform ligament/segment or an alternative vein) were performed. No cases of early or late graft thrombosis or stenosis were reported. In conclusion, PV/SMV reconstruction using autologous grafts in PD is feasible and enhances the potential for achieving radical surgery in cases of locally invasive duodenal-pancreatic head cancer.

Keywords: autologous graft, case series, pancreaticoduodenectomy, portal vein resection.

Classification number: 3.2

1. Introduction

Cancer in the periampullary region, particularly pancreatic cancer, remains associated with a poor prognosis. To date, pancreaticoduodenectomy (PD) remains the only potentially curative approach for this disease group. Tumours located in the Vater region, duodenum, or bile duct are more resectable due to limited vascular invasion. However, two-thirds of patients with pancreatic cancer present with advanced or metastatic disease at the time of diagnosis, and even for resectable cases, the 5-year overall survival rate is only 15-20% [1]. The main factor contributing to this low survival rate is the inability to achieve negative resection margins. Studies have established that resection margin status significantly impacts overall and disease-free survival in patients undergoing PD [2, 3]. G.R. Varadhachary, et al. (2006) [2] introduced the concept of borderline resectable pancreatic cancer for cases with locally advanced invasion. For patients with borderline resectable disease, current treatment strategies incorporate neoadjuvant chemotherapy and/or radiotherapy, followed by PD with/without vascular resection, to increase the likelihood of achieving

R0 resection [4]. Moreover, studies have shown that the superior mesenteric artery (SMA) first approach in PD enhances negative margin rates and provides better vascular control and resection capabilities.

The International Study Group of Pancreatic Surgery (ISGPS) recommends exploratory and vascular resections, particularly portal vein (PV) and superior mesenteric vein (SMV), where feasible and specifically advised to achieve R0 resection despite high perioperative risk. The International Study Group of Pancreatic Surgery has also classified PV/SMV resections into four distinct types [5]:

Type 1: Partial resection with direct closure.

Type 2: Partial resection requiring vascular grafting.

Type 3: Segmental resection with direct anastomosis.

Type 4: Segmental resection necessitating the creation of two or more vascular anastomoses.

From 2008 to 2019, similar guidelines have been published in France [6], recommending vascular reconstruction in cases of extensive invasion, with options for autologous, allogeneic, or synthetic grafts where direct

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anastomosis is unachievable [7]. Each reconstruction technique has inherent benefits and limitations, and thus, there is ongoing debate over the optimal method. Our study aims to evaluate the outcomes of PV reconstruction using autologous grafts (falciform ligament or alternative vein) in PD at Bach Mai Hospital, alongside a literature review to compare this technique with alternative methods.

2. Study population and methods

2.1. Study population

Between October 2020 and October 2024, patients with periampullary cancer who underwent PD with simultaneous PV/SMV resection and reconstruction using autologous grafts (falciform ligament or alternative veins) were included in the study at Bach Mai Hospital's Digestive Surgery Centre. The TNM (tumour, nodes, metastasis) staging was based on the eighth edition of the AJCC/UICC system of periampullary malignancies [8]. All patients underwent a thorough workup, including a contrast multi-slice computed tomography (MSCT) scan to evaluate anatomical variants of vessels and plan for vascular approach and control. The imaging was performed with maximum intensity projection by an experienced radiologist. The study algorithm is illustrated in Fig. 1. Retrospective evaluation of medical records and imaging was conducted. Data collected included baseline information, clinical characteristics, surgical details, and postoperative vascular status. The study was approved by the Bach Mai Hospital Ethics Committee. Tumour invasion of the PV/SMV was preoperatively assessed using A. Nakao, et al. (1995) [9]'s classification by multi-slice computed tomography [9]: type A, normal; type B, unilateral narrowing of PV/SMV; type C, bilateral narrowing of PV/SMV; and type D, severe narrowing or obstruction with collateral veins.

The classification of PV/SMV invasion in postoperative pathology also followed A. Nakao, et al. (1995) [9]'s criteria: grade 0, no cancer invasion into the vessel wall; grade I, invasion into the serosa or muscle layer; and grade II, invasion into the mucosal and submucosal layers.

In our centre, we have used two types of autologous grafts: falciform ligament and alternative veins. In cases of type 2 PV/SMV resection as per the International Study Group on Pancreatic Surgery classification, we have used falciform ligaments. Otherwise, in cases where segmental resection necessitated the creation of two or more vascular anastomoses, we have used alternative veins.

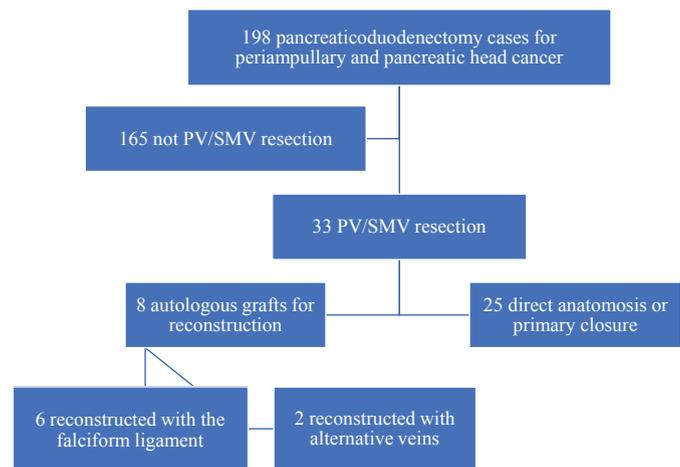


Fig. 1. Study algorithm.

2.2. Methods

For cases with suspected PV/SMV invasion by the head of periampullary tumours, the PD was conducted using the single (left-sided or inframesocolic) or dual (posterior and left-sided) SMA first approach, combined with triangle resection, removing tissue posterior to the pancreatic head between the common hepatic artery (CHA), SMA, and PV/SMV (Fig. 2). The detailed procedure was as follows:

- Kocher manoeuvre, Cattel Braasch manoeuvre.

Posterior superior mesenteric artery approach: Dissection of lymph node groups 16a2 and 16b1 to expose the inferior vena cava (IVC), left renal vein (LRV), and abdominal aorta. Right sympathetic lymph nodes just above the LRV were dissected, and the right diaphragmatic crus was incised to expose and mobilise the root of the SMA. The SMA was freed over a 3-4 cm segment from the aorta, typically an avascular area.

- Left-sided (or inframesocolic) SMA approach:

- The peritoneum of the jejunal mesentery was opened, exposing and mobilising the SMA and SMV beneath the mesentery while preserving the ileocolic artery, which crosses anteriorly to the SMV. Dissection along the SMA continued towards its origin in a leftward and anterior direction, with ligation of the middle colic artery (MCA) close to its root. The connective tissue on the left border of the SMA was opened until the previously dissected origin of the artery was reached.

- The first jejunal arcade was ligated, and the corresponding segment of the mesentery was divided. Dissection of the SMA continued left posteriorly, with ligation of the inferior pancreaticoduodenal artery (IPDA) at

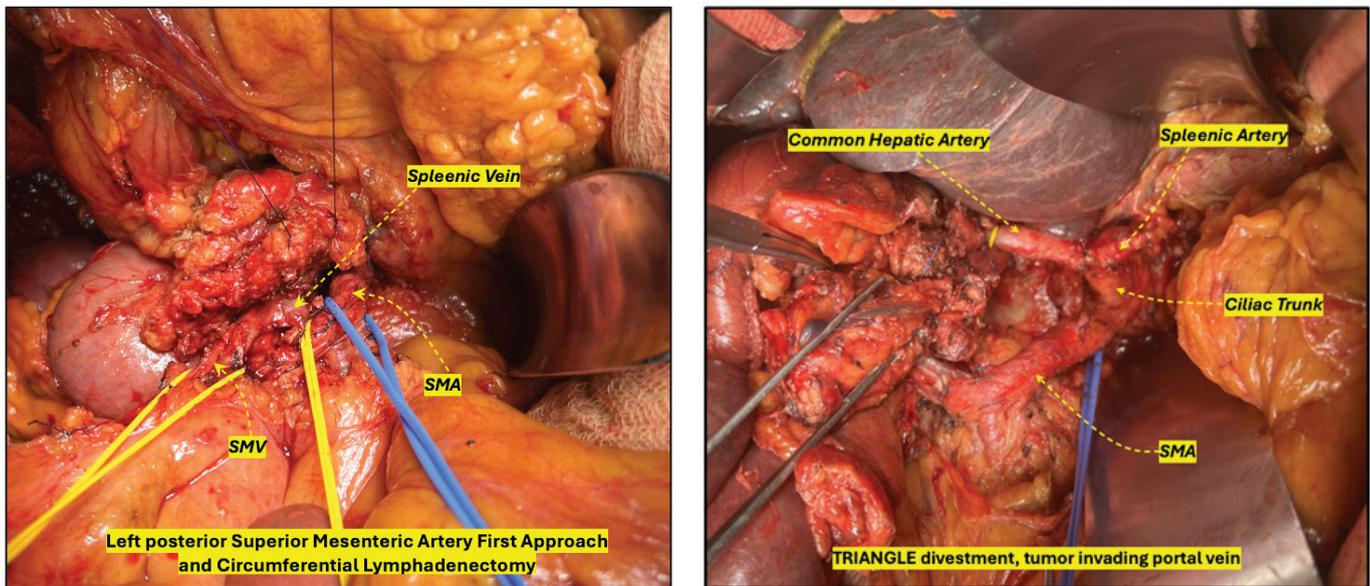


Fig. 2. Left-posterior superior mesenteric artery approach, triangle resection, with the tumour and invaded portal vein/ superior mesenteric vein segments resected last.

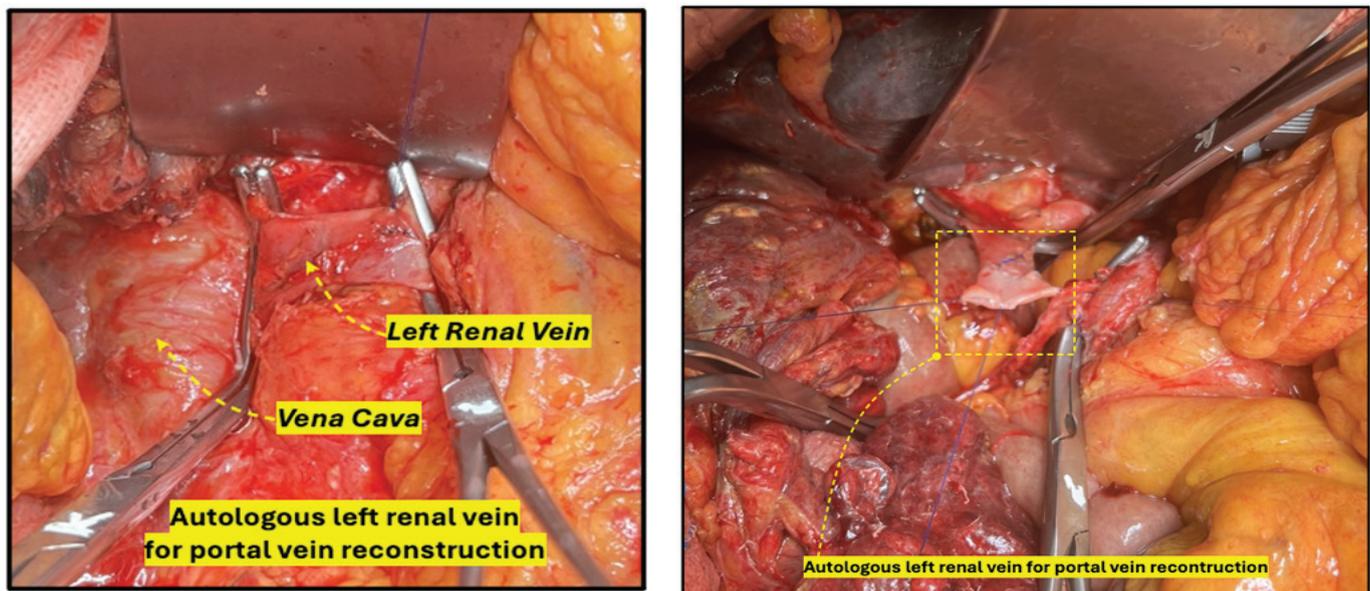


Fig. 3. Portal vein reconstruction with left renal vein.

its origin behind the SMA. Dissection was further extended along the right border of the SMA to its root. The transverse mesocolon was separated from the pancreatic head.

- Hepatic pedicle dissection was performed, with removal of nerve tissue around the CHA, proper hepatic artery, and the right half of the coeliac trunk. The PV was maximally exposed and mobilised for control.

- The tumour, along with the invaded segments of the PV/SMV, was resected last. Depending on the invasion pattern, different resection and reconstruction techniques were employed:

+ Lateral venous resection and repair using the falciform ligament was used for tumours invading only one side of the vein (Nakao type B). A segment of the falciform ligament was harvested and patched precisely onto the resected area of the PV.

+ For extensive venous invasion with no possibility of direct anastomosis, resection and reconstruction with the alternative (left renal vein or splenic vein) graft were performed. A segment of the alternative vein was harvested, (left renal vein (Fig. 3): Extending from the lateral wall of the inferior vena cava to just distal to the gonadal vein

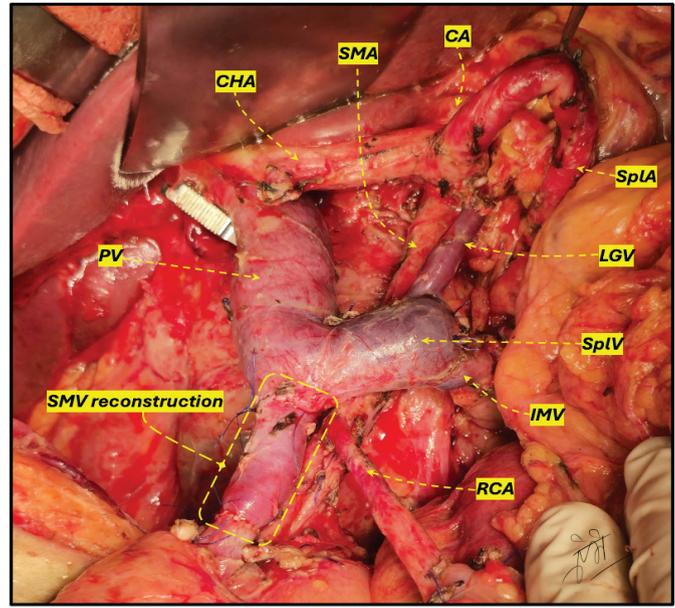
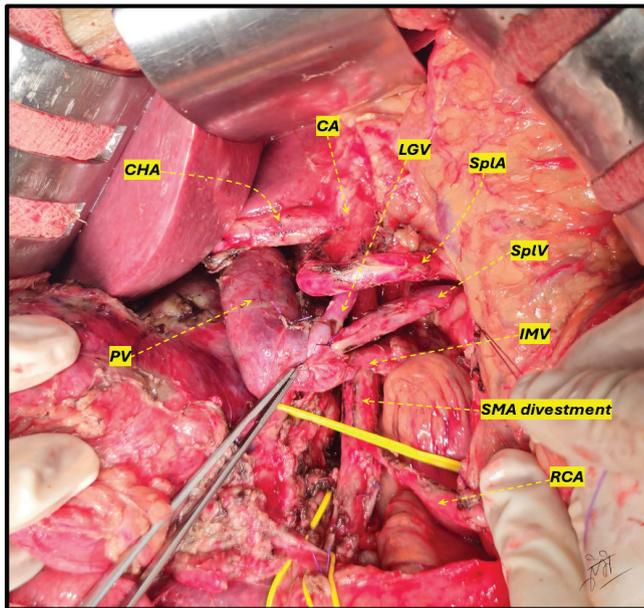


Fig. 4. Portal vein reconstruction with splenic vein.

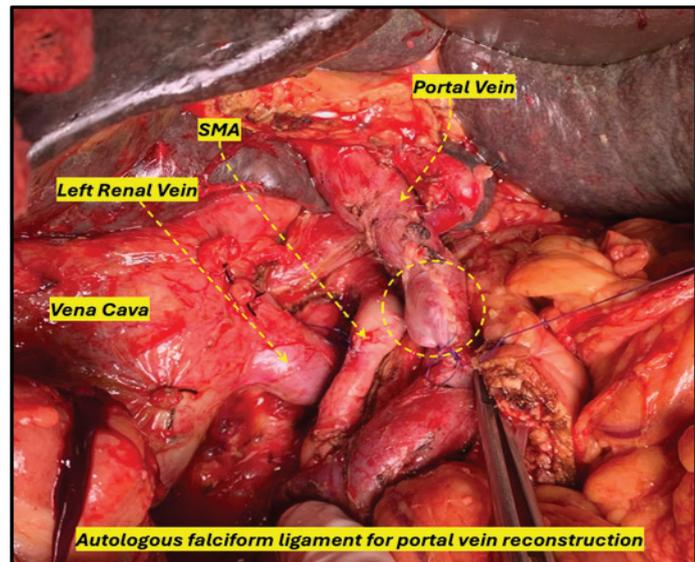
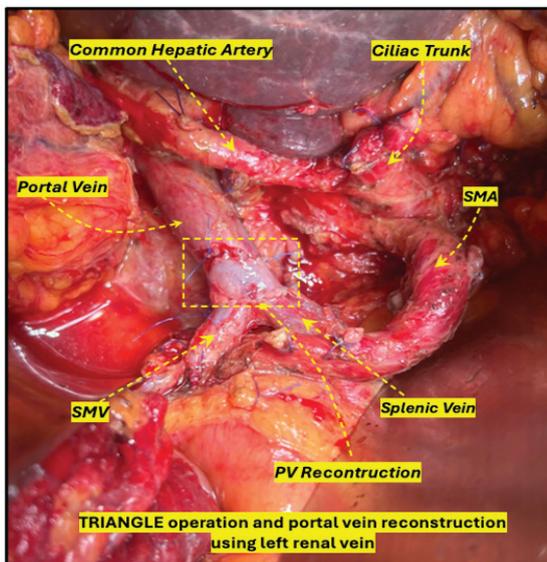


Fig. 5. Portal vein anastomosis post-reconstruction.

Fig. 6. Portal vein anastomosis using falciform ligament graft.

confluence; splenic vein (Fig. 4): From the splenic pedicle to the anterior confluence with the inferior mesenteric vein and left gastric vein). This segment was then anastomosed end-to-end with the proximal and distal ends of the PV-SMV complex.

2.3. Postoperative care and follow-up

Postoperatively, all PD-PVR patients received prophylactic anticoagulation, with PV/SMV flow assessed by Doppler ultrasound two weeks postoperatively (Figs. 5, 6) and CT scans performed at two months. Graft patency was defined

as normal blood flow in the PV with intact hepatic function, regardless of any anatomical narrowing. Failure was defined by compromised PV flow with abnormal liver function tests. Postoperative complications were classified according to the International Study Group on Pancreatic Surgery [10] and the Dindo-Clavien classification system [11].

3. Results

Between October 2020 and October 2024, 33 vein reconstructions were performed during PD or total pancreatectomy, with eight cases using autologous grafts.

Table 1. Detail of patients' information and graft outcomes.

N	Aged (year)	Diagnosis	Invasive classification	Vascular reconstruction techniques	Operative time (minute)	PV clamping time (minute)	Wall invasion level	Graft thrombosis	Graft stenosis
1	59	Tumours of the pancreatic head	B	Lateral venous repair (Falciform ligament graft)	390	17	II	No	No
2	52	Distal cholangiocarcinoma	B	Lateral venous repair (Falciform ligament graft)	375	13	I	No	No
3	64	Tumours of the pancreatic head	B	Lateral venous repair (Falciform ligament graft)	330	8	I	No	No
4	66	Tumours of the pancreatic head	B	Lateral venous repair (Falciform ligament graft)	310	22	II	No	No
5	67	Tumours of the pancreatic head	B	Lateral venous repair (Falciform ligament graft)	240	5	0	No	No
6	67	Tumours of the pancreatic head	B	Lateral venous repair (Falciform ligament graft)	310	10	I	No	No
7	71	Tumours of the pancreatic head	C	End-to-end anastomosis (Left renal vein)	420	25	I	No	No
8	63	Tumours of the pancreatic head and body	C	End-to-end anastomosis (Splenic vein)	440	35	I	No	No

This group included five males and three females, with an average age of 63.7 ± 6.3 years (range 52-71 years). The mean and median PV/SMV clamping times were 14.3 ± 7.4 minutes and 15.5 minutes (range 5-25 minutes), respectively. No patients required reoperation for bleeding or died during the hospital stay. Tables 1 and 2 summarise the details of the eight patients who underwent PV/SMV reconstruction using autologous grafts, as well as some intraoperative data and graft outcomes.

Table 2. Summary of intraoperative data and graft outcomes.

Index	N=8	
Male:Female	5:3	
Average age (years, min-max)	63.7±6.3 years (52-71)	
The mean operative time (minutes, min-max)	352 minutes (240-440)	
The mean PV/SMV clamping times (minutes, min-max)	14.3±7.4 minutes (5-25)	
The mean operative blood loss (ml, min-max)	143 ml (50-500)	
Number of resected lymph nodes (mean±SD, min-max)	37.6±22.6 (17-74)	
Graft stenosis or thrombus	0	
Types of autologous grafts	Falciform ligament graft	6
	Alternative veins	2
Circumferential resection margins	R0	5
	R1	3

Regarding pathological results, seven patients had pancreatic tumours, and one had distal cholangiocarcinoma, with 100% showing PV/SMV wall invasion. The mean number of lymph nodes resected was 37.6 ± 22.6 (range: 17-74). Negative circumferential resection margins (R0) were achieved in five cases, while two cases had margins within less than 1 mm from the tumour.

Graft status: All eight cases demonstrated graft patency on Doppler ultrasound at the two-week mark post-surgery (Fig. 7), and CT scans conducted two months post-surgery revealed no stenosis in any of the grafts (Fig. 8).



Fig. 7. Two-week postoperative Doppler ultrasound assessment showed patency in grafts of all 8 patients.

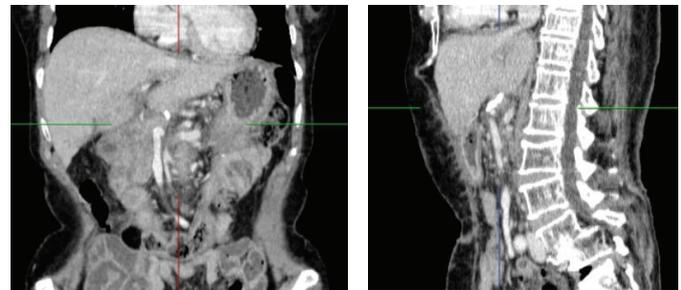


Fig. 8. Two-month postoperative computed tomography evaluation of the portal vein/superior mesenteric vein graft.

4. Discussion

Various techniques have been developed to approach and manage PV/SMV resection and reconstruction based on the extent of vascular invasion. The first reported PD with venous resection was by G.E. Moore, et al. (1951) [12] and subsequently by S. Asada, et al. (1963) [13]. For cases of limited invasion, partial venous resection and repair using autologous grafts or direct closure methods are preferred. However, in cases of extensive invasion,

segmental resection with reconstruction using autologous, allogeneic, or synthetic grafts (type 2 and 4) is necessary. Recent studies support autologous grafts as a viable choice in such cases [14, 15].

For the group with PV reconstruction using the falciform ligament or peritoneum, Y. Shao, et al. (2021) [14] reviewed 146 patients, including 13 with falciform ligament grafts. The primary aim of the study was to compare venous reconstruction using the falciform ligament graft with other graft types. The other techniques included direct end-to-end anastomosis (n=30), partial resection with primary closure (n=19), synthetic grafts (n=24), iliac vein grafts (n=47), and allogeneic grafts (n=13). Their study demonstrated that patients with falciform ligament reconstruction had lower graft stenosis rates and required fewer anticoagulants. Complication rates and survival outcomes did not differ significantly between groups. A separate study by Y. Zhiying, et al. (2017) [16] documented 10 cases using falciform ligament grafts, with minor complications such as one case of thrombosis and three cases of stenosis observed over a two-month follow-up period. The authors concluded that the autologous falciform ligament graft could be a viable alternative to other graft types for venous reconstruction. In our study, six patients with type B PV invasion underwent reconstruction using the falciform ligament graft. We found this approach beneficial for right-sided PV invasion as it preserved much of the PV-SMV system's structure, reducing the need for further splenic vein-mesenteric vein anastomosis.

For the group undergoing end-to-end anastomosis with autologous vein segments, the left renal vein was first used by R.L. Smoot, et al. (2007) [17]. N.O. Glebova, et al. (2015) [18] analysed 173 patients who underwent pancreaticoduodenectomy with portal vein reconstruction from 1970 to 2014. Their study recommended partial resection for tumours invading less than 30% of the vessel diameter and segmental resection for those invading more than 30%. For invasions longer than 2-3 cm, segmental resection with grafting was advised, while shorter invasions could be managed with end-to-end anastomosis. The graft options evaluated included the internal iliac vein, left renal vein, splenic vein, and great saphenous vein [18].

Recently, a comprehensive review of 34 studies involving 603 patients identified four types of grafts: autologous vein,

peritoneum/falciform ligament, donor/allogeneic vein, and synthetic grafts. Early and overall graft thrombosis rates were found to be 7.5 and 22.2% for synthetic grafts, 5.6 and 11.7% for autologous veins, 6.7 and 8.9% for peritoneum/falciform ligament, and 2.5 and 6.2% for allogeneic grafts. The review concluded that autologous, allogeneic, or synthetic grafts can be safely and effectively used for superior mesenteric vein (SMV) reconstruction. However, synthetic grafts have a higher thrombosis rate [15]. In our study, two patients required an alternative vein (left renal vein or splenic vein) graft for SMV reconstruction due to a resection length greater than 4 cm. We found that the left renal or splenic vein was well-suited for this purpose, as its diameter matched that of the portal vein and SMV. Its anatomical location just beneath the root of the SMA provided a favourable position.

Thus, the choice of vascular resection and reconstruction technique is dependent on the extent of vascular invasion. Most authors agree that the best patency rates are achieved with partial vein resection, followed by segmental resection with direct anastomosis, renal vein grafting, and synthetic grafting. The decision on how much of the vessel to resect depends on the degree of invasion, either by diameter or length. This is a complex technique and should be performed at major hepato-pancreato-biliary centres by experienced hepato-pancreato-biliary and vascular surgeons [5, 19].

5. Conclusions

Our preliminary results indicate that autologous graft PV reconstruction in PD is feasible and improves the chances of achieving radical resection for duodenal-pancreatic cancers with PV invasion. Nevertheless, this is a complex procedure and should be performed at specialised hepato-pancreato-biliary centres by experienced surgeons.

CRedit author statement

Duong Duc Hung: Visualisation, Investigation; Nguyen Thanh Khiem: Original Idea, Main Surgeon, Writing - Reviewing and Editing; Nguyen Ham Hoi: Supervision; Luong Tuan Hiep: Data curation, Writing - Original draft preparation, Software, Validation.

COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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