Vascular resection and reconstruction in pancreatic head cancer

F Ativitch Asavachaisuvikom

Asst. Prof. Paramin Muangkaew

HPB surgery unit, Faculty of Medicine, Ramathibodi hospital, Mahidol University

Outline

- Venous resection and reconstruction
- Artery
  - Artery divesment
  - Resection and reconstruction

Introduction

- Pancreatic ductal adenocarcinoma (PDAC) is a lethal disease with a poor prognosis and increased incidence.[1]
- Margin resection status is a very important prognostic factor for OS and disease-free survival (DFS) in patients undergoing pancreatectomy for PDAC[1]
- Vascular invasion is a relatively frequent discovery in pancreatic cancer; found in 21-64%[2-3]
- Vascular resection might improve survival by enhancing tumor clearance, and, specifically, that tumor adherence to the PV or SMV.[1]

[1]Crippa S, Giannone F, Schiavo Lena M et al. R Status is a Relevant Prognostic Factor for Recurrence and Survival After Pancreatic Head Resection for Ductal Adenocarcinoma. Ann Surg Oncol. 2021 Aug;28(8):4602-4612.

[2]Arslan A, Buanes T, Geitung JT. Pancreatic carcinoma: MR, MR angiography and dynamic helical CT in the evaluation of vascular invasion. Eur J Radiol 2001; 38: 151-159

[3]Megibow AJ, Zhou XH, Rotterdam H et al. Pancreatic adenocarcinoma: CT versus MR imaging in the evaluation of resectability--report of the Radiology Diagnostic Oncology Group. Radiology 1995; 195: 327-332

Introduction

- Vascular resection
  - Might improve survival by enhancing tumor clearance, and, specifically, that tumor adherence to the PV or SMV.
  - Isolated hepatic arterial resection are deemed appropriate in carefully selected patients
  - Do not consider routine SMA resection and reconstruction appropriate because the most recent review of the literature revealed a 20% operative mortality rate and an 11-month disease-specific survival

Introduction

Resectability Status	Arterial	Venous
Resectable	• No arterial tumor contact (celiac axis [CA], superior mesenteric artery [SMA], or common hepatic artery [CHA]).	• No tumor contact with the superior mesenteric vein (SMV) or portal vein (PV) or ≤180° contact without vein contour irregularity.
Borderline Resectable[b]	<u>Pancreatic head/uncinate process</u>: • Solid tumor contact with CHA without extension to CA or hepatic artery bifurcation allowing for safe and complete resection and reconstruction. • Solid tumor contact with the SMA of ≤180°. • Solid tumor contact with variant arterial anatomy (eg, accessory right hepatic artery, replaced right hepatic artery, replaced CHA, and the origin of replaced or accessory artery) and the presence and degree of tumor contact should be noted if present, as it may affect surgical planning. <u>Pancreatic body/tail</u>: • Solid tumor contact with the CA of ≤180°.	• Solid tumor contact with the SMV or PV of >180°, contact of ≤180° with contour irregularity of the vein or thrombosis of the vein but with suitable vessel proximal and distal to the site of involvement allowing for safe and complete resection and vein reconstruction. • Solid tumor contact with the inferior vena cava (IVC).
Locally Advanced[b,c,d]	<u>Head/uncinate process</u>: • Solid tumor contact >180° with the SMA or CA. <u>Pancreatic body/tail</u>: • Solid tumor contact of >180° with the SMA or CA. • Solid tumor contact with the CA and aortic involvement.	• Not currently amenable to resection and primary reconstruction due to complete occlusion of SMV/PV

NCCN 2024

Introduction

T	Primary Tumor	N	Number of Regional PLNs	Stage	T	N	M
T1	≤2 cm	N0	0	IA	1	0	0
T2	>2 cm, ≤4 cm	N1	1 to 3	IB	2	0	0
T3	>4 cm	N2	≥4	IIA	3	0	0
T4	CA, SMA, and/or CHA invasion			IIB	1–3	1	0
				III	4	Any	0
					Any	2	
				IV	Any	Any	1

Abbreviations: PLN—positive lymph node; CA—celiac axis; SMA—superior mesenteric artery; CHA—common hepatic artery.

American Joint Committee on Cancer (AJCC) 7th edition staging

Introduction

PV or SMV resection	Should not be a contraindication to resection if technically feasible
Hepatic artery	Carefully selected patients
SMA	Not routine No data support to improve survival

Blumgart's surgery 7th

Introduction

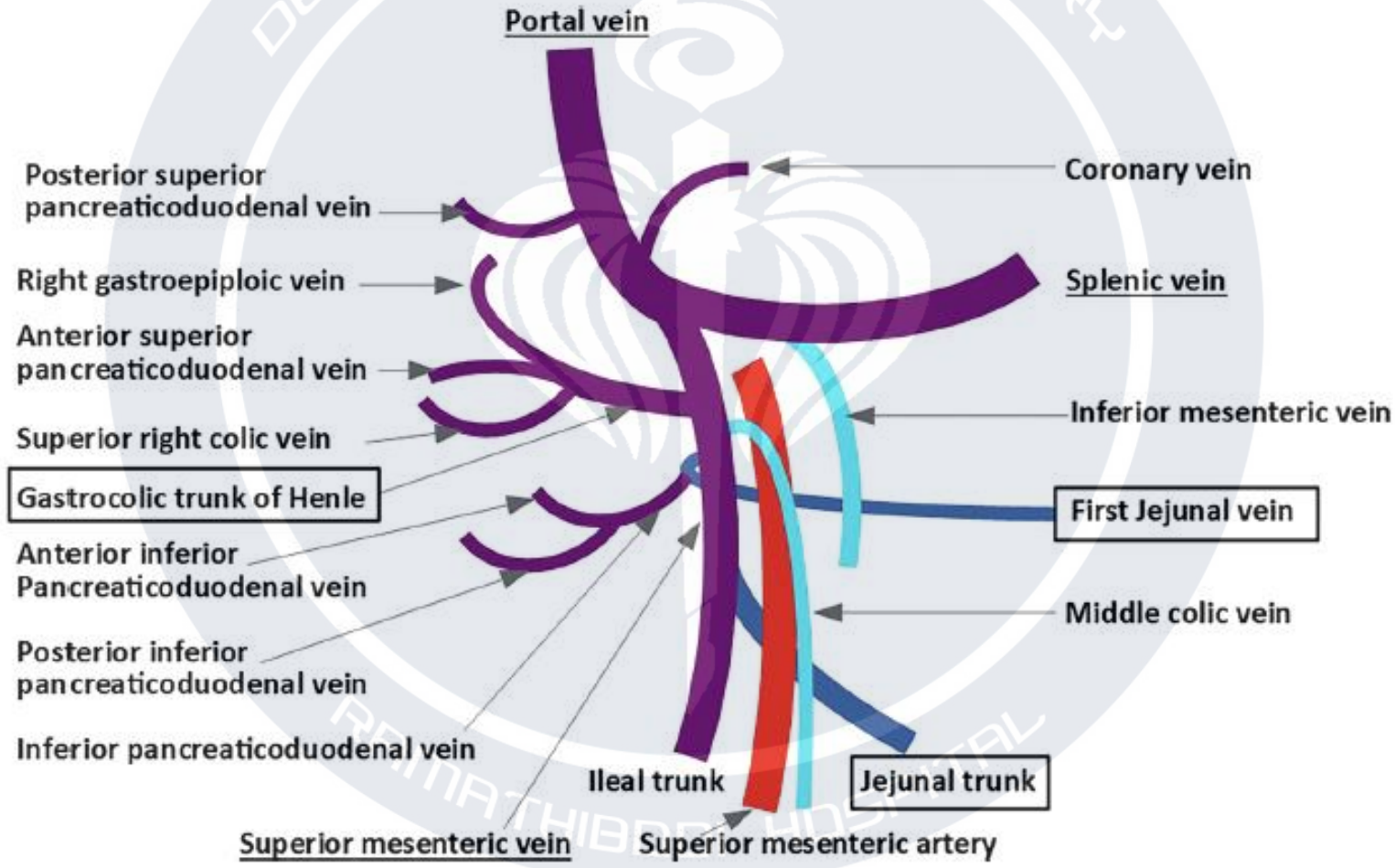
Venous resection → Technical options of reconstruction are given

Artery resection → Not recommend for routine

Maximilian Bockhorn, Falk G. Uzunoğlu, Mustapha Adham et al. Borderline resectable pancreatic cancer: A consensus statement by the International Study Group of Pancreatic Surgery (ISGPS), Surgery, Volume 155, Issue 6, 2014

Venous resection and reconstruction

Mesenteric venous anatomy and variation



Desai C, Wagle PK. First jejunal vein, jejunal trunk, and pancreaticoduodenectomy: resolving the literature conundrum. Langenbecks Arch Surg. 2023 Feb 24;408(1):104

Mesenteric venous anatomy and variation

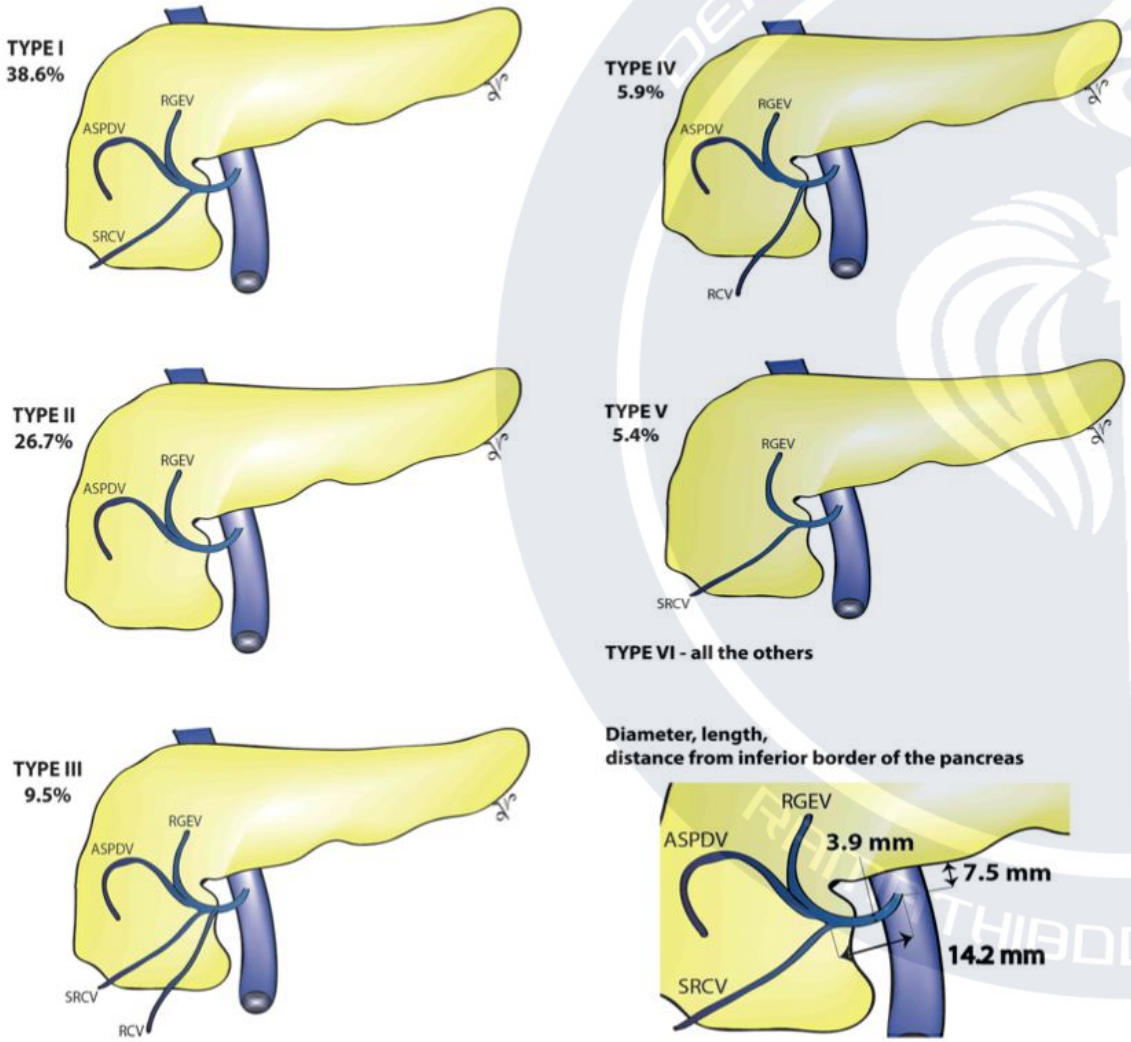


Figure 7. Our proposed standardized terminology for Henle trunk surgical anatomy. ASPDV – anterosuperior pancreaticoduodenal vein; RGEV – right gastroepiploic vein; RCV – right colic vein; SRCV – superior right colic vein. To proposed a common terminology for Henle trunk, we grouped all the anatomical variants with a pooled prevalence less than 5.0% in the 'other' group of 'Type VI'. Should be noted that Type I has the highest pooled prevalence, and the Type V the lowest.

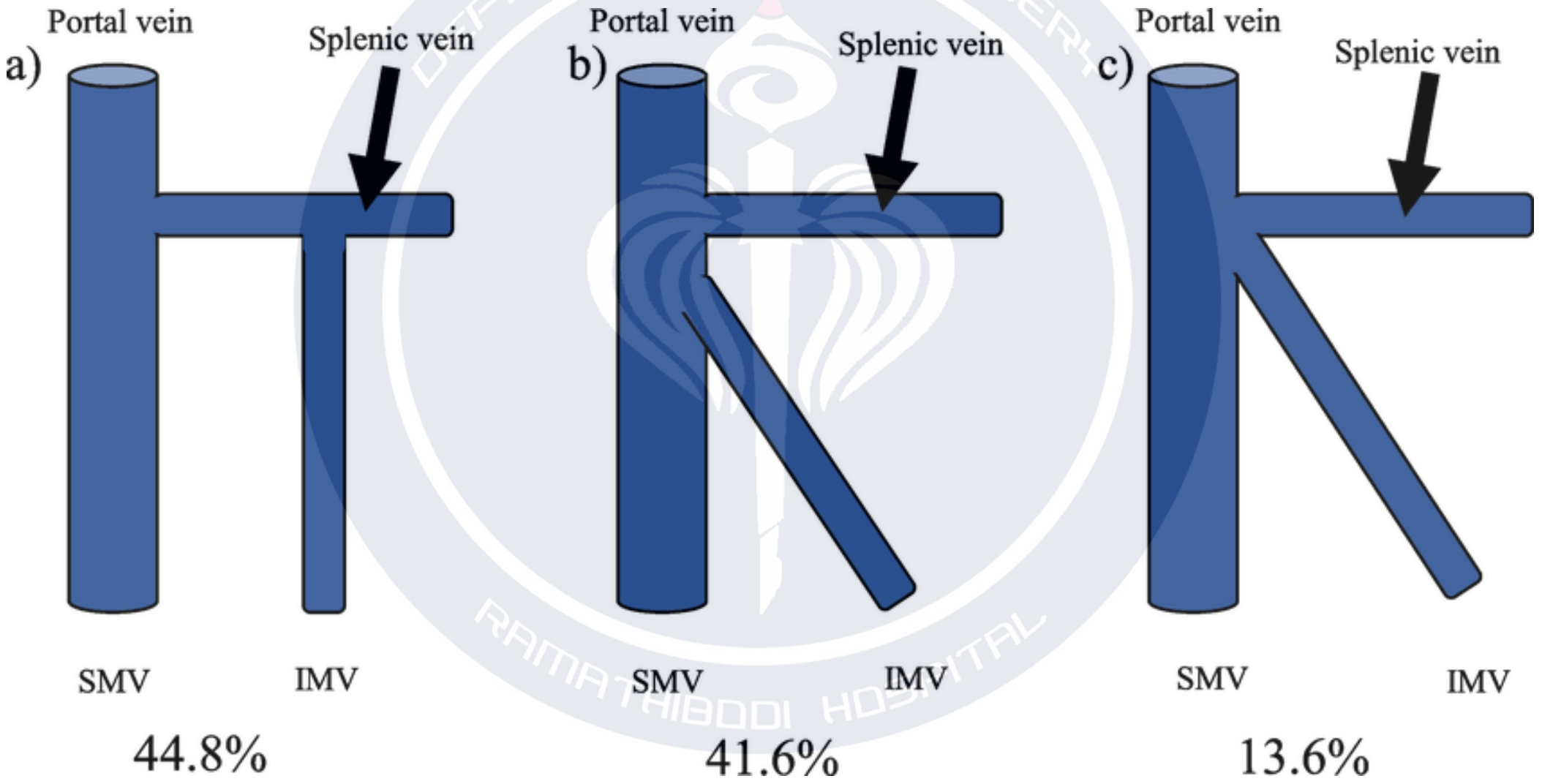
Negoi I, Beuran M, Hostiuc S, Negoi RI, Inoue Y. Surgical Anatomy of the Superior Mesenteric Vessels Related to Colon and Pancreatic Surgery: A Systematic Review and Meta-Analysis. Sci Rep. 2018 Mar 8;8(1):4184. doi: 10.1038/s41598-018-22641-x.

Mesenteric venous anatomy and variation

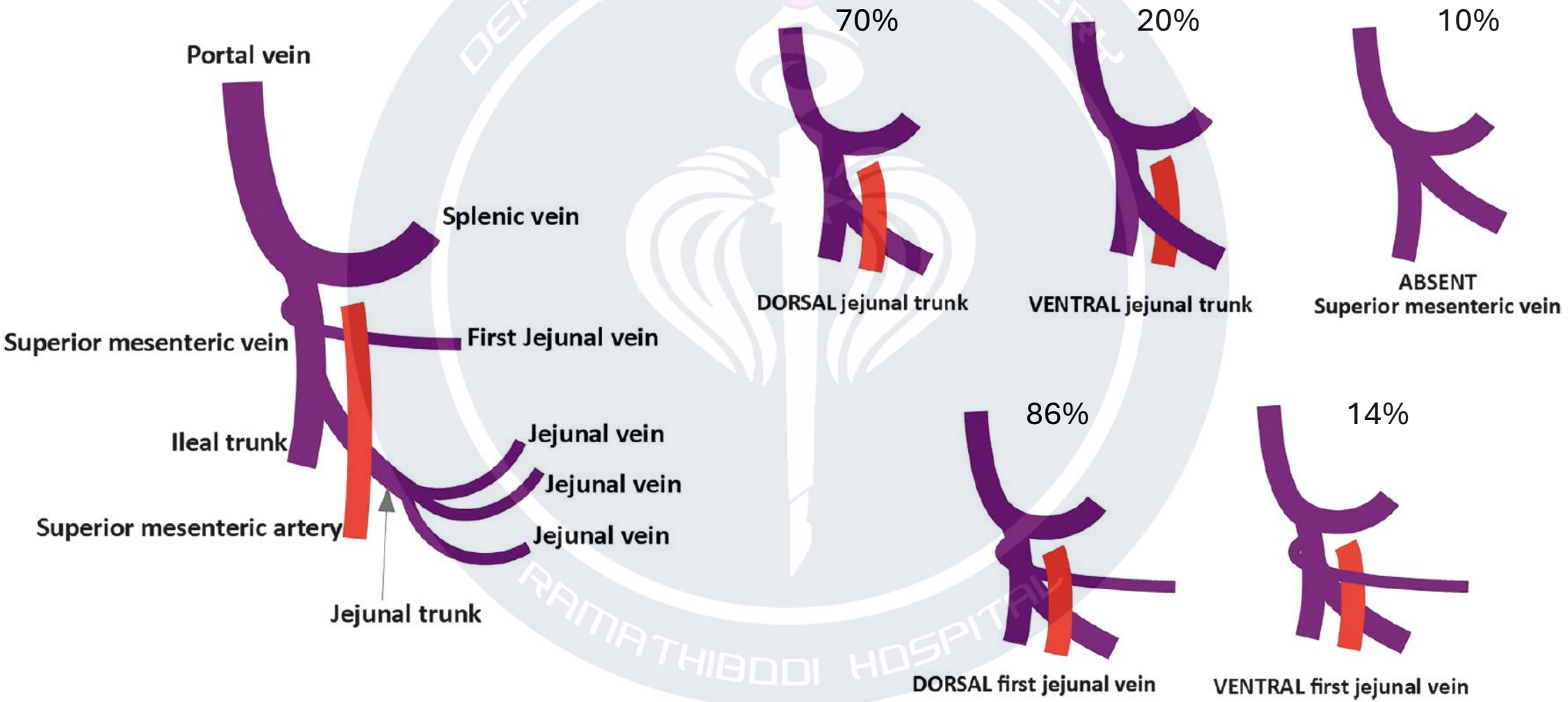
First author (References)	Number of patients with MCV (%)	Modality	Veins into which the MCV drained *n* (%)					Notes
			SMV	GCT	IMV	SV	JV	PSPDV
Ibukuro et al (1996)[6]	36/50 (72)	CT	27 (75)	5 (14)	4 (11)	0 (0)	0 (0)	1 (3)
Yamaguchi et al (2002)[8]	58/58 (100)	Cadavers	49 (84)	7 (12)	1 (2)	2 (3)	0 (0)	Main MCV[a] 1 MCV, *n* = 22 (38%) Multiple *n* = 36 (62%) 2 MCVs, *n* = 29 (50%) 3 MCVs, *n* = 7 (12%)
Jin et al (2006)[9]	9/9 (100)	Cadavers	8 (89)	1 (11)	0 (0)	0 (0)	0 (0)	–
Sakaguchi et al (2010)[2]	96/102 (94)	CT	SMV left trunk					Total *n* = 107 (single and multiple type) 1 MCV *n* = 86 (84%), multiple *n* = 10 (10%) 2 MCVs, *n* = 9 (2%) 3 MCVs, *n* = 1 (1%)
			77 (72)	21 (20)	9 (8)			
			62 (72)	20 (23	4 (5)			Single type
Ogino et al (2014)[3]	81/81 (100)	CT	55 (68)	16 (20)	4 (5)	1 (1)	5 (6)	Main MCV[a] 1 MCV, *n* = 40 (49%), 2 MCVs, *n* = 37 (46%), 3 MCVs, *n* = 4 (5%)
This study	331/331 (100)	CT	207 (63)	97 (29)	16 (5)	9 (3)	2 (1)	–

Maki Y, Mizutani M, Morimoto M, Kawai T et als. The variations of the middle colic vein tributaries: depiction by three-dimensional CT angiography. Br J Radiol. 2016 Jul;89(1063):20150841. doi: 10.1259/bjr.20150841. Epub 2016 Apr 25.

Mesenteric venous anatomy and variation



Mesenteric venous anatomy and variation



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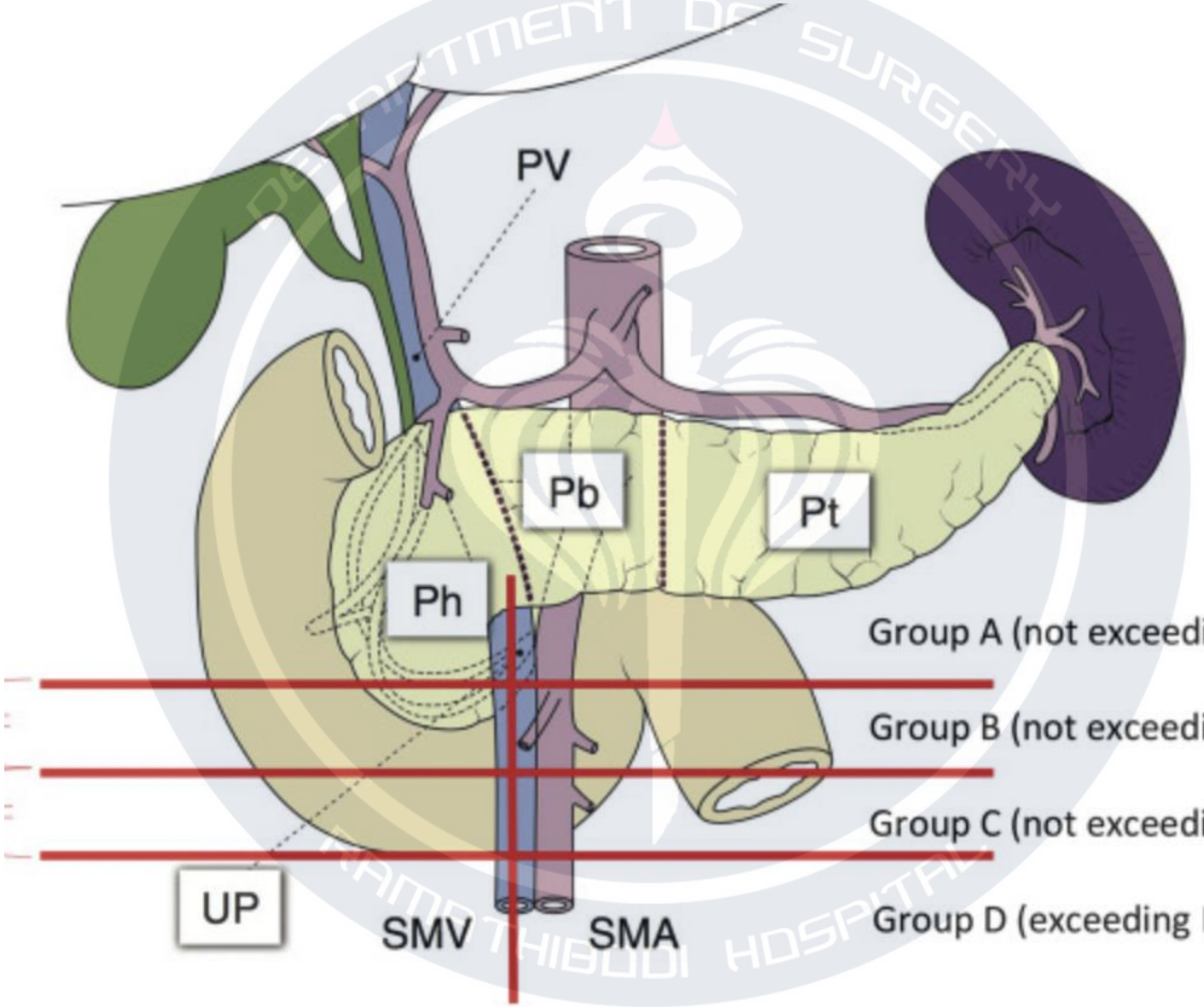


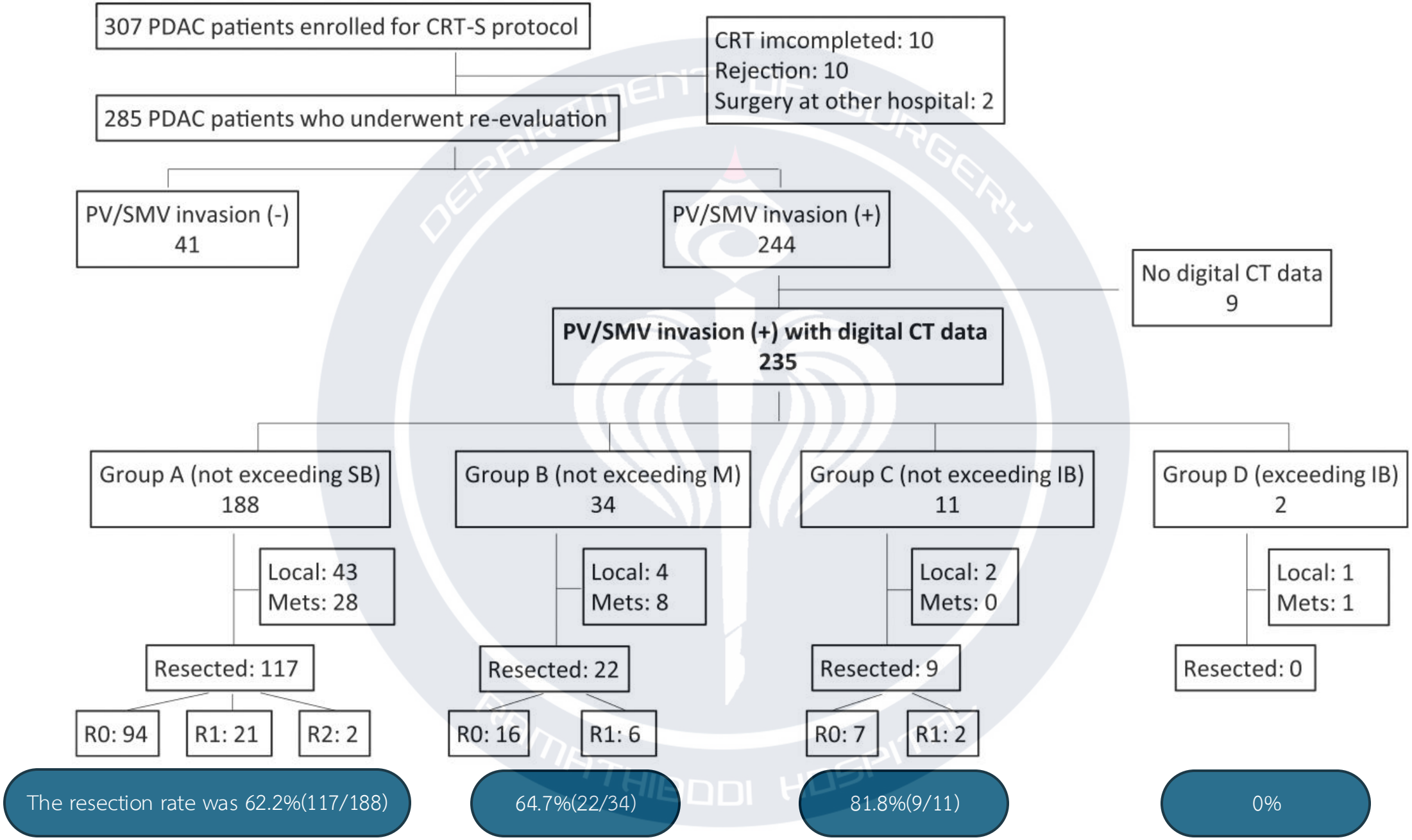
188/235(80%)

34/235(14.4%)

11/235(4.6%)

1/235(0.01%)

Isaji S, Mizuno S, Windsor JA, Bassi C, et al.. International consensus on definition and criteria of borderline resectable pancreatic ductal adenocarcinoma 2017. Pancreatology. 2018 Jan;18(1):2-11.



Isaji S, Mizuno S, Windsor JA, Bassi C, et al.. International consensus on definition and criteria of borderline resectable pancreatic ductal adenocarcinoma 2017. Pancreatology. 2018 Jan;18(1):2-11.

Clinical significance of portal invasion by pancreatic head carcinoma

Akimasa Nakao, MD, Akio Harada, MD, Toshiaki Nonami, MD, Tetsuya Kaneko, MD, Soichiro Inoue, MD, *and* **Hiroshi Takagi, MD,** *Nagoya, Japan*

Background. *The purpose of the present study was to clarify the indication of aggressive surgery for pancreatic head carcinoma.*
Methods. *Laparatomy was performed in 153 patients with carcinoma, 101 of whom underwent resection of the carcinoma. With histologic examination the degree of carcinoma invasion into the portal vein was classified into grades 0, I, or II according to the depth of invasion by the carcinoma. Macroscopic carcinoma invasion into portal vein was classified into types A, B, C, or D according to preoperative findings on the portal phase of superior mesenteric angiography or intraoperative*
Results. *Ma*
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During the 1990s that some authors suggested that a suspected isolated portal vein involvement should not contraindicate pancreatic resection in patients with PDAC

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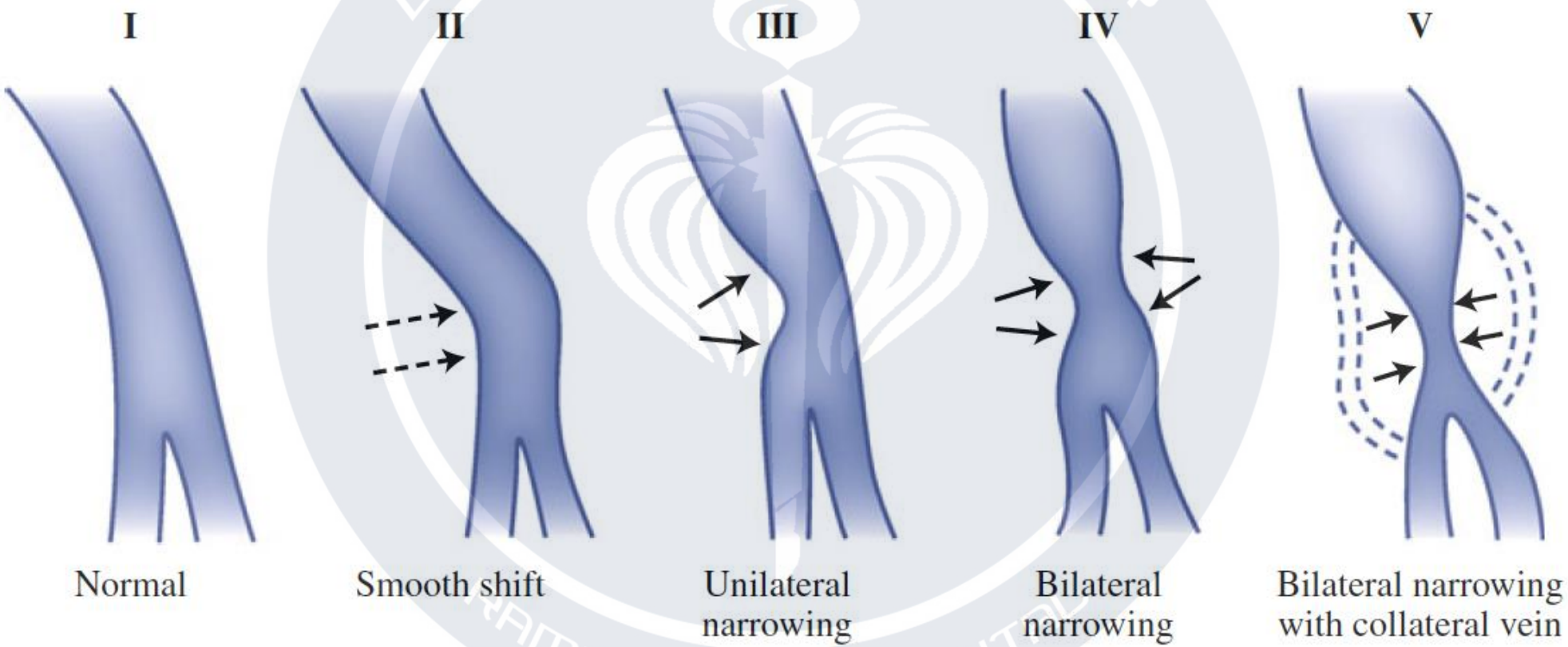
George M. Fuhrman, M.D.,* Steven D. Leach, M.D.,* Charles A. Staley, M.D.,* James C. Cusack, M.D.,* Chusilp Charnsangavej, M.D.,‡ Karen R. Cleary, M.D.,† Adel K. El-Naggar, M.D., Ph.D.,† Claudia J. Fenoglio, R.N.,* Jeffrey E. Lee, M.D.,* and Douglas B. Evans, M.D.*

From the Pancreatic Tumor Study Group, Departments of Surgical Oncology, Diagnostic Radiology‡, and Pathology†, The University of Texas, M.D. Anderson Cancer Center, Houston, Texas*

Conclusions
When necessary, segmental resection of the SMPV confluence may be performed safely during pancreaticoduodenectomy for periampullary malignant tumors. Tumors invading the SMPV confluence are not associated with histologic parameters suggesting a poor prognosis. Our data suggest that venous involvement is a function of tumor location rather than an indicator of aggressive tumor biology.

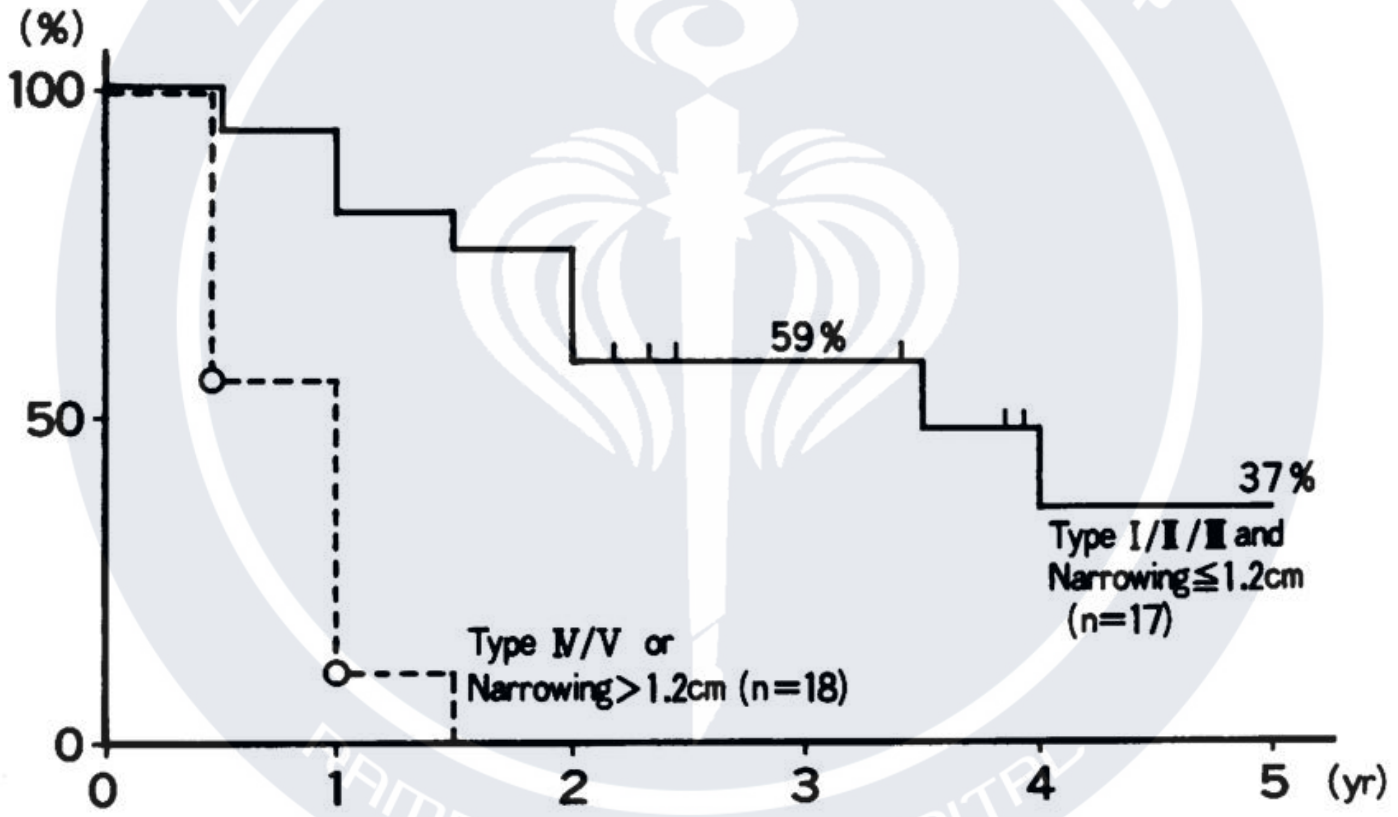
Preoperative part

Ishikawa classification



Ishikawa O, Ohigashi H, Imaoka S, Furukawa H, Sasaki Y, Fujita M, Kuroda C, Iwanaga T. Preoperative indications for extended pancreatectomy for locally advanced pancreas cancer involving the portal vein. Ann Surg. 1992 Mar;215(3):231-6.

Ishikawa classification



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Correlation Between Radiographic Classification and Pathological Grade of Portal Vein Wall Invasion in Pancreatic Head Cancer

Akimasa Nakao, MD, PhD, Akiyuki Kanzaki, MD,* Tsutomu Fujii, MD, PhD,* Yasuhiro Kodera, MD, PhD,*
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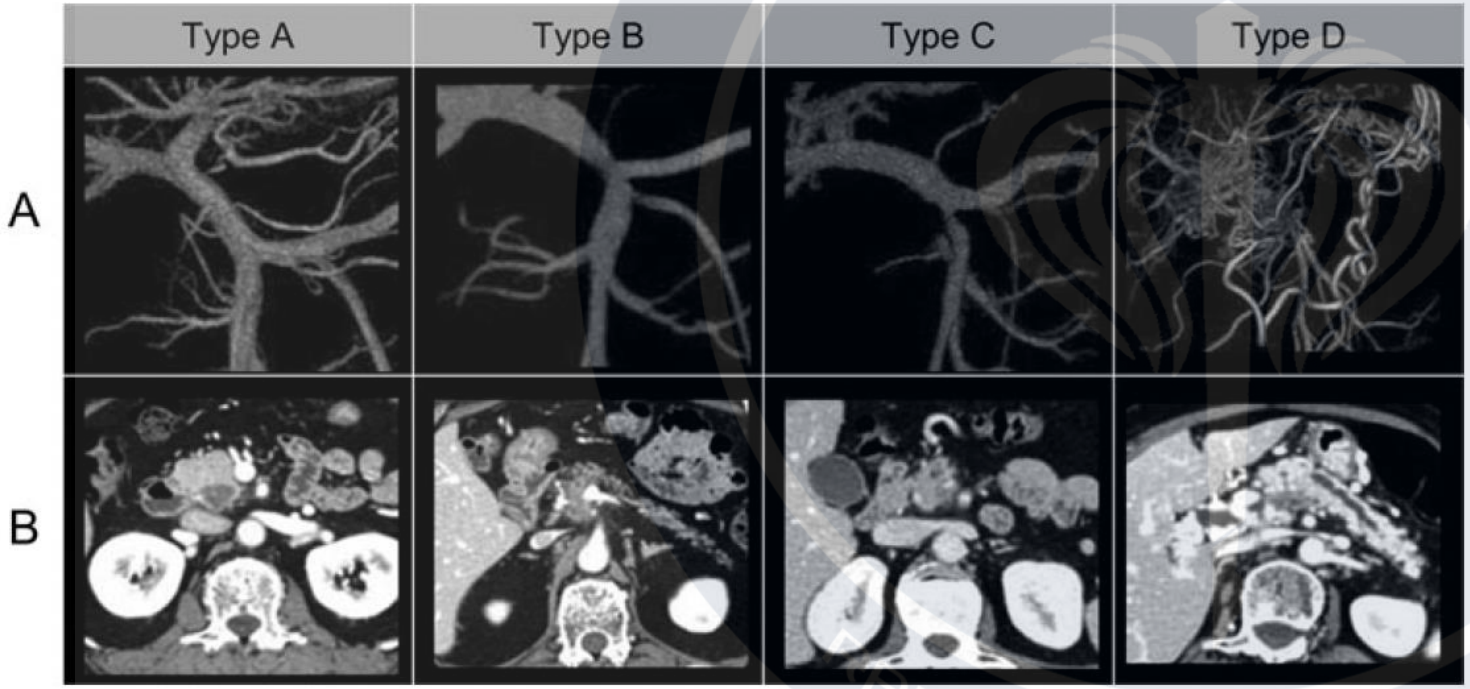
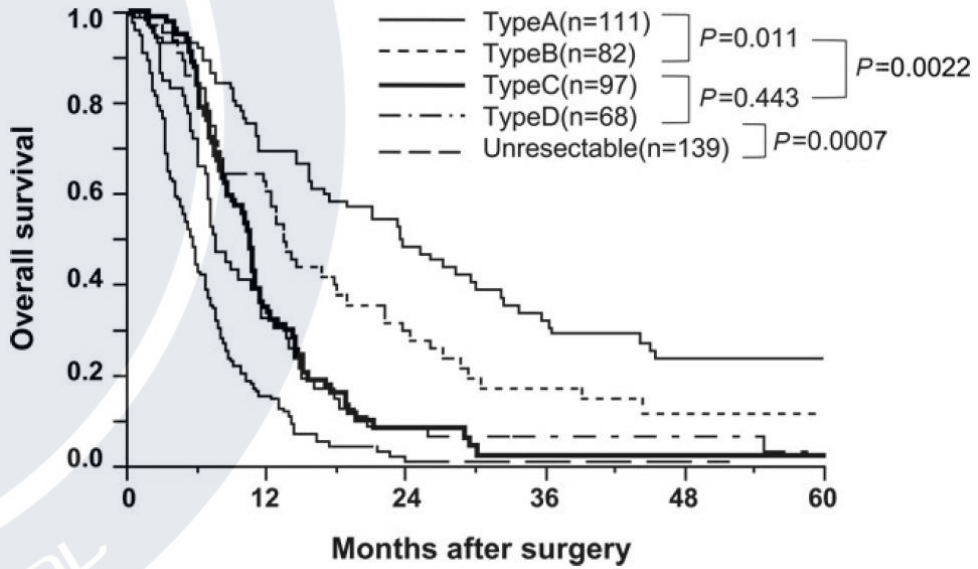
Shigeo Nakamura, MD, PhD,† Satoshi Morita, PhD,‡ and Shin Takeda, MD, PhD**





Type A *absent*

Type B *unilateral narrowing*

Type C *bilateral narrowing*

Type D *stenosis or obstruction with collaterals*

Nakao A, Kanzaki A, Fujii T, Kodera Y, Yamada S. Correlation between radiographic classification and pathological grade of portal vein wall invasion in pancreatic head cancer. Ann Surg. 2012 Jan;255(1):103-8.

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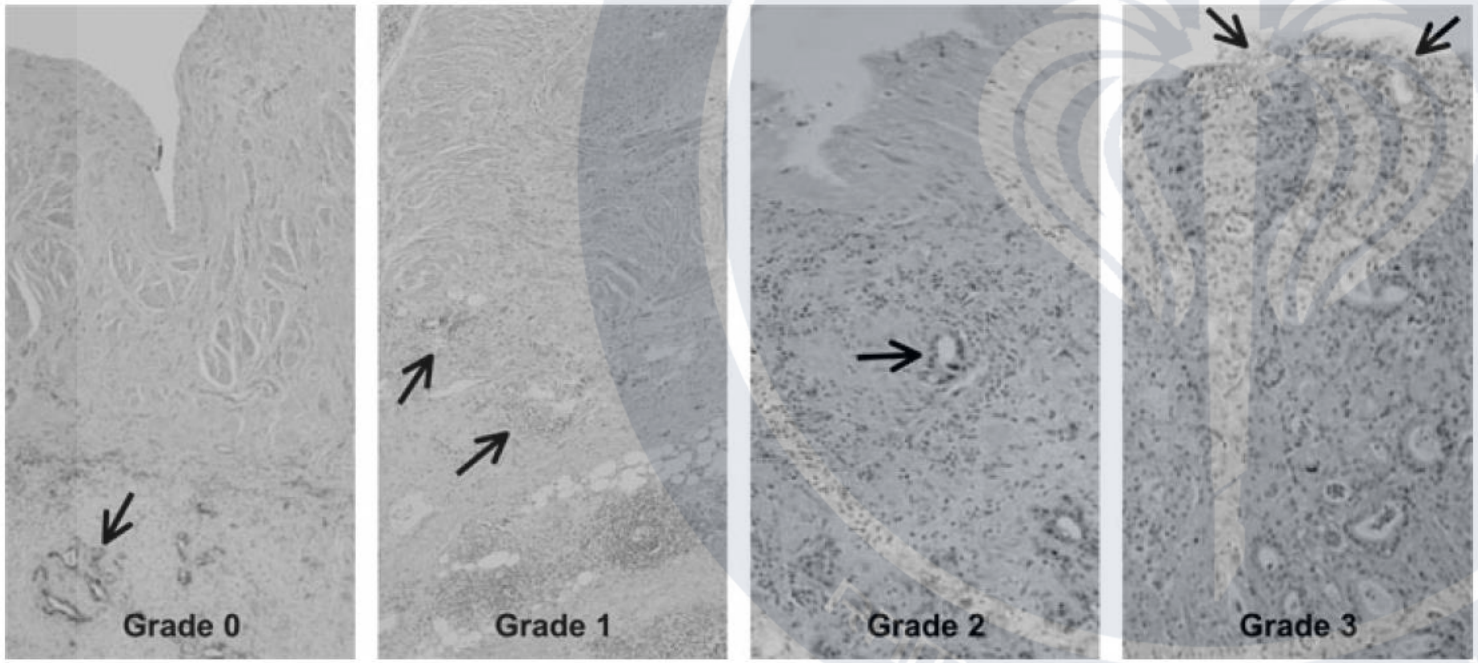
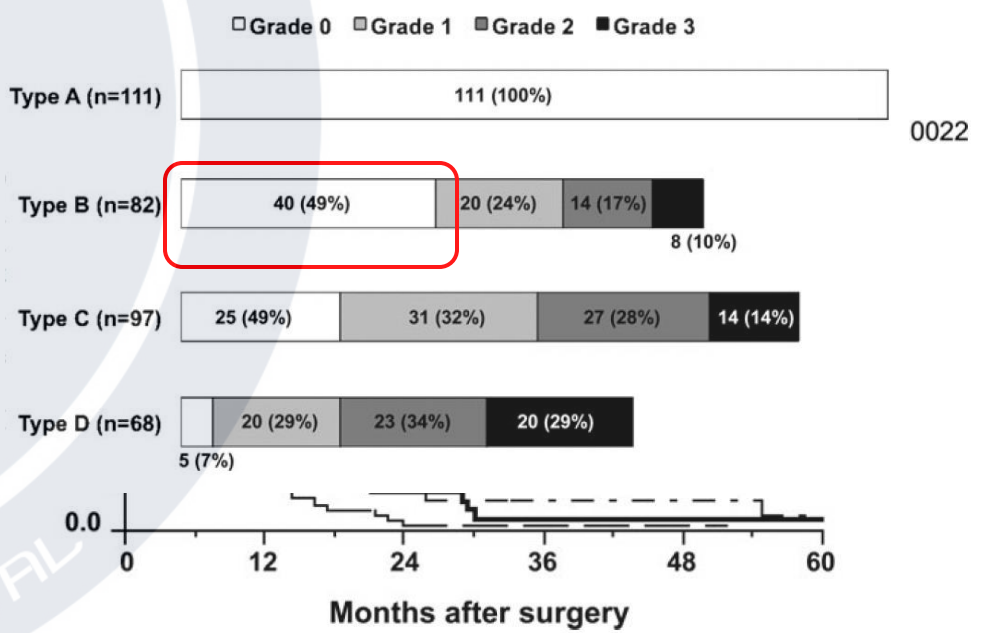


No invasion

Tunica adventitia invasion

Tunica media invasion

Tunica intima invasion



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Nakao A, Kanzaki A, Fujii T, Kodera Y, Yamada S. Correlation between radiographic classification and pathological grade of portal vein wall invasion in pancreatic head cancer. Ann Surg. 2012 Jan;255(1):103-8.

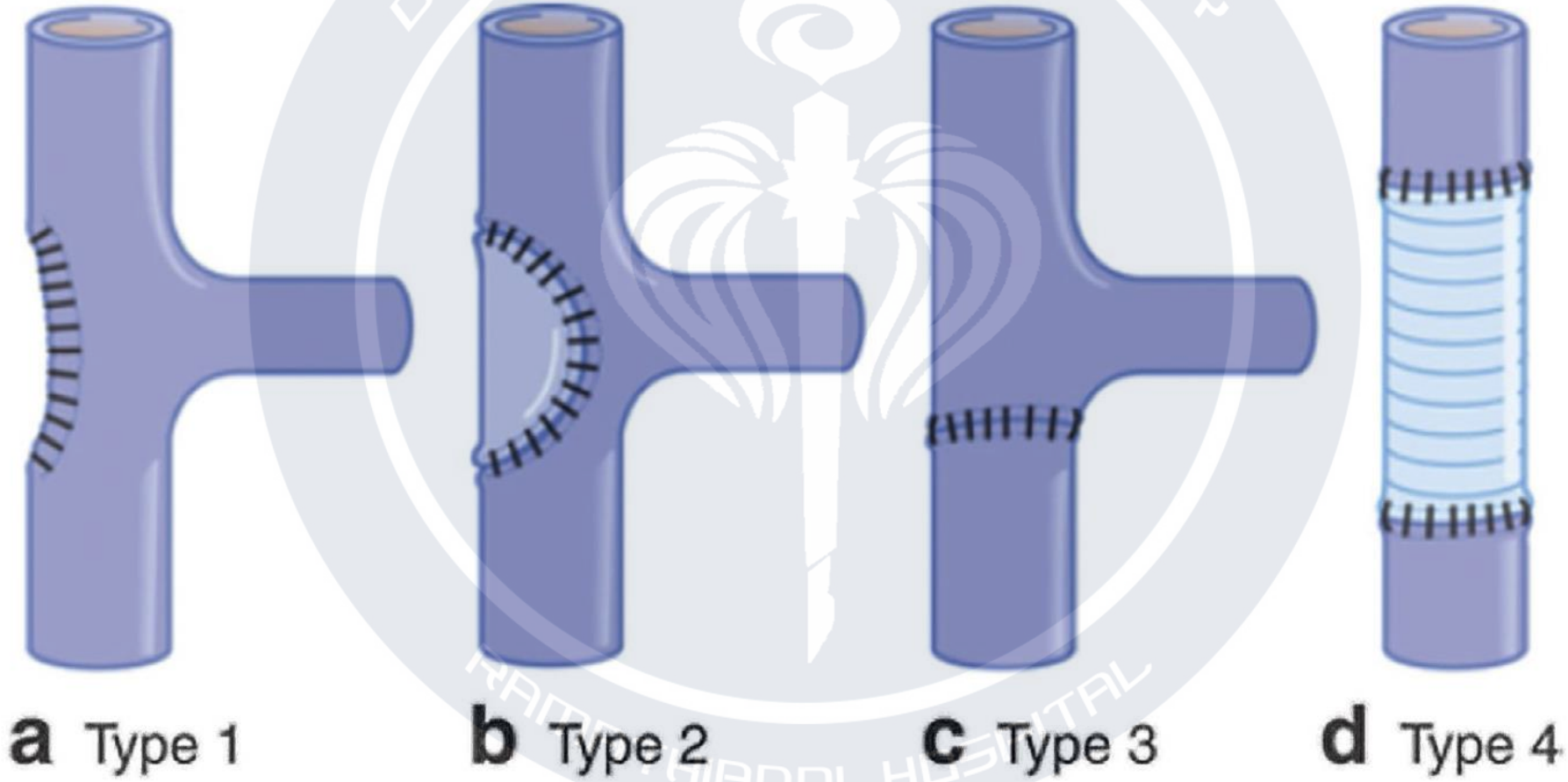
	No invasion	Smooth shift	Unilateral narrowing	Bilateral narrowing	Bilateral narrowing with collateral vein
Ishikawa	I	II	III	IV	V
Nakao	A	B		C	D
TRUE INVASION	0%	51%		51%	93%

Ishikawa O, Ohigashi H, Imaoka S, Furukawa H, Sasaki Y, Fujita M, Kuroda C, Iwanaga T. Preoperative indications for extended pancreatectomy for locally advanced pancreas cancer involving the portal vein. Ann Surg. 1992 Mar;215(3):231-6.

Nakao A, Kanzaki A, Fujii T, Kodera Y, Yamada S. Correlation between radiographic classification and pathological grade of portal vein wall invasion in pancreatic head cancer. Ann Surg. 2012 Jan;255(1):103-8.

Intraoperative part

ISGPS classification of venous resections



Maximilian Bockhorn, Faik G. Uzunoglu, Mustapha Adham, et al., Borderline resectable pancreatic cancer: A consensus statement by the International Study Group of Pancreatic Surgery (ISGPS), Surgery, Volume 155, Issue 6, 2014

Sara Sentí Fontanals, Fernando Pardo Aranda, María Gutiérrez Recasens,, et als, Venous resection in pancreatic oncologic surgery: Different techniques for different situations, Cirugía Española (English Edition), Volume 101, Issue 12, 2023

Tumor location

1. Only invades a small part of the wall of PV and/or SMV

   Option : Direct repair, venous patch or segmental end to end anastomosis

Li J, Liu Z, Xu X, Chen J. The role of vascular resection and reconstruction in pancreaticoduodenectomy. Asian J Surg. 2024 Jan;47(1):63-71. doi: 10.1016/j.asjsur.2023.09.039. Epub 2023 Sep 16. PMID: 37723030.

Tumor location

2. Invades most part of the wall of PV and/or SMV

Option : necessary to remove the segment of PV and/or SMV

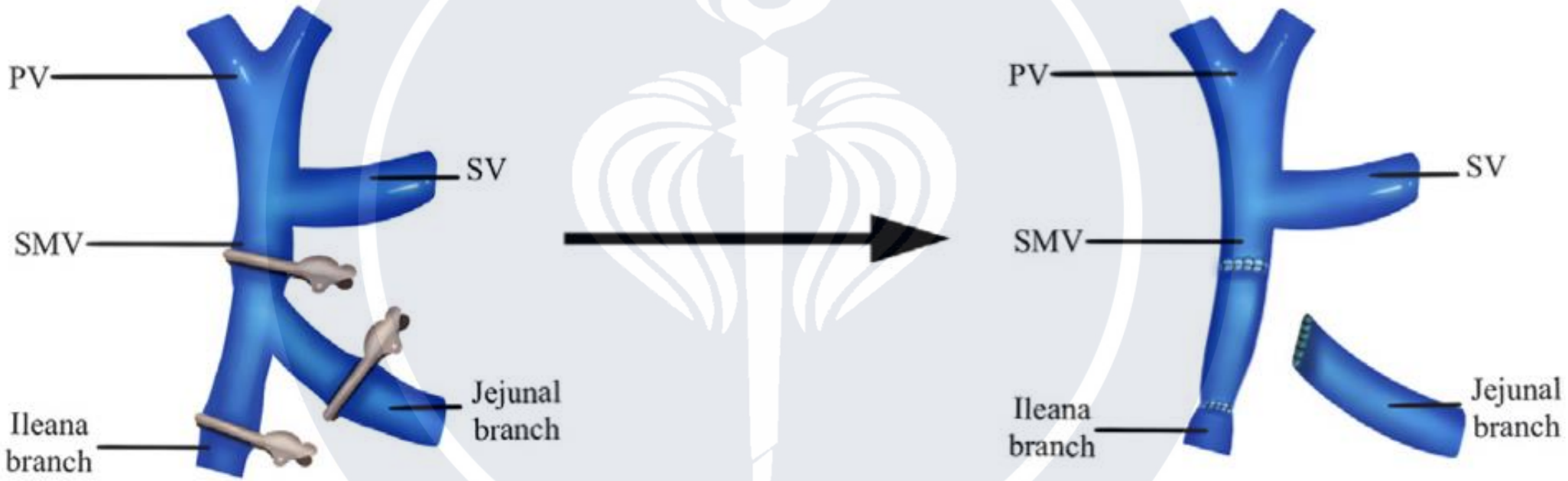
Proximal anastomosis : PV trunk

Distal anastomosis : Base on tumor location

Tumor not invade the distal jejunal and ileal branches of SMV → Distal anastomosis is SMV trunk

Li J, Liu Z, Xu X, Chen J. The role of vascular resection and reconstruction in pancreaticoduodenectomy. Asian J Surg. 2024 Jan;47(1):63-71. doi: 10.1016/j.asjsur.2023.09.039. Epub 2023 Sep 16. PMID: 37723030.

Tumor invade the distal jejunal and ileal branches of SMV

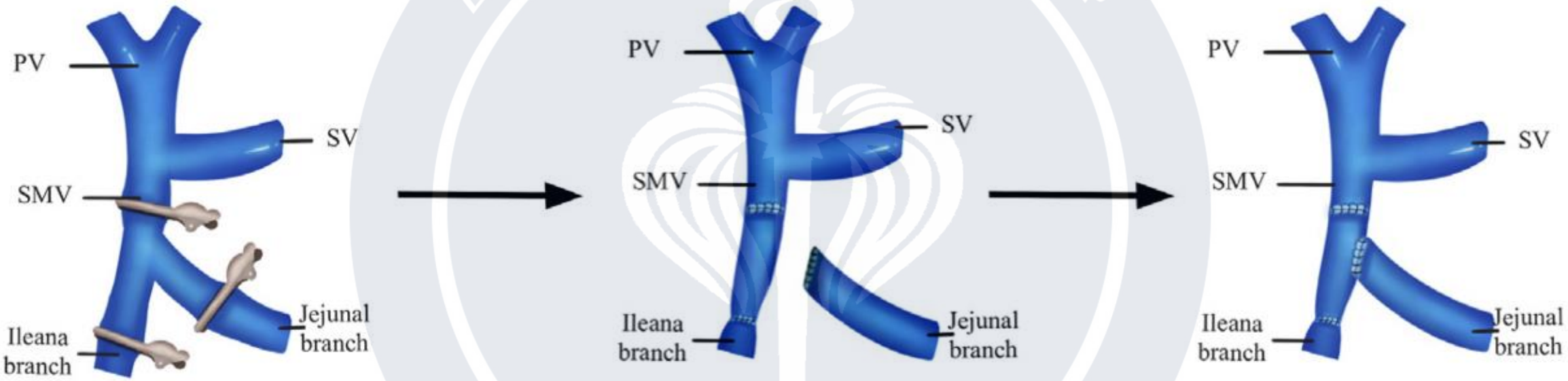


Ileum branch is preferred to anastomose with the proximal vein

Assessment : preoperative CT, the diameter of ileal branch is 1.5 times larger than that of SMA

Li J, Liu Z, Xu X, Chen J. The role of vascular resection and reconstruction in pancreaticoduodenectomy. Asian J Surg. 2024 Jan;47(1):63-71. doi: 10.1016/j.asjsur.2023.09.039. Epub 2023 Sep 16. PMID: 37723030.

Tumor invade the distal jejunal and ileal branches of SMV



But if still intestinal congestion > should evaluate angle of anastomosis, and even the detection of the blood flow of the reconstructed vessels by vascular ultrasound Doppler.

it is necessary to anastomose both ileum branch and jejunum branch to the proximal vein

Li J, Liu Z, Xu X, Chen J. The role of vascular resection and reconstruction in pancreaticoduodenectomy. Asian J Surg. 2024 Jan;47(1):63-71. doi: 10.1016/j.asjsur.2023.09.039. Epub 2023 Sep 16. PMID: 37723030.

Tumor location

3. Invade splenic vein-portal vein-superior mesenteric vein (SV-PV-SMV) junctions

- SV-PV is preserved → Do not splenic vein resection
- SV-PV cannot preserved

Li J, Liu Z, Xu X, Chen J. The role of vascular resection and reconstruction in pancreaticoduodenectomy. Asian J Surg. 2024 Jan;47(1):63-71. doi: 10.1016/j.asjsur.2023.09.039. Epub 2023 Sep 16. PMID: 37723030.

After segmental PV-SMV resection

- End-to-end anastomosis is simple and preferable to an interposition graft
  - Pancreaticoduodenectomy
  - Distal pancreatectomy
  - Total pancreatectomy

If reconstruction creates excessive tension. . .

the rate of thrombosis and stricture/occlusion may increase

Fujii T et al. Venous resection, PTFE graft during pancreatectomy are associated with poor 1-year patency rates. Surgery. 2015 Apr;157(4):708-15.

After segmental PV-SMV resection

- End-to-end anastomosis is simple and preferable to an interposition graft
  - Pancreaticoduodenectomy
  - Distal pancreatectomy
  - Total pancreatectomy

How to decrease excessive tension ?

Fujii T, et al. Vein resection, PV-SMV during pancreatectomy are associated with poor 1-year patency rates. Surgery. 2015 Apr;157(4):708-15.

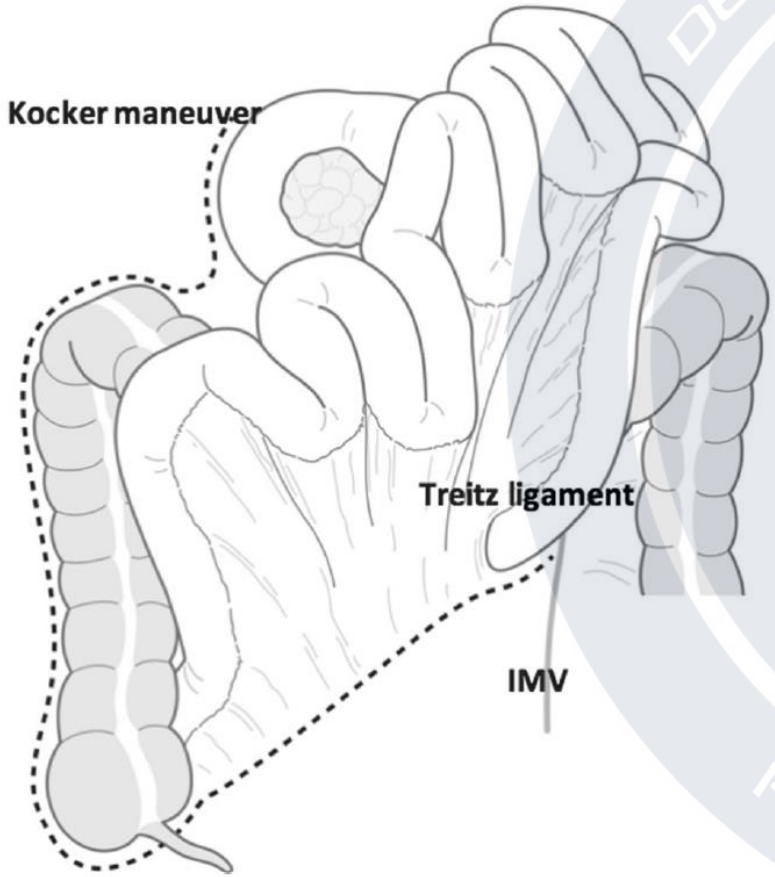
Procedures for release tension

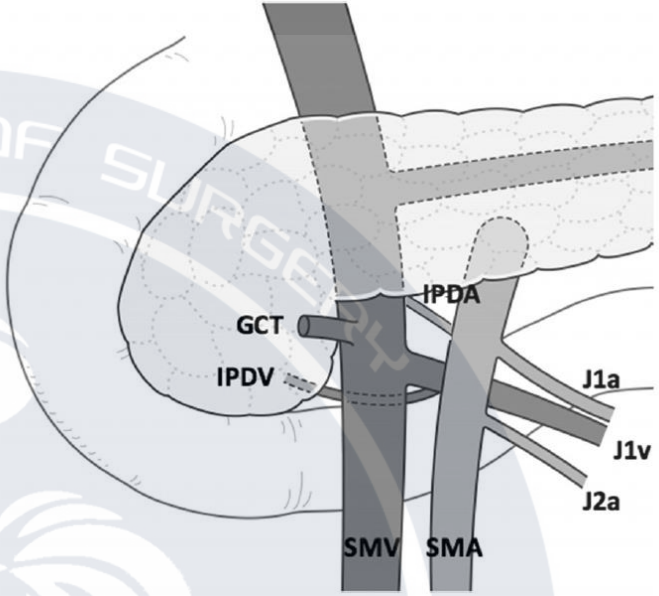
- Cattell-Braasch manuever
- Transection of transverse mesocolon(anterior surface of duodenum and pancrease)
- Lymphadenectomy of left, dorsal and right aspect of SMA
- Splenic vein resection
- Parachute technique

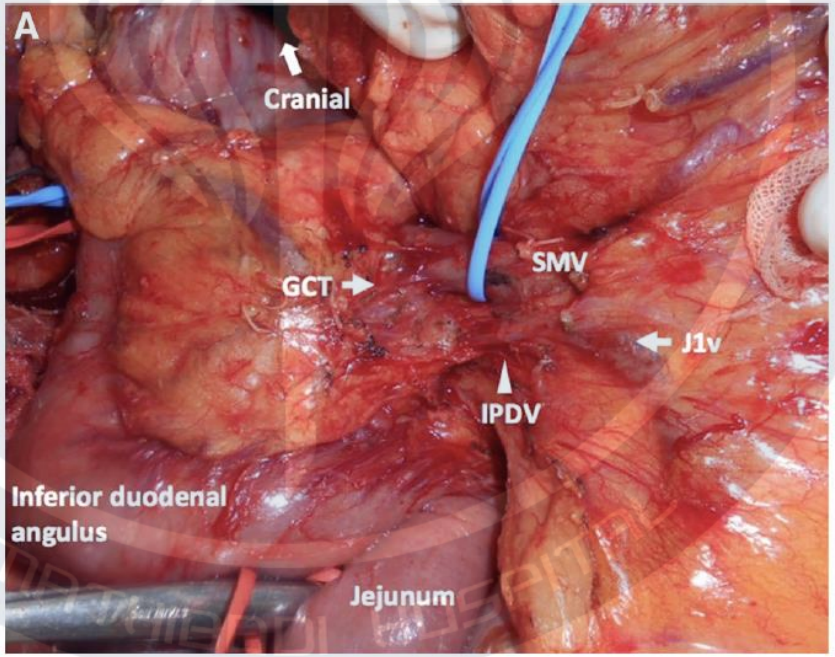
Addeo, P., & Bachellier, P. (2021). *Pancreaticoduodenectomy with Segmental Venous Resection: a Standardized Technique Avoiding Graft Interposition. Journal of Gastrointestinal Surgery, 25(7), 1925–1931.*

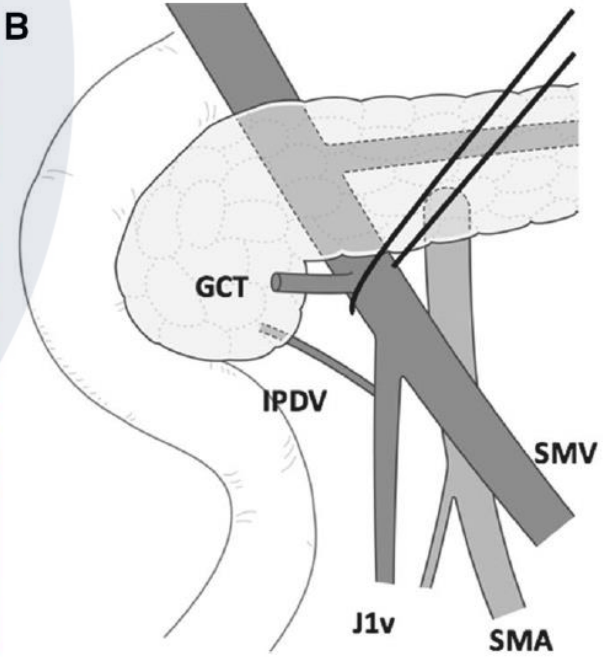
Younan G, Tsai S, Evans DB, Christians KK. Techniques of Vascular Resection and Reconstruction in Pancreatic Cancer. Surg Clin North Am. 2016 Dec;96(6):1351-1370.

Cattell-Braasch manuever









Akita M, Maeda E, Nishimura T et als, Anatomical change of SMV branches after the Cattell Braasch maneuver facilitates safe resection around the uncinated process in pancreatoduodenectomy. BMC Surg. 2021 Sep 8;21(1):341

Splenic vein ligation

May be require ligation when[1]

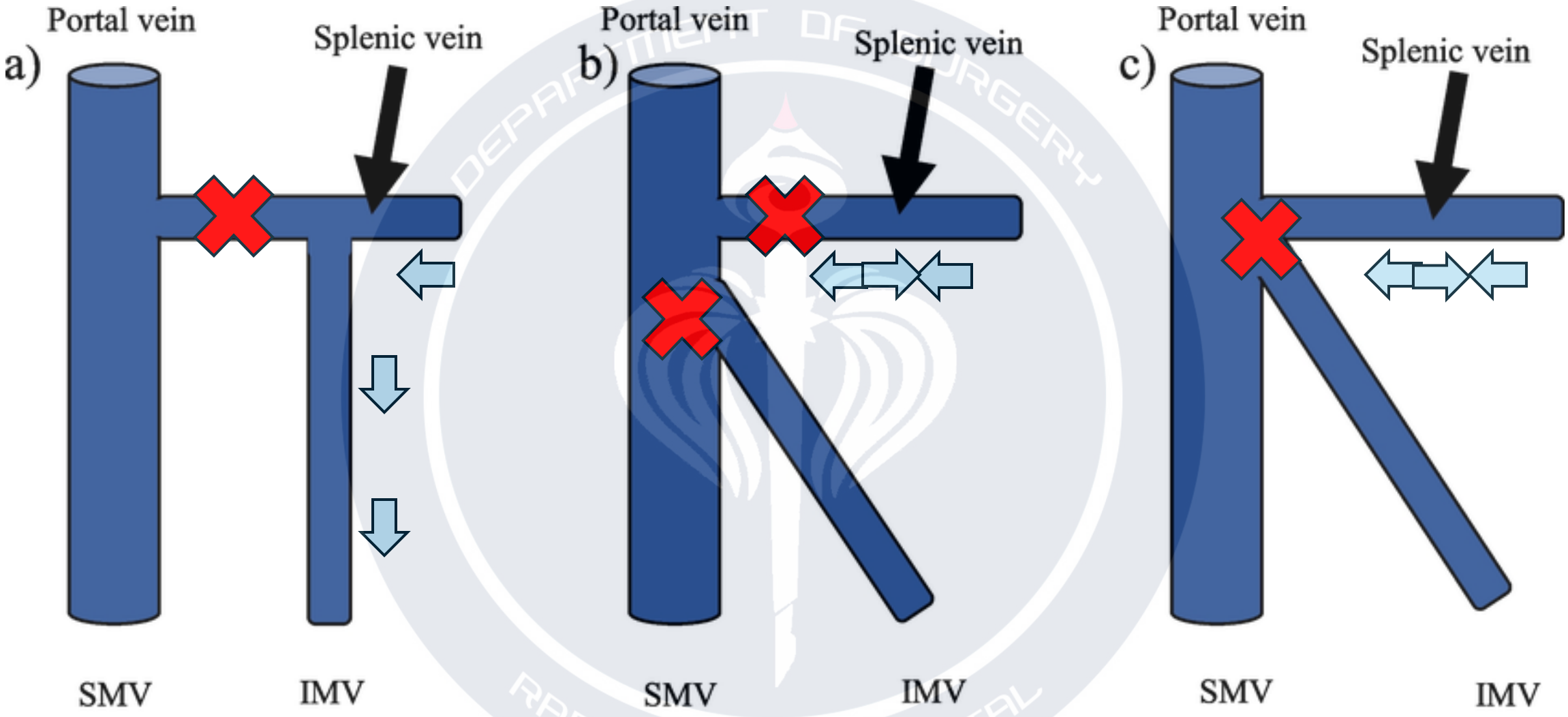
1. the SMV-PV confluence is encased by tumor
2. improve exposure of the proximal SMA
3. increase length in needed for primary anastomosis of the SMV to the PV

Left-sided portal hypertension (LSPH), leading to variceal bleeding and hypersplenism-associated thrombocytopenia

Incidence about 7.7 - 63% after splenic vein ligation[2]

[1]Younan G, Tsai S, Evans DB, Christians KK. Techniques of Vascular Resection and Reconstruction in Pancreatic Cancer. Surg Clin North Am. 2016 Dec;96(6):1351-1370.

[2]Petrucciani N, Debs T, Rosso E, et al. Left-sided portal hypertension after pancreatoduodenectomy with resection of the portal/superior mesenteric vein confluence. Results of a systematic review. Surgery. 2020;168:434-439.



No Left-sided portal hypertension (LSPH)

Left-sided portal hypertension (LSPH)

Left-sided portal hypertension (LSPH)

Youman G, Tsai S, Evans DB, Christians KK. Techniques of Vascular Resection and Reconstruction in Pancreatic Cancer. Surg Clin North Am. 2016 Dec;96(6):1351-1370

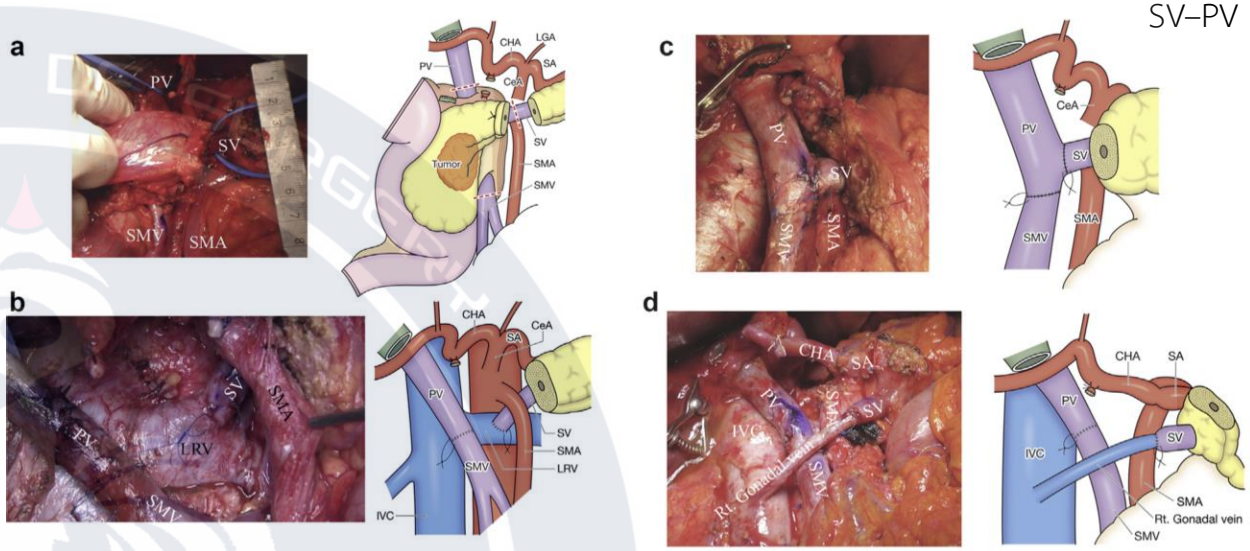
ORIGINAL ARTICLE

Techniques for splenic vein reconstruction after pancreaticoduodenectomy with portal vein resection for pancreatic cancer

Yoshihiro Ono[1], Masayuki Tanaka[1], Kiyoshi Matsueda[2], Makiko Hiratsuka[2], Yu Takahashi[1], Yoshihiro Mise[1], Yosuke Inoue[1], Takafumi Sato[1], Hiromichi Ito[1] & Akio Saiura[1]

[1]Department of Gastroenterological Surgery, and [2]Department of Diagnostic Imaging, Cancer Institute Hospital, Japanese Foundation for Cancer Research, Japan

SV–PV



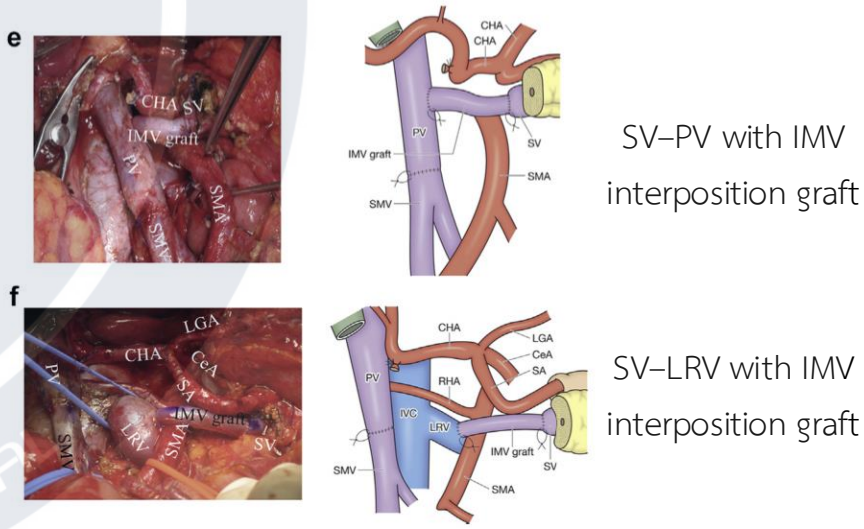
SV–left renal vein (LRV)

SV–right gonadal vein anastomoses

30 patients

End to side : Splenorenal shunt, Spleno portal shunt(10 patients)

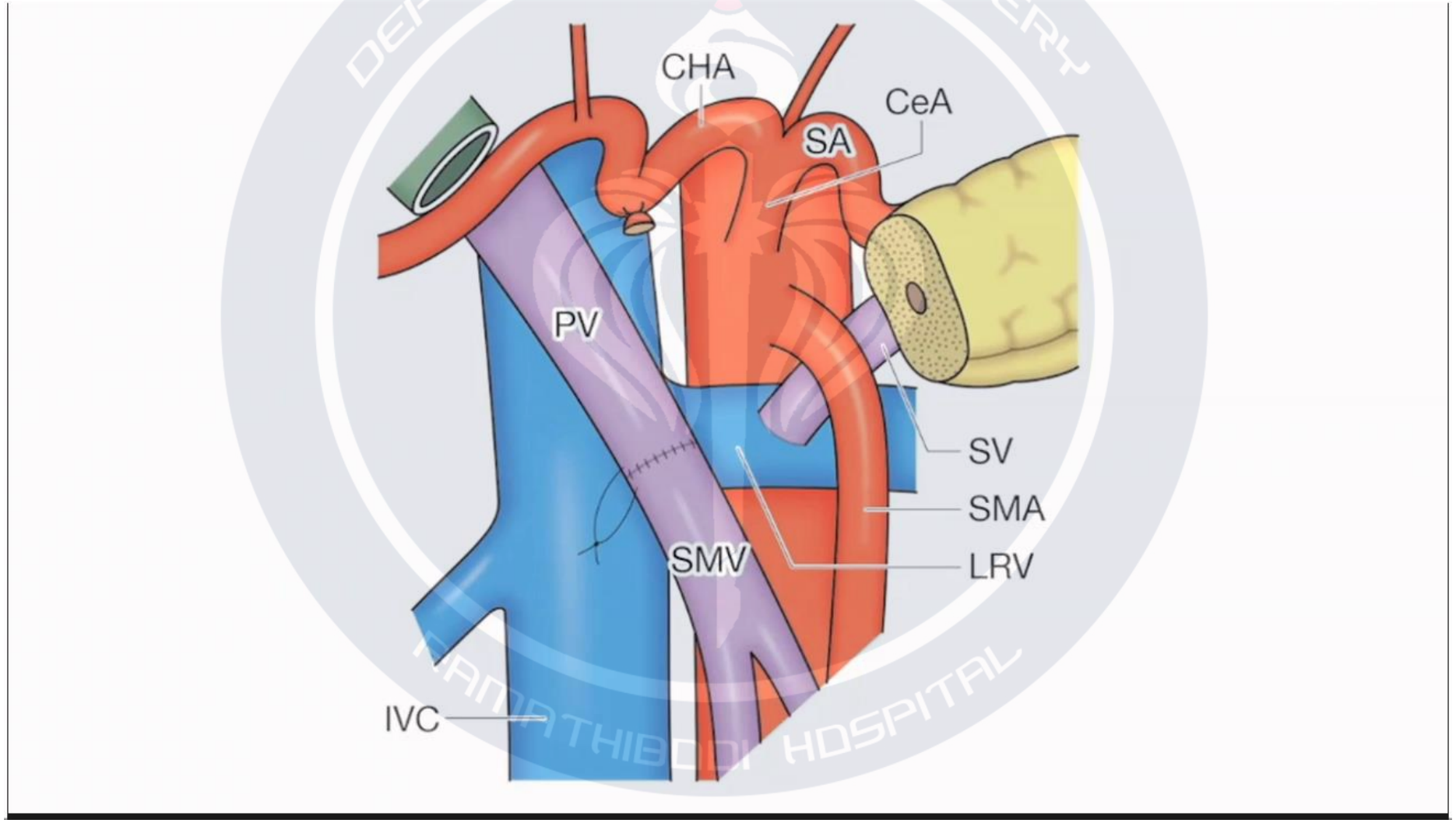
End to end : spleno - gonadal, spleno – left adrenal, and spleno – jejunal vein or spleno – interposition graft – PV/left renal vein(20 patients)



SV–PV with IMV interposition graft

SV–LRV with IMV interposition graft

Splenorenal shunt



Yoshihiro Ono, Masayuki Tanaka, Ryoshi Matsueda et al. Techniques for splenic vein reconstruction after pancreaticoduodenectomy with portal vein resection for pancreatic cancer, HPB, Volume 21, Issue 10, 2019

ORIGINAL ARTICLE

Techniques for splenic vein reconstruction after pancreaticoduodenectomy with portal vein resection for pancreatic cancer

Yoshihiro Ono[1], Masayuki Tanaka[1], Kiyoshi Matsueda[2], Makiko Hiratsuka[2], Yu Takahashi[1], Yoshihiro Mise[1], Yosuke Inoue[1], Takafumi Sato[1], Hiromichi Ito[1] & Akio Saiura[1]

[1]Department of Gastroenterological Surgery, and [2]Department of Diagnostic Imaging, Cancer Institute Hospital, Japanese Foundation for Cancer Research, Japan

Type of anastomosis	Anastomosed with	n	Patency rate		GI varices	
End-to-side[a] (n = 10)	LRV	8	7 (88)	9 (90)	1 (13)	1 (10)
	PV	2	2 (100)		0	
End-to-end[b] (n = 20)	Rt gonadal vein	5	3 (60)	9 (45)	2 (40)	7 (35)
	Lt adrenal vein	1	0 (0)		1 (100)	
	Jejunum vein	1	0 (0)		1 (100)	
	Interposition graft	13	6 (46)		3 (23)	
	IMV	10	5 (50)		3 (30)	
	Rt gonadal vein	2	1 (50)		0	
	MCV	1	0 (0)		0	

The patency rate for the reconstructed SV-PV/LRV was 90% (9/10), compared with 45% (9/20) SV-smaller vein or graft (P = 0.024)

Incidence of SPH after SV reconstruction : 10% of patients with a patent reconstructed SV (2/20) developed gastrointestinal varices, 50% of patients (6/12) whose anastomosis was occluded (p = 0.034)

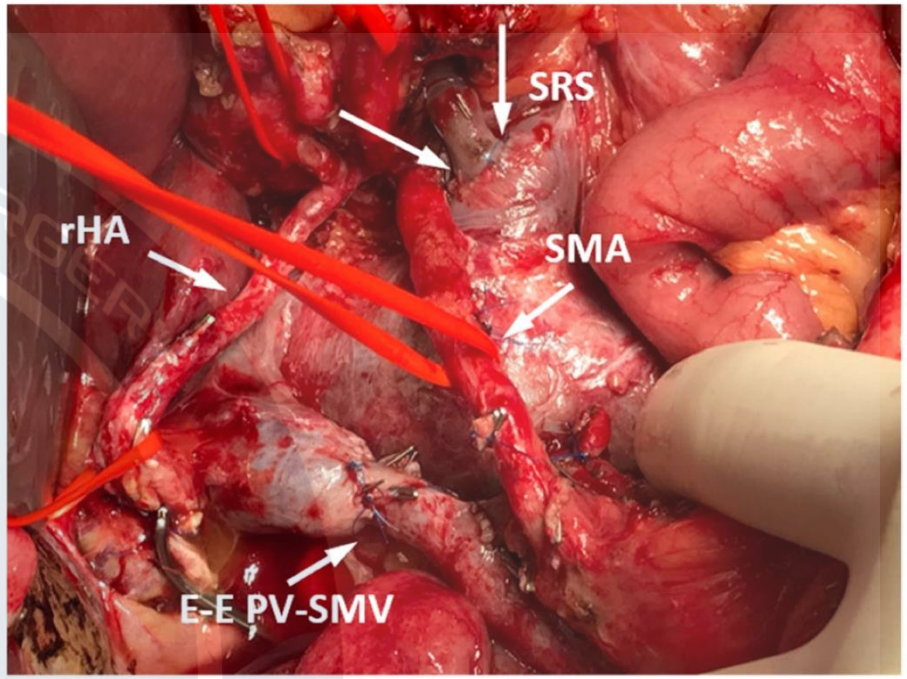
Yoshihiro Ono, Masayuki Tanaka, Kiyoshi Matsueda et al. Techniques for splenic vein reconstruction after pancreaticoduodenectomy with portal vein resection for pancreatic cancer, HPB, Volume 21, Issue 10, 2019

Splenorenal shunt for reconstruction of the gastric and splenic venous drainage during pancreatoduodenectomy with resection of the portal venous confluence

Mohammed Al-Saeedi[1] · Leonie Frank-Moldzio[1] · Pietro Contin[1] · Philipp Mayer[2] · Martin Loos[1] · Thomas Schmidt[1] · Martin Schneider[1] · Beat P. Müller-Stich[1] · Christoph Berchtold[1] · Arianeb Mehrabi[1] · Thilo Hackert[1] · Markus W. Büchler[1] · Oliver Strobel[1,3]

Received: 25 June 2021 / Accepted: 25 August 2021

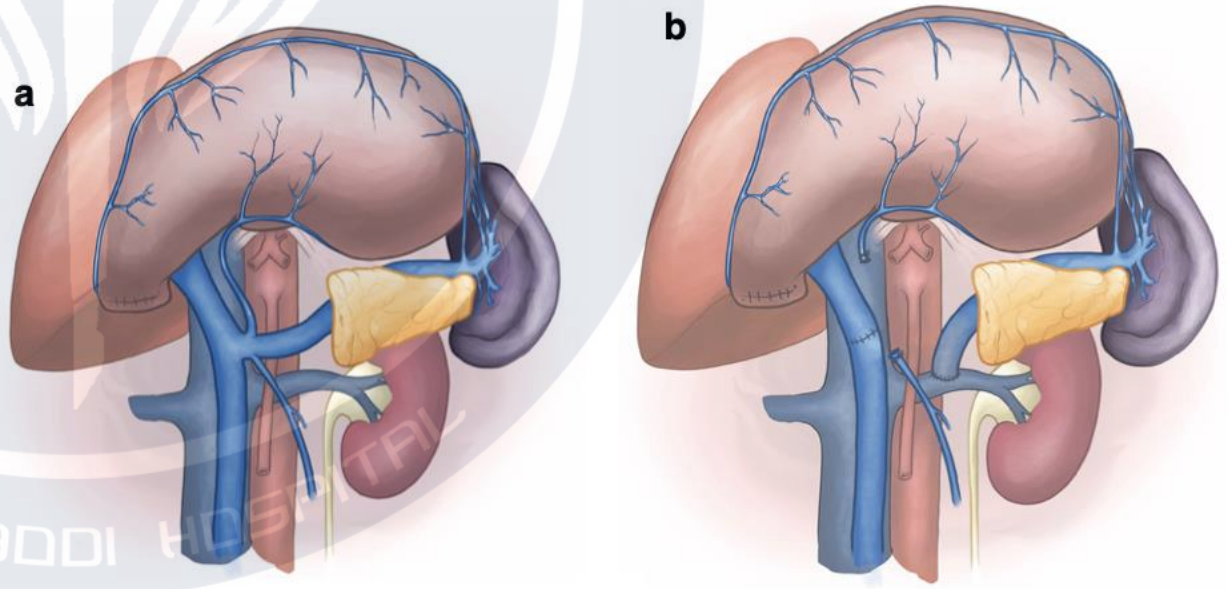
University Hospital Heidelberg, Heidelberg, Germany



10 patients (9 PDAC and 1 PNET)

1-year patency rate: 68.9%

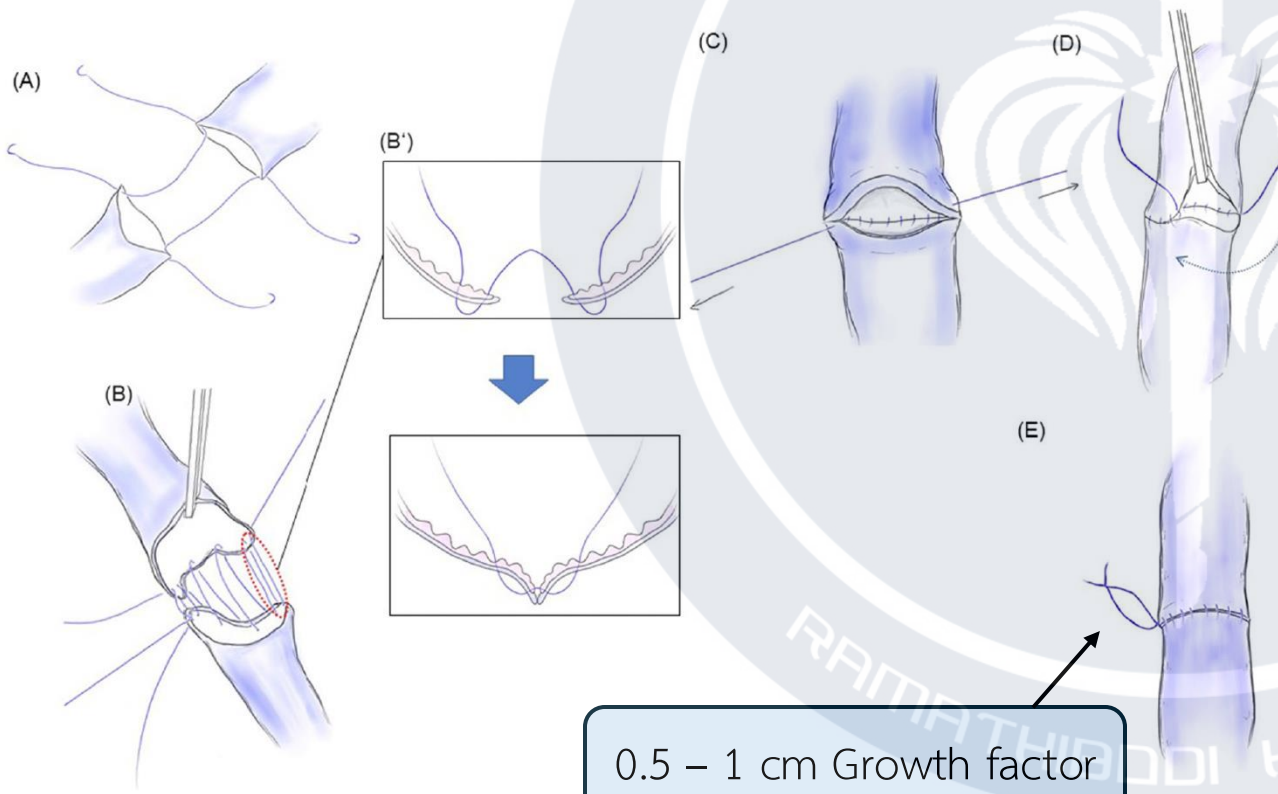
No perioperative complications related to left-sided portal hypertension such as gastrointestinal bleeding and gastric/splenic ischemia



Al-Saeedi M, Frank-Moldzio L, Contin P, Mayer P et al. Splenorenal shunt for reconstruction of the gastric and splenic venous drainage during pancreatoduodenectomy with resection of the portal venous confluence. Langenbecks Arch Surg. 2021 Nov;406(7):2535-2543

Parachute technique for portal vein reconstruction during pancreaticoduodenectomy with portal vein resection in patients with pancreatic head cancer

Shoichi Irie[1,2] · Ryuji Yoshioka[1] · Hiroshi Imamura[1] · Yoshihiro Ono[2] · Takafumi Sato[2] · Yosuke Inoue[2] · Hiromichi Ito[2] · Yoshihiro Mise[1,2] · Yu Takahashi[2] · Akio Saiura[1,2]



0.5 – 1 cm Growth factor

In the present series, the distance between the resected PV and SMV(median[range]:5 [3-6] cm was relatively long

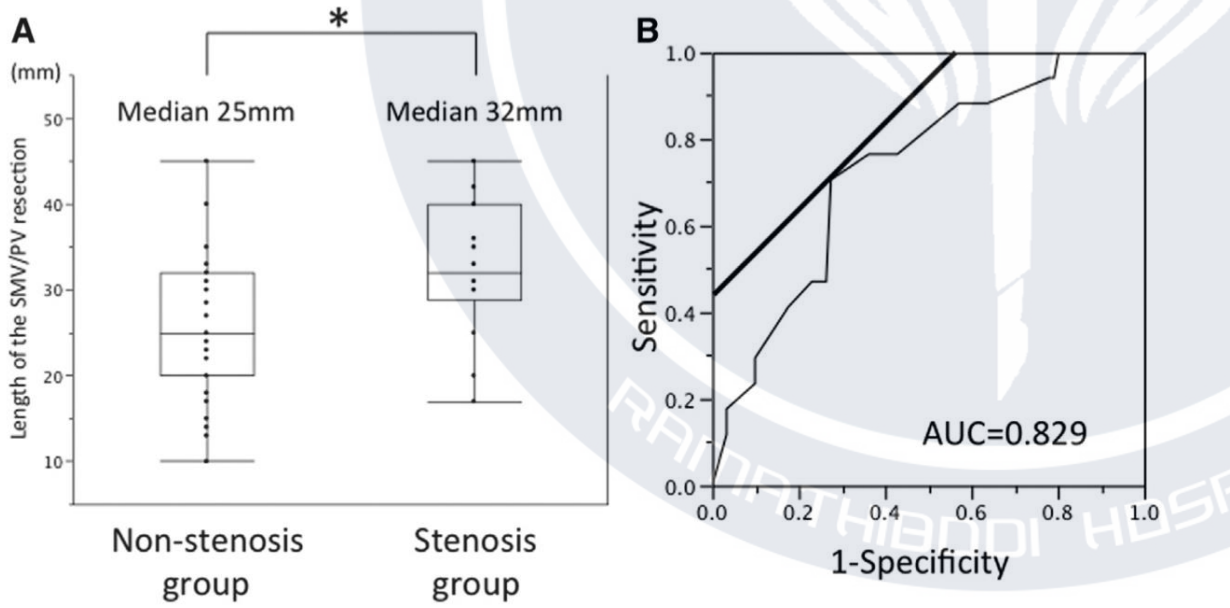
Median [range]: 18 [1–45] months

1-year PV patency rate was 87%

Irie S, Yoshioka R, Imamura H, Ono Y, Sato T, et al. Parachute technique for portal vein reconstruction during pancreaticoduodenectomy with portal vein resection in patients with pancreatic head cancer. Langenbecks Arch Surg. 2022 Feb;407(1):383-389.

Vein resections >3 cm during pancreatectomy are associated with poor 1-year patency rates

Tsutomu Fujii, MD, PhD, FACS,[a] Akimasa Nakao, MD, PhD, FACS,[a] Suguru Yamada, MD, PhD, FACS,[a] Masaya Suenaga, MD, PhD,[a] Masashi Hattori, MD,[a] Hideki Takami, MD,[a] Yoshikuni Inokawa, MD, PhD,[a] Mitsuro Kanda, MD, PhD,[a] Hiroyuki Sugimoto, MD, PhD,[a] Shuji Nomoto, MD, PhD,[a] Kenta Murotani, PhD,[b] *and* Yasuhiro Kodera, MD, PhD, FACS,[a] *Nagoya, Japan*



Age, y, median (range)	65.0 (27–83)
Sex, male/female	111/86
Preoperative diabetes, *n* (%)	77 (39)
Preoperative body mass index, median (range)	20.7 (13.6–33.3)
Preoperative biliary drainage, *n* (%)	118 (60)
Disease	
Pancreatic cancer	191
Bile duct cancer	3
Intraductal papillary mucinous carcinoma	1
Endocrine neoplasm	1
Metastatic tumor	1
Nakao classification	
Type A/B	12/79
Type C/D	63/43
Operative method	
cPD	87
SSPPD	72
PPPD	17
TP	16
DP	5
Length of PV resection, mm, median (range)	25 (10–50)
Splenic vein resection, *n* (%)	126 (64)
Concomitant resection of major artery, *n* (%)	5 (3)
Concomitant resection of other organs, *n* (%)	9 (5)
Operative time, min, mean ± SD	496 ± 101
Blood loss, mL, mean ± SD	1,376 ± 1,150
Intraoperative blood transfusion, *n* (%)	54 (27%)
Pancreatic texture, soft/hard	42/155
Main pancreatic duct diameter (mm), mean ± SD	4.7 ± 2.6
Length of the hospital stay, d, median (range)	26 (14–139)

Fujii T, Nakao A, Yamada S, Suenaga M, et al. Vein resections >3 cm during pancreatectomy are associated with poor 1-year patency rates. Surgery. 2015 Apr;157(4):708-15. doi: 10.1016/j.surg.2014.12.002.

Table III. Predictive factors of severe stenosis of the anastomotic site of SMV/PV

Variables	n	*Univariate*			*Multivariate*		
		Odds ratio	*95% CI*	P *value*	*Hazard ratio*	*95% CI*	P *value*
Age (≥65 y)	97	0.94	0.34–2.61	.898			
Sex (male)	103	1.12	0.41–3.18	.827			
Preoperative biliary drainage	48	2.54	0.30–53.34	.407			
Preoperative diabetes mellitus	72	0.97	0.33–2.71	.958			
Preoperative serum total protein (<6.7 g/dL)	59	0.42	0.11–1.35	.151			
Preoperative total lymphocyte count (<1,200/mm^3)	55	2.24	0.75–6.92	.147			
Preoperative platelet count (≥16.6 × 10^4/mm^3)	134	4.06	0.83–11.22	.083			
Nakao classification (Type C and D)	102	2.44	0.87–7.53	.092			
Pancreatic texture (soft)	40	1.23	0.36–3.69	.728			
Operative time (≥520 min)	71	15.78	4.10–104.39	<.001	15.24	3.75–104.41	<.001
Intraoperative blood transfusion	51	1.28	0.41–3.69	.658			
Length of SMV/PV resection (≥31 mm)	54	6.86	2.33–23.25	<.001	5.96	1.79–22.69	.003
Splenic vein resection	120	1.99	0.65–7.47	.237			
Postoperative pancreatic fistula	26	1.71	0.44–5.70	.415			

CI, Confidence interval; *PV*, portal vein; *SMV*, superior mesenteric vein.

Fujii T, Nakao A, Yamada S, Sugimoto M, et al. Vein resections >3 cm during pancreatectomy are associated with poor 1-year patency rates. Surgery. 2015 Apr;157(4):708-15. doi: 10.1016/j.surg.2014.12.002.

Bridging vessels

1. Autogenous vessels
2. Allogenic vessels
3. Artificial vessels
4. Bovine pericardium

Labori KJ, Kleive D, Khan A, Farnes I, Fosby B, Line PD. Graft type for superior mesenteric and portal vein reconstruction in pancreatic surgery - a systematic review. HPB : the official journal of the International Hepato Pancreato Biliary Association. 2021;23(4):483e494.

Li J, Liu Z, Xu X, Chen J. The role of vascular resection and reconstruction in pancreaticoduodenectomy. Asian J Surg. 2024 Jan;47(1):63-71. doi: 10.1016/j.asjsur.2023.09.039. Epub 2023 Sep 16. PMID: 37723030.

1. Autogenous vessels

Autogenous vessel	Pro	Cons
Left renal vein[2](proximal IVC)	- Easily to exposed during abdominal dissection - Patency 100% in some research(graft thrombosis 10%)	- Limited length 4-5 cm - Transient post operative AKI
External iliac vein and saphenous vein[3]	- Patency 80% in some research	- May deep vein thrombosis - The acquisition of vessels is easier but need addition incision - Contraindicate in compromise quality of saphenous vein including cellulitis, thrombosis
IJV[4]	- Minimal morbidity and probably the quickest and easiest option - Sufficient length(5-7 cm) and well match diameter	- Need addition incision - Risk cerebral edema(If others side does not patent)

[1]Labori KJ, Kleive D, Khan A, Farnes I, Fosby B, Line PD. Graft type for superior mesenteric and portal vein reconstruction in pancreatic surgery - a systematic review. HPB : the official journal of the International Hepato Pancreato Biliary Association. 2021

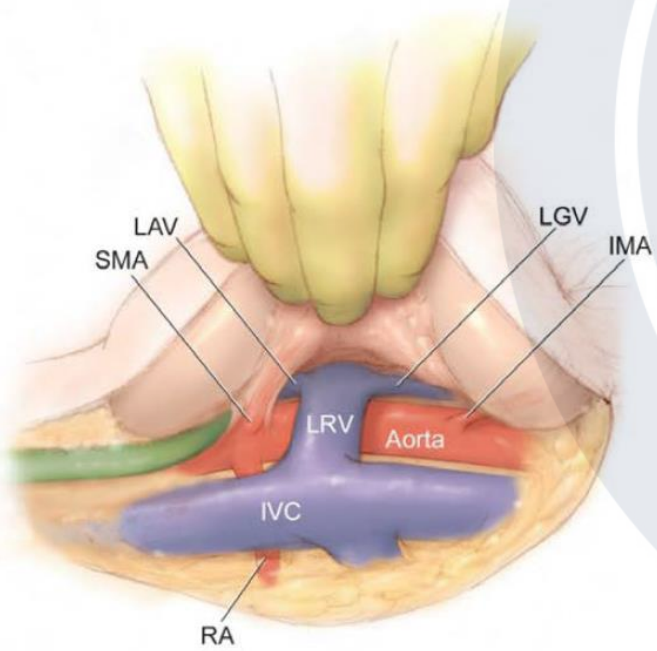
[2]Ohwada S, Hamada K, Kawate S, et al. Left renal vein graft for vascular reconstruction in abdominal malignancy. World J Surg. 2007;31(6):1215e1220.

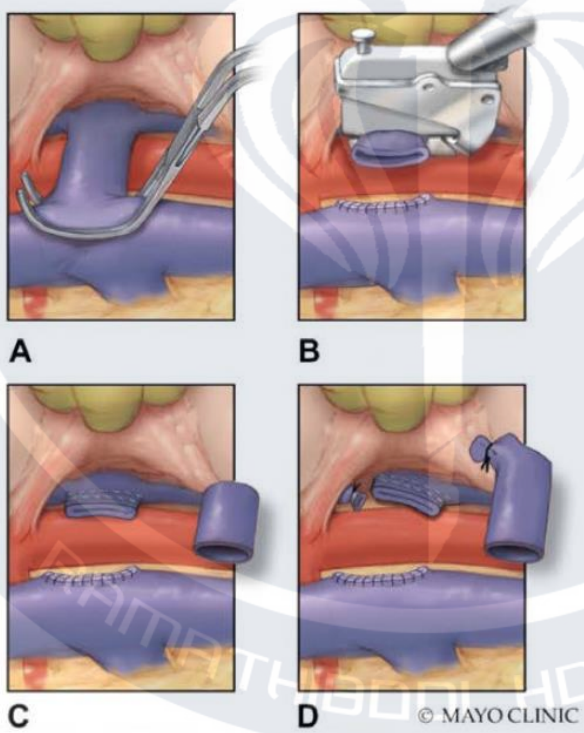
[3]Lee DY, Mitchell EL, Jones MA, et al. Techniques and results of portal vein/ superior mesenteric vein reconstruction using femoral and saphenous vein during pancreaticoduodenectomy. J Vasc Surg. 2010;51(3):662e666.

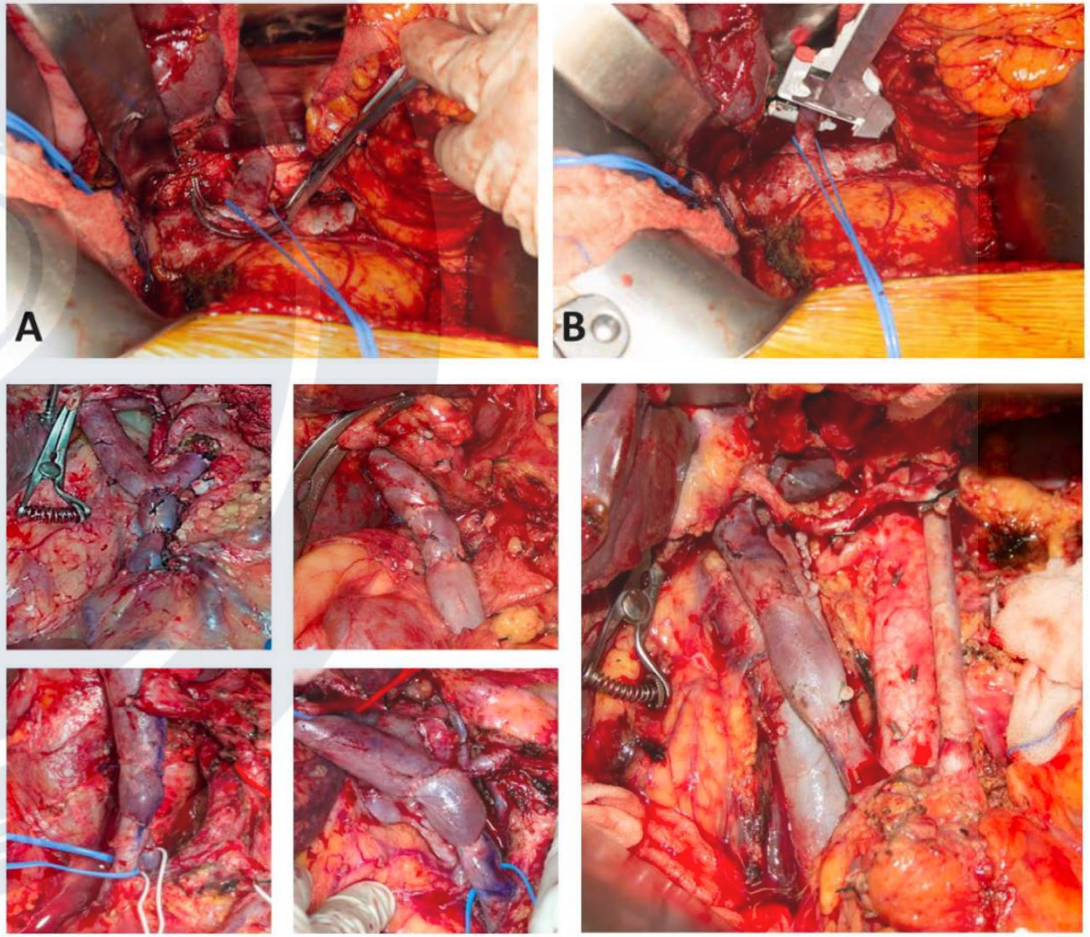
[4]Gunn B, Tsai S, Evans DB, Christians KK. Techniques of Vascular Resection and Reconstruction in Pancreatic Cancer. Surg Clin North Am. 2016 Dec;96(6):1351-1370.

Technical Outcomes of Porto-Mesenteric Venous Reconstruction in Pancreatic Resection Using Autologous Left Renal Vein Graft as Conduit

Alessandro Fogliati, MD, Guido Fiorentini, MD, Roberto Alva-Ruiz, MD, Amro M Abdelrahman, MBBS, Andrea Zironda, MD, Isaac T Lynch, Rory L Smoot, MD, Patrick P Starlinger, MD, PhD, Sean P Cleary, MD, FACS, Michael L Kendrick, MD, FACS, Mark J Truty, MD, MSc, FACS







Fogliati, Alessandro, Fiorentini, Guido, et al. "Technical Outcomes of Porto-Mesenteric Venous Reconstruction in Pancreatic Resection Using Autologous Left Renal Vein Graft as Conduit. Journal of the American College of Surgeons 237(1):p 58-67, July 2023.

Technical Outcomes of Porto-Mesenteric Venous Reconstruction in Pancreatic Resection Using Autologous Left Renal Vein Graft as Conduit

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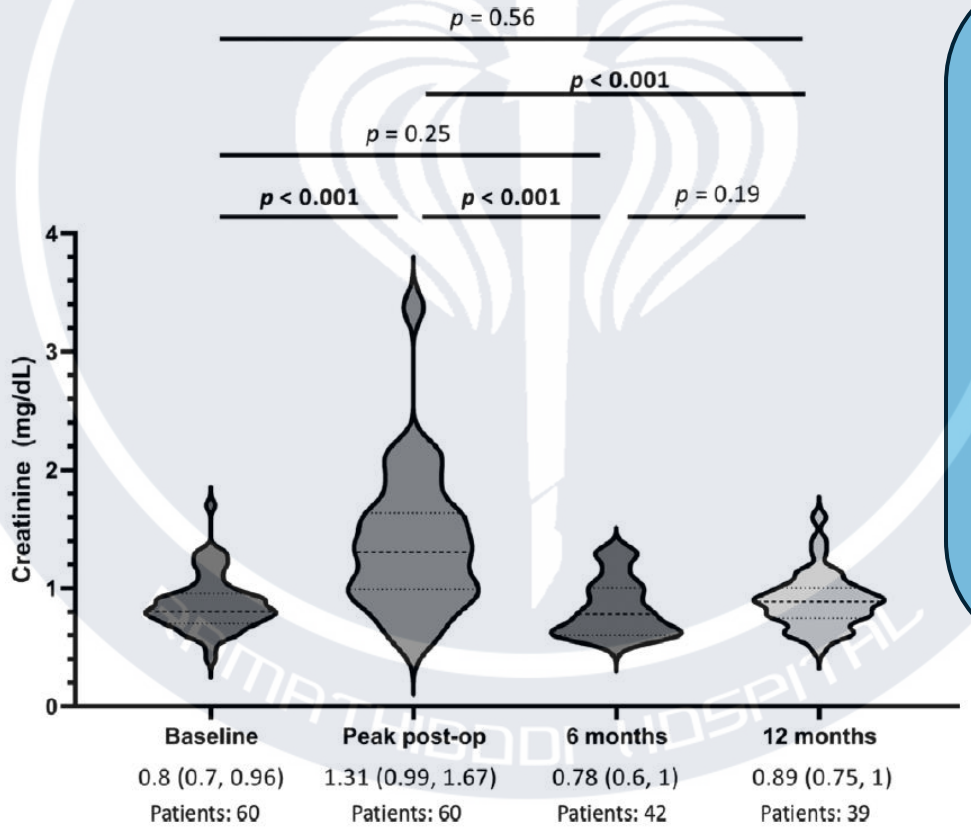
Variable	Data
Total number of patients, N	65
Technical feasibility, n (%)	59 (91)
Type of resection, n (%)	
Pancreaticoduodenectomy	40 (62)
Distal pancreatectomy	4 (6)
Total pancreatectomy	21 (32)
Minimally invasive surgery, n (%)	
Open surgery	51 (78)
Laparoscopic	14 (22)
Conversion to open	7/14 (50)
Arterial reconstruction,* n (%)	19 (29)
Celiac axis	5/19 (26)
Common hepatic artery	12/19 (63)
Superior mesenteric artery	7/19 (37)
Resected venous segment, n (%)	
Patch repair	1/60 (2)
SMV only	16/60 (27)
Portal vein only	6/60 (10)
PV-SMV confluence	37/60 (62)
Splenic vein management, n (%)	
Preserved	22 (34)
Reimplanted	1 (2)
Ligated/resected	42 (65)
Left adrenal vein management, n (%)	
Preserved	29 (45)
Ligated	36 (55)



- 65 Patients
- Gap of at least 4 to 5 cm(an additional 1 to 2 cm if adrenal vein ligate)
- LRV patency 90%
- LRV mortality 5%

Fogliati, Alessandro, Fiorentini, Guido, et al. "Technical Outcomes of Porto-Mesenteric Venous Reconstruction in Pancreatic Resection Using Autologous Left Renal Vein Graft as Conduit. Journal of the American College of Surgeons 237(1):p 58-67, July 2023.

Techniques and results of portal vein/superior mesenteric vein reconstruction using femoral and saphenous vein during pancreaticoduodenectomy

Dae Y. Lee, MD,[a] Erica L. Mitchell, MD,[a] Mark A. Jones, MD,[a] Gregory J. Landry, MD,[a] Timothy K. Liem, MD,[a] Brett C. Sheppard, MD,[b] Kevin G. Billingsley, MD,[b,c] and Gregory L. Moneta, MD,[a] *Portland, Ore*

Techniques

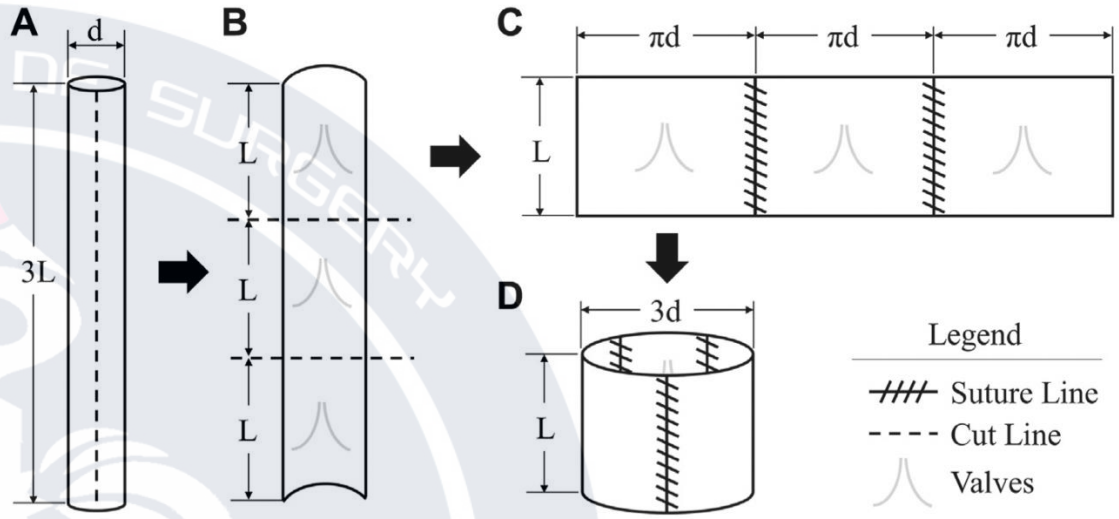
- Preoperatively, vein mapping was performed to evaluate the diameter and wall characteristics of the GSV and FVs of both lower extremities. 3000 to 4000 units of heparin were given before clamping the splanchnic veins
- Leg veins were harvested through continuous incisions. If the FV was harvested, a closed suction drain was left in place until the output was less than 40 mL/day. Profunda femoris vein is preserved
- Patency 88% in 5 months
- Presence DVT 3/34(8.8%) in 2 year

D.Y. Lee, E.L. Mitchell, M.A. Jones, et al. Techniques and results of portal vein/superior mesenteric vein reconstruction using femoral and saphenous vein during pancreaticoduodenectomy, J Vasc Surg, 51 (5) (2010), pp. 662-666

Clinical Research

Paneled Saphenous Vein Grafts Compared to Internal Jugular Vein Grafts in Venous Reconstruction after Pancreaticoduodenectomy

Joe L. Pantoja, Kevin Chang, Peter A. Pellionisz, Karen Woo, and Steven M. Farley, Los Angeles, California



Outcomes	IJVG ($n = 5$)	SVG ($n = 13$)
Graft thrombosis during initial hospitalization	2 (40%)	2 (15.3%)
Length of stay (days)	15.2 +/− 5.5	10.2 +/− 3.3
Liver enzymes elevated on postoperative day 1−3	2 (40%)	5 (38.5%)
Liver enzymes elevated on postoperative day 4−6	0 (0%)	2 (15.3%)
Ascites	1 (20%)	3 (23.1%)
Late mortality (>30 days after venous reconstruction)	1 (20%)	3 (23.1%)

Patency 60% in 5 months

Patency 76.9% in 5 months

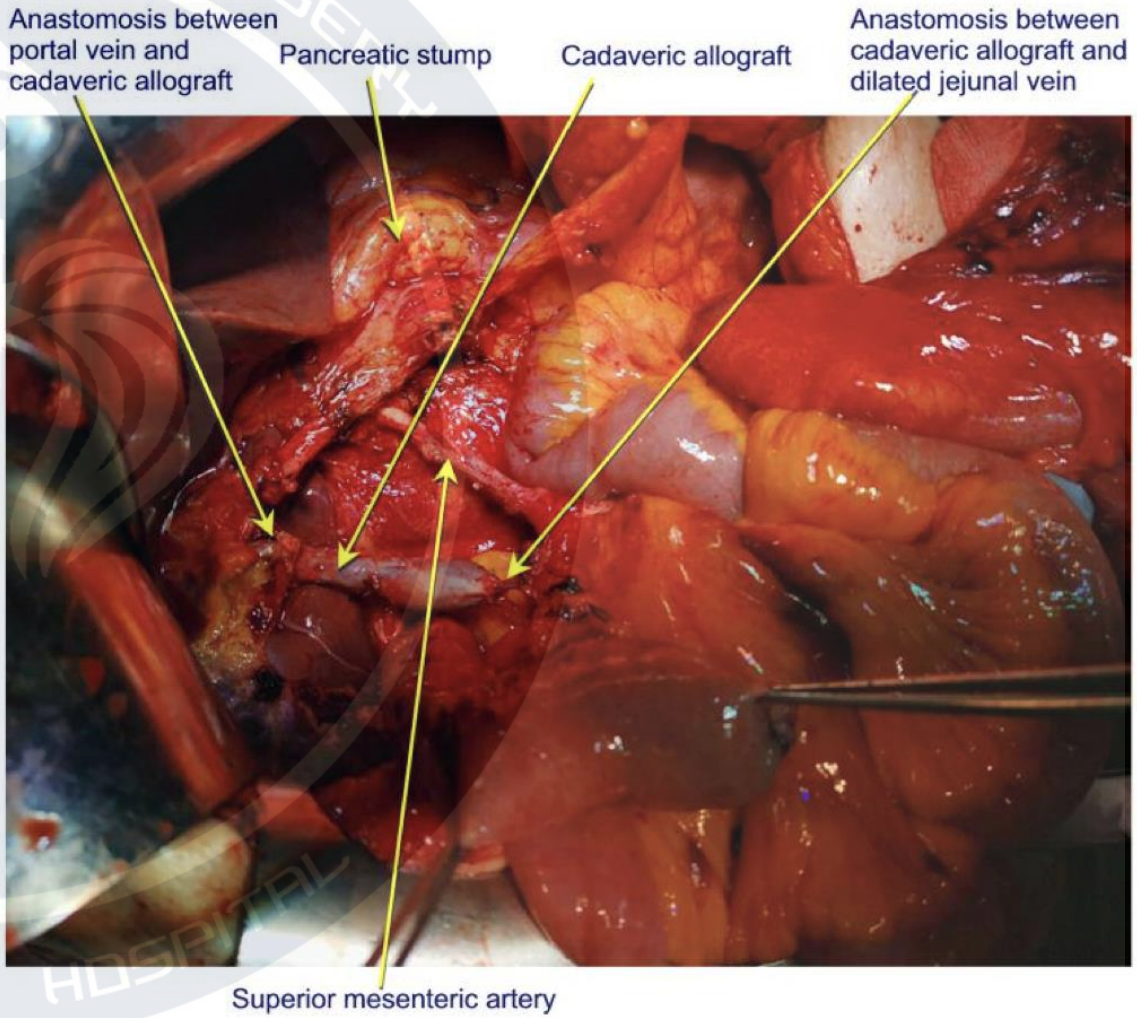
Pantoja JL, Chang K, Pellionisz PA, et al. Paneled Saphenous Vein Grafts Compared to Internal Jugular Vein Grafts in Venous Reconstruction after Pancreaticoduodenectomy. Ann Vasc Surg. 2020 May;65:17-24.

2. Allogenic vessels

Cadaveric iliac vein is the most frequently used allogeneic vessels in vascular reconstruction.

Decrease the operative time compared with autogenous vessels

Some studies showed high vascular patency, while some studies showed relatively low vascular patency



Meniconi RL, Santoro R, Guglielmo N, et al. Pancreaticoduodenectomy with venous reconstruction using cold-stored vein allografts: long-term results of a single center experience. J Hepato-Biliary-Pancreatic Sci. 2016;23(1):43e49.
Bacalbasa N, Balescu I, Vilcu M, et al. Superior Mesenteric and Portal Vein Reconstruction With Cadaveric Allograft During Pancreatoduodenectomy - A Case Report and Literature Review. In Vivo. 2020 Mar-Apr;34(2):787-79.

3. Artificial vessels

Artificial blood vessels including polytetrafluoroethylene (PTFE) materials, polyester fiber materials, etc.

Easy to obtain, and suitable diameters and lengths can be selected according to actual needs.

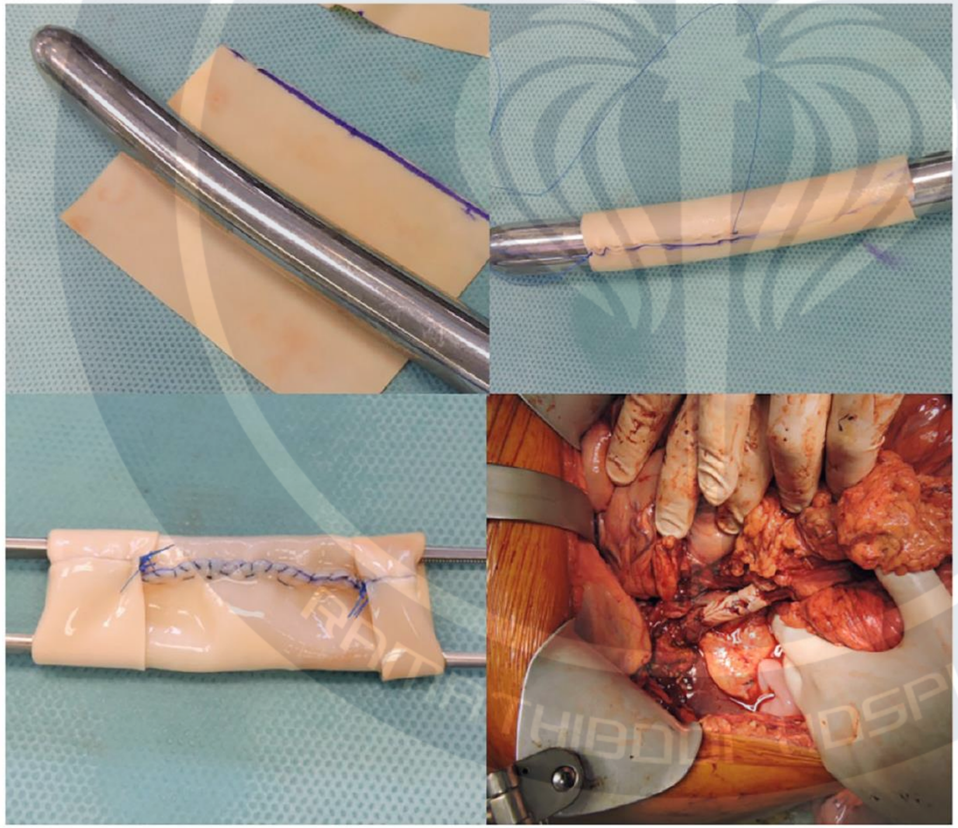
Relatively higher incidence of graft thrombosis compared with autologous vessels (overall graft thrombosis 22.2% vs 11.7%, systematic review), no graft infection

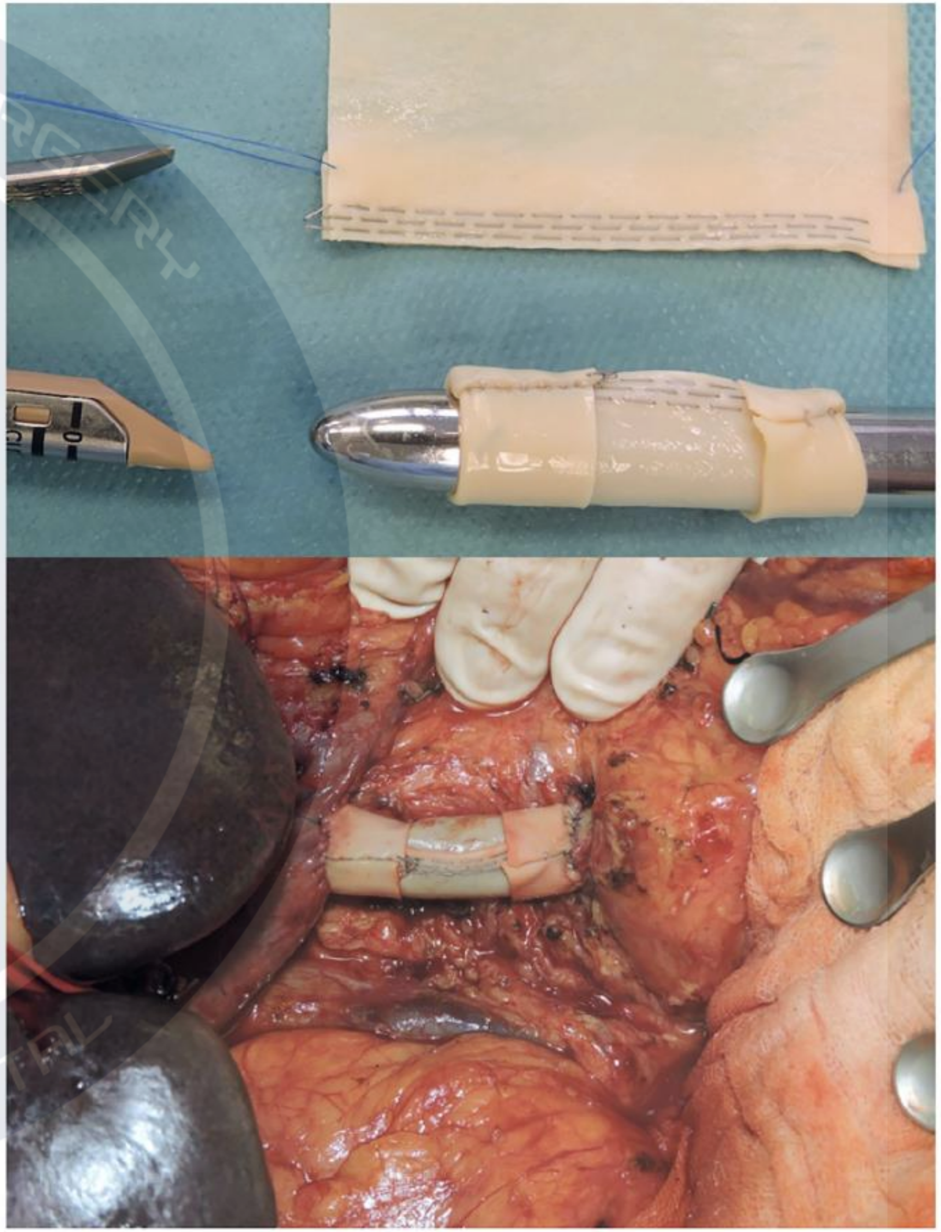
Labori KJ, Kleive D, Khan A, Farnes I, Fosby B, Line PD. Graft type for superior mesenteric and portal vein reconstruction in pancreatic surgery - a systematic review. HPB : the official journal of the International Hepato Pancreato Biliary Association. 2021;23(4):483e494.

4. Bovine pericardium

In a study including 15 surgical procedures, 13/15 patients (87%) had a patent graft

Vary size





Burla L, Schwerdel I, Weibel P, Weber M, Zientara A, Attigah N. Intraoperatively self-made bovine pericardial graft for portomesenteric reconstruction in pancreatic surgery. Langenbeck's Arch Surg 2020;405(5):705e712.

Vascular complication

	Autologous	Allogenic	Artificial(PTFE)	Bovine pericardium
Graft patency	85-100%	56-100%	77-100%	87%
Graft thrombosis/Stenosis	11.7%	6.2%	22.2%	13%
Mortality	2.7%	3.2%	2.7%	NS

Burla L, Schwegler I, Weibel P, Weber M, Zientara A, Attigah N. Intraoperatively self-made bovine pericardial graft for portomesenteric reconstruction in pancreatic surgery. Langenbeck's Arch Surg. 2020;405(5):705e712.
Labori KS, Kleive D, Khan A et al. Graft type for superior mesenteric and portal vein reconstruction in pancreatic surgery - A systematic review. HPB (Oxford). 2021 Apr;23(4):483-494.

Post-operative part

Post operative evaluation

- Routine duplex ultrasound examinations
- Serum liver enzymes are closely monitored to recognize potential venous flow impairments immediately.
- In doubtful duplex findings suggesting stenosis or occlusion of the anastomosis, a CE-CT is the diagnostic method of choice to clarify the situation and allow decision-making for the further management.

Alexis Ulrich, Pietro Contin, and Thilo Hackert, Portal Vein Resection: How I Do It, Surgery for Pancreatic and Periampullary Cancer, 2018

Role of Antiplatelets and anticoagulant

Anticoagulation policy after venous resection with a pancreatectomy: a systematic review. HPB (Oxford). 2014

- AC + 8 studies(n = 266 patients) and AC- 5 studies(n = 95 patients)
- Highly heterogeneity
- Early portal vein thrombosis : AC+ group 18/266 (7%) compared with the AC– group 2/70 (3%) *P* = 0.270
- Bleeding : AC+ group 22/255(8%) compared with the AC- group 7/32 P = 0.025
- Mortality : AC+ group 12/266(5%) compared with the AC- group 6/95 P = 0.583

Chandrasegaram MD, Eslick GD, Lee W et als.Anticoagulation policy after venous resection with a pancreatectomy: a systematic review. HPB (Oxford). 2014 Aug;16(8):691-8.

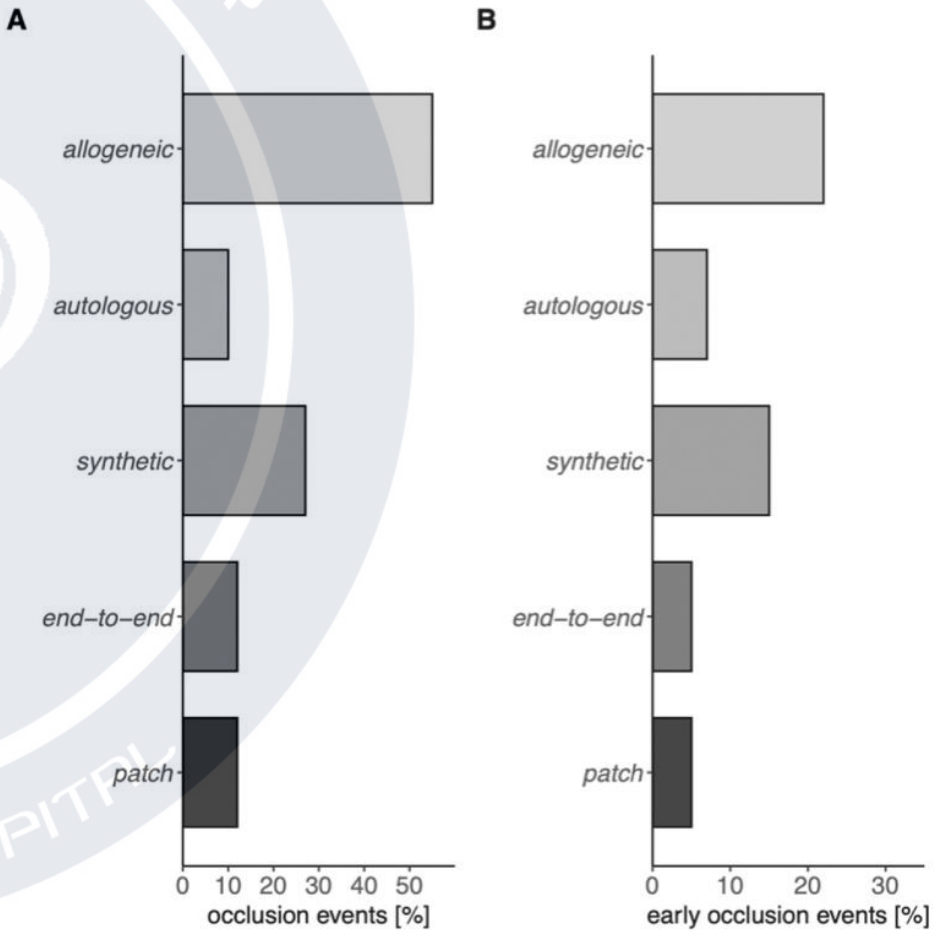
Table 1 Anticoagulation group (AC+ group, $n = 8$)

First author Country Year	n_{PVR}	Tangential PVR with primary repair (*n*)	Segmental PVR with primary repair (*n*)	Prosthetic grafts (*n*)	Vein patch or interposition	Intra-operative heparinization	Clamp time (min)	SMA inflow occlusion	AC+ policy	AC+ (*n*)	EPVT (*n*)	Bleeding (*n*)
Carrère N France 2006[18]	45	25	19	0	1	NR	Mean 19 ± 3 (range 7–58)	Not used	1st 15 patients therapeutic systematic heparin, all others received subcutaneous prophylactic LMWH	15	2	7
Smoot RL US 2006[19]	64	29	13	18	4	Not used	Mean 14	Yes	Aspirin $n = 19$, Warfarin $n = 11$, Clopidogrel $n = 4$	34	3	2
Riedinger H Germany 2006[20]	53	34	17	0	2	NR	NR	NR	Systemic therapeutic heparin aiming APTT 40–50 for segmental resection ($n = 17/53$), all others received prophylactic low dose heparin	17	0	4
Smoot RL US 2007[21]	9	0	0	0	9	Not used	NR	Yes	One patient received clopidogrel, and the remainder daily aspirin if no clot on post-operative imaging. If clot noted on imaging systemic heparin used.	9	0	1
Illuminati G Italy 2008[22]	29	15	11	0	3	Systemic heparin 0.5 mg/kg	9	Not used	LMWH for one month followed by aspirin 100 mg/daily	29	0	1
Ouaïssi M France 2008[15]	27	24	1	2	0	NR	<20	Not used	Systemic therapeutic heparin 500 U/kg/day for 10 days followed by warfarin for 3 months in $n = 8/27$; PTFE $n = 2$, t angential SMV/PV resection $n = 6$. All others, $n = 19/27$ received preventative LMWH.	8	7	4
Stauffer JA US 2009[14]	28	1	10	10	7	Not used	18	NR	Autologous PVR had standard perioperative thromboprophylaxis, PTFE grafts $n = 10/28$, had thromboprophylaxis plus low dose warfarin 1–2 mg for 3 months.	10	6	0
Kendrick ML US 2011[23]	11	6	0	0	5	Systemic heparin intraoperative 3000–5000 units	35	Not used	Low dose aspirin 81 mg for 3 months. If cancer or previous thrombosis, warfarin given.	11	0	3
Total	266	134	71	30	31					133 (50%)	18 (7%)	22 (8%)

Role of Antiplatelets and anticoagulant

Thrombosis and anticoagulation after portal vein reconstruction during pancreatic surgery: a systematic review. J Gastrointest Surg. 2025 Jan

- Role of antiplatelets and anticoagulant remains unclear



Heckler M, Tolychronidis G, Kinny-Köster B, et al. Thrombosis and anticoagulation after portal vein reconstruction during pancreatic surgery: a systematic review. J Gastrointest Surg. 2025 Jan;29(1):101852.

Anticoagulation strategies of included studies.

Authors	Year	Anticoagulation strategy
Smoot et al.[24]	2006	Surgeons preference (aspirin, warfarin, clopidogrel, or none)
Stauffer et al.[25]	2009	1–2 mg/d of warfarin
Lee et al.[36]	2010	Intraoperative: 3000–4000 IU heparin
Chu et al.[40]	2010	Intraoperative: 3000–5000 IU heparin; postoperative: low-dose aspirin or low-dose warfarin
Gawlas et al.[44]	2014	DVT prophylaxis
Hirono et al.[41]	2014	No routine anticoagulation, therapeutic anticoagulation for PTFE recipients with complications
Liao et al.[43]	2014	No routine anticoagulation
Kang et al.[46]	2015	NA
Iorgulescu et al.[26]	2015	prophylactic LMWH
Selvaggi et al.[42]	2014	NA
Meniconi et al.[27]	2016	Prophylactic LMWH (for 30 d)
Yamamoto et al.[29]	2017	NA
Kleive et al.[28]	2016	LMWH (200 IU/kg 1 mo; 100 IU/kg 2 mo)
Glebova et al.[45]	2015	No routine anticoagulation
Miyazaki et al.[30]	2017	Systemic heparinization during the first postoperative week
Kleive et al.[31]	2018	Half-dose or full-dose LMWH. Lifelong aspirin “at the surgeon’s discretion”
Al Faraï et al.[32]	2019	Therapeutic anticoagulation in PTFE recipients
Groen et al.[34]	2022	NA
Roch et al.[38]	2022	Surgeons preference
Hackert et al.[37]	2022	PTT controlled heparinization 48–72 h with transition to therapeutic LMWH (graft interposition)
Kinny-Köster et al.[35]	2022	Intraoperative: 80–100 IU/kg heparin; postoperative: lifelong aspirin (325/81 mg), heparin derivates not routinely used
Vuorela et al.[33]	2022	Full heparinization with ACT of 200–300 s
Fogliati et al.[39]	2023	Intraoperative heparinization (not further specified)

ACT, activated clotting time; DVT, deep vein thrombosis; LMWH, low-molecular-weight heparin; NA, not available; PTFE, polytetrafluoroethylene; PTT, partial thromboplastin time.

Portal Vein Resection in Pancreatic Cancer Surgery: Risk of Thrombosis and Radicality Determine Survival

Thilo Hackert, MD, Ulla Klaiber, MD, Ulf Hinz, MSc, Susanne Strunk, MD, Martin Loos, MD, Oliver Strobel, MD, Christoph Berchtold, MD, Yakup Kulu, MD, Arianeb Mehrabi, MD, Beat P. Müller-Stich, MD, Martin Schneider, MD, and Markus W. Büchler, MD ✉

Of 2265 PDAC resections, 1571 (69.4%) were standard resections and 694 (30.6%) were resections with PVR,

including 149 (21.5%) tangential resections with venorrhaphy (ISGPS type 1), 21 (3.0%) resections with patch

reconstruction (type 2), 491 (70.7%) end-to-end anastomoses (type 3), and 33 (4.8%) resections with graft interposition (type 4).

Protocol

Start heparin after 4 hours postoperatively(keep PTT 40-60) then switch to LMWH after 48-72 hours postoperatively

Hackert, Thilo MD; Klaiber, Ulla MD; Hinz, Ulf MSc, Portal Vein Resection in Pancreatic Cancer Surgery: Risk of Thrombosis and Radicality Determine Survival. Annals of Surgery 277(6):p e1291-e1298, June 2023.

Portal Vein Resection in Pancreatic Cancer Surgery: Risk of Thrombosis and Radicality Determine Survival

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	Total (n = 694)	Type 1 (n = 149)	Type 2 (n = 21)	Type 3 (n = 491)	Type 4 (n = 33)	*P*
Morbidity						
Nonsurgical	127 (18.3)	22 (14.8)	3 (14.3)	97 (19.8)	5 (15.2)	0.544
Pneumonia	41 (5.9)	9 (6.0)	1 (4.8)	29 (5.9)	2 (6.1)	1.0
Urinary tract infection	59 (8.5)	7 (4.7)	2 (9.5)	47 (9.6)	3 (9.1)	0.253
Surgical pancreas specific	193 (27.8)	29 (19.5)	8 (38.1)	140 (28.5)	16 (48.5)	0.0038
Pancreatic fistula	40 (5.8)	13 (8.7)	2 (9.5)	24 (4.9)	1 (3.0)	0.204
Pancreatic fistula B	32 (4.6)	12 (8.0)	2 (9.5)	17 (3.5)	1 (3.0)	
Pancreatic fistula C	8 (1.2)	1 (0.7)	0 (0.0)	7 (1.4)	0 (0.0)	
Delayed gastric emptying	90 (13.0)	5 (3.4)	4 (19.0)	73 (14.9)	8 (24.2)	<0.0001
Hemorrhage	49 (7.1)	12 (8.0)	1 (4.8)	35 (7.1)	1 (3.0)	0.875
Interventional/conservative	17 (1.7)	6 (4.0)	0 (0.0)	11 (2.2)	0 (0.0)	
Operative	32 (4.6)	6 (4.0)	1 (4.8)	24 (4.9)	1 (3.0)	
Portal vein thrombosis	50 (7.2)	5 (3.4)	11 (4.8)	37 (7.5)	7 (21.2)	0.0077
Relaparotomy	112 (16.1)	13 (8.7)	3 (14.3)	85 (17.3)	11 (33.3)	0.0029
Completion pancreatectomy	12 (1.7)	1 (0.7)	0 (0.0)	10 (2.0)	1 (3.0)	0.561

Hackert, Thilo MD; Klaiber, Ulla MD; Hinz, Ulf MSc, Portal Vein Resection in Pancreatic Cancer Surgery: Risk of Thrombosis and Radicality Determine Survival. Annals of Surgery 277(6):p e1291-e1298, June 2023.

Management of acute portal vein thrombosis

- Incidence 2-6% after hepatobiliary surgery
- Sign & Symptoms : abdominal pain, bloody stool, Ascites, abnormal liver function test
- Need high index of suspicious
- Diagnosis test
  - Color doppler : sens 88%, spec 92%
  - CT scan : sens 90%, spec 99%
  - MRV : sens 100%, spec 90% (usually is not required but is instead more useful in the chronic state)

Thomas RM, Ahmad SA. Management of acute post-operative portal venous thrombosis. J Gastrointest Surg. 2010 Mar;14(3):570-7.

Management of acute portal vein thrombosis

- Management
  - Anticoagulant[1]
    - 83%(50% Recanalization) were started on anticoagulation within 1 week of symptoms.
    - LMWH or unfractionated heparin then switch to oral anticoagulant or DOAC, keep INR 2-3[2]
    - Major bleeding was reported by 5.8% (95% CI: 3.7–8.9%; I^2 = 29.2%; p = 0.125)[2]
    - Duration at least three to six months or lifelong in high risk for coagulant was not correct or extending to mesenteric vein[2]

[1]Thomas RM, Ahmad SA. Management of acute post-operative portal venous thrombosis. J Gastrointest Surg. 2010 Mar;14(3):570-7.

[2]Boccatonda A, Gentilini S, Zanata E, Simion C, Serra C, Simioni P, Piscaglia F, Campello E, Ageno W. Portal Vein Thrombosis: State-of-the-Art Review. Journal of Clinical Medicine. 2024; 13(5):1517.

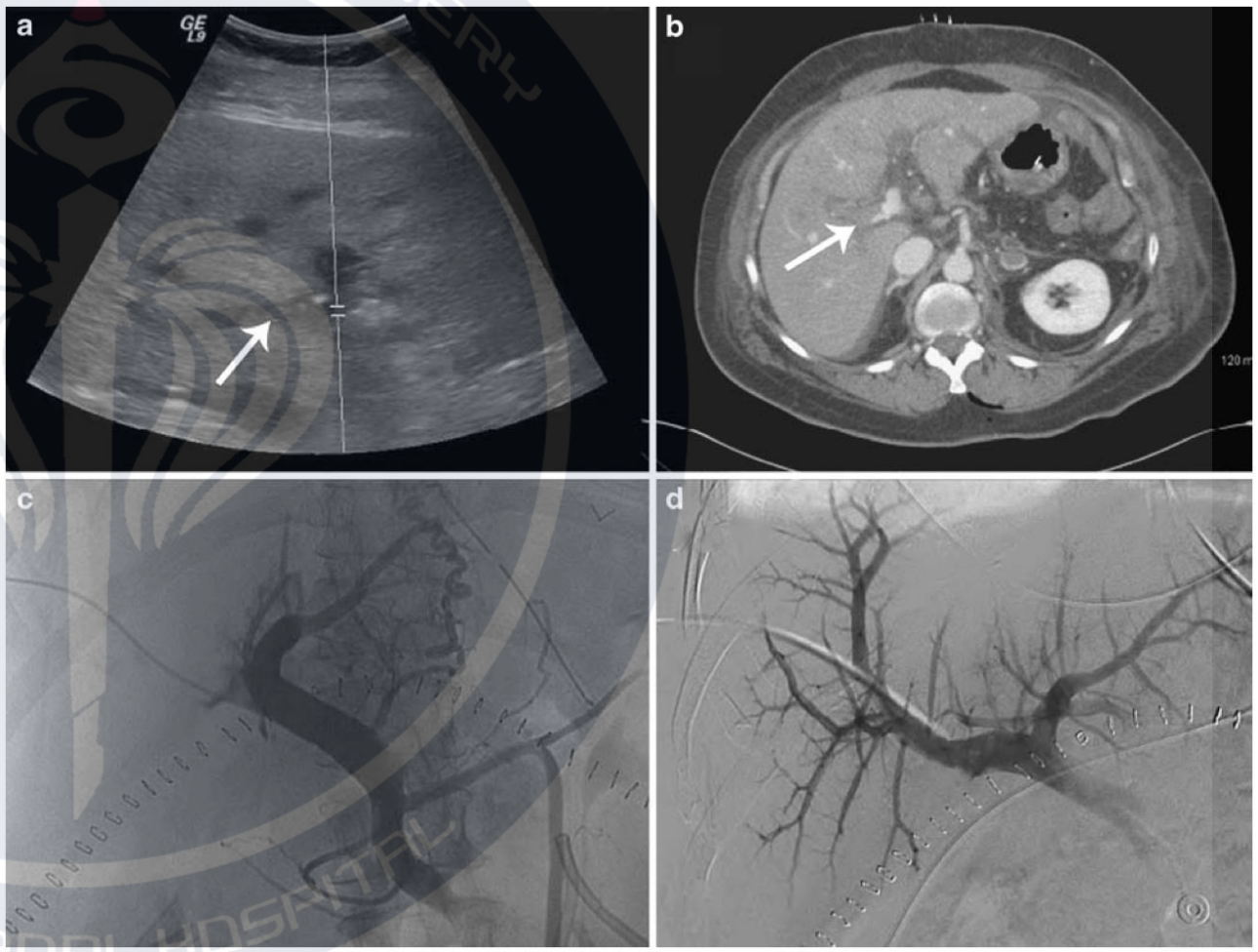
Management of acute portal vein thrombosis

- Management
  - Thrombolytic therapy
    - Condat et al.[3]
      - Only 37% of patients have complete recanalization
      - 55.5% and 7.4% of patients demonstrating incomplete or no recanalization with only anticoagulation as treatment
      - SMA-directed thrombolytics
      - PV route thrombolytics
        - better recanalization with the PV route compared to the SMA route (83% partial recanalization versus 50%, respectively)

Condat B, Pessione F, Helene Denninger M, Hillaire S et al. Recent portal or mesenteric venous thrombosis: increased recog- nition and frequent recanalization on anticoagulant therapy. Hepatology 2000;32(3):466-470.

Management of acute portal vein thrombosis

- Management
  - Operative and mechanical thrombectomy
    - Undergoing bowel infarction surgery and performed during laparotomy
    - high technical success rates have been observed in some case series
    - Suggest performed with thombolytic



[1]Thomas RM, Ahmad SA. Management of acute post-operative portal venous thrombosis. J Gastrointest Surg. 2010 Mar;14(3):570-7.

[2]Boccatonda A, Gentilini S, Zanata E, Simion C, Serra C, Simioni P, Piscaglia F, Campello E, Ageno W. Portal Vein Thrombosis: State-of-the-Art Review. Journal of Clinical Medicine. 2024; 13(5):1517.

Vascular resection and reconstruction in pancreatic head cancer (part II)

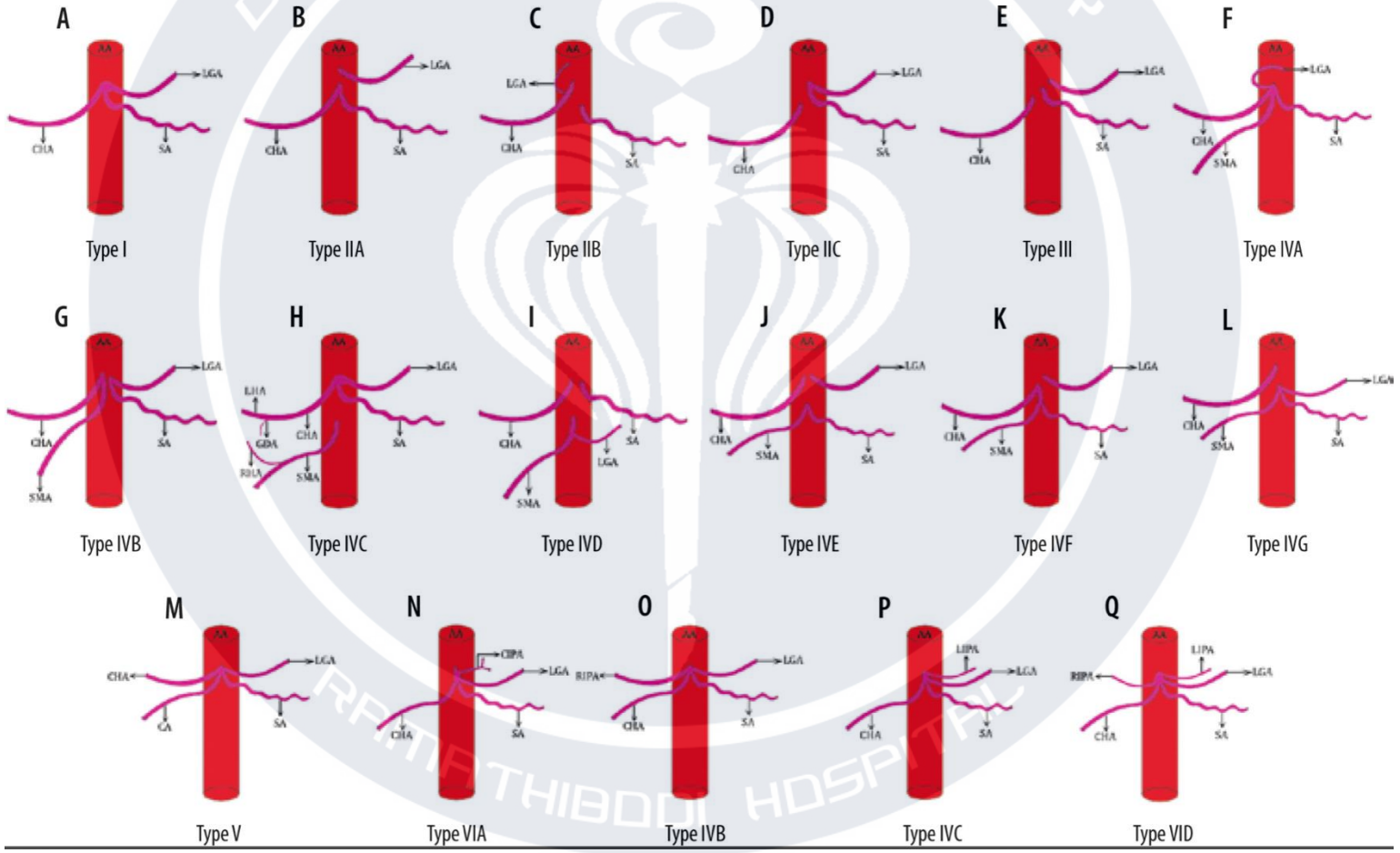
F Ativitch Asavachaisuvikom

Asst. Prof. Paramin Muangkaew

HPB surgery unit, Faculty of Medicine, Ramathibodi hospital, Mahidol University

Artery

Anatomy of artery and variation

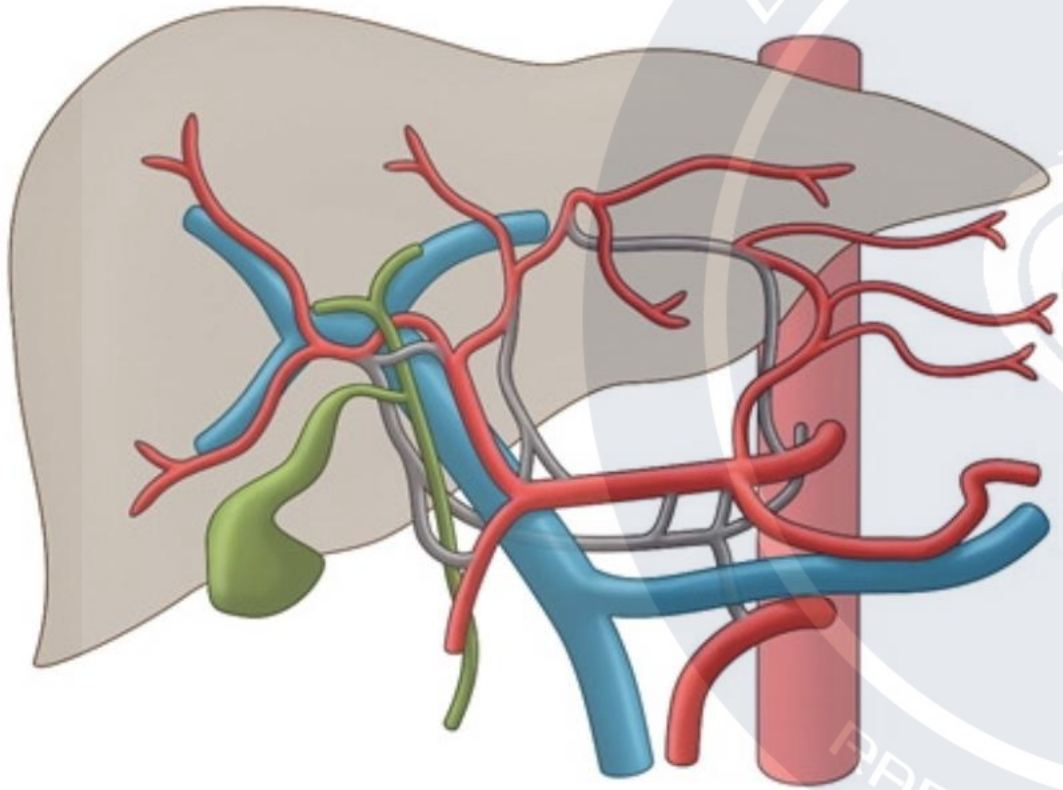


Ethiraj B, Kalyanasundaram S, Indiran V, et al. Newly proposed classification of celiac artery variations based on embryology and correlation with computed tomography angiography. Polish Journal of Radiology. 2022;87:563-573.

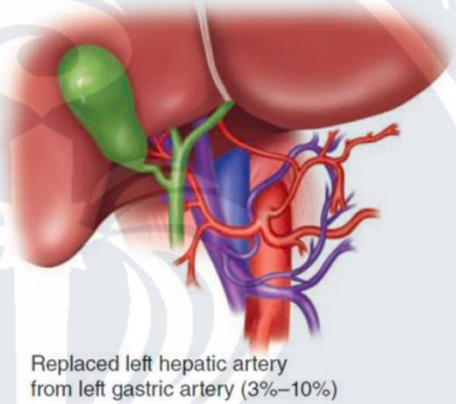
Types	CT branching pattern	Embryological basis
I	Normal trifurcation	Regression of 11th, and 12th ventral segmental roots, the persistence of the 10th and 13th roots forms CT and SMA
II(a)	Hepatosplenic trunk	Persistence of 10th, 11th, and 13th roots along with regression of horizontal part between 12th root and persistence of ventral anastomosis between 11th and 12th
II(b)	Hepatogastric trunk	Persistence of 10th,11th, and 13th roots and ventral anastomosis of 10th and 12th along with regression of horizontal part between 12th root and ventral anastomosis
II(c)	Gastrosplenic trunk	Persistence of 10th root and ventral anastomosis between 10th and 11th along with regression of horizontal part between 11th root and ventral anastomosis
III	No celiac trunk	Persistence of 10th, 11th, 12th, and 13th roots and regression of ventral anastomosis
IV(a)	Celiomesenteric trunk	Regression of horizontal part between 10th, 11th, and 12th roots and persistence of 13th root along with ventral anastomosis
IV(b)	Hepatomesenteric trunk	Regression of horizontal part of 13th root along with the persistence of 10th, 11th, and 12th roots and ventral anastomosis between 12th and 13th
IV(c)	Right hepatomesenteric trunk	Regression of 11th and 12th ventral segmental roots, the persistence of the 10th and 13th roots and part of 12th segment may attach with 13th ventral segmental branch
IV(d)	Gastro mesenteric trunk	Regression of horizontal part between 13th root and ventral anastomosis, and persistence of ventral anastomosis between 10th and 13th
IV(e)	Splenomesenteric trunk	Regression of horizontal part between 13th root and ventral anastomosis, and persistence of ventral anastomosis between 11th and 13th
IV(f)	Hepatosplenomesenteric trunk	Regression of horizontal part of 12th and 13th roots, and persistence of ventral anastomosis between 11th, 12th, and 13th
IV(g)	Gatrosplenomesenteric trunk	Regression of horizontal part of 11th and 13th roots and persistence of ventral anastomosis between 10th, 11th, and 13th.
V	Celiac-colic trunk	Regression of 11th and 12th ventral segmental roots, the persistence of the 10th and 13th roots and part of 13th segment may attach with 12th ventral segmental branch
VI(a)	Coeliophrenic trunk (CT+ CIPA)	Celiaco-phrenic trunk – according to our hypothesis, celiac trunk arises from first ventral branch and IPA arises from first lateral branch, origins of these are at the same vertebral level. During embryogenesis, persistence and regression of lateral splanchnic branches and ventral branches may cause the anomalous origin of IPA from the celiac trunk.
VI(b)	Coeliophrenic trunk (CT+ RIPA)	
VI(c)	Coeliophrenic trunk (CT+ LIPA)	
VI(d)	Coeliophrenic trunk (CT+ RIPA + LIPA)	

S. No.	Types	Computed tomography branching pattern	Incidence in subtypes	Incidence in main types
1	I	Normal trifurcation	38.85%	38.85%
2	II(a)	Hepatosplenic trunk	2.66%	6.19%
3	II(b)	Hepatogastric trunk	0.09%	
4	II(c)	Gastrosplenic trunk	3.43%	
5	III	No celiactrunk	0.57%	0.57%
6	IV(a)	Celiomesenteric tTrunk	0.19%	7.71%
7	IV(b)	Hepatomesenteric trunk	0.95%	
8	IV(c)	Right hepatomesenteric trunk	6.09%	
9	IV(d)	Gastromesenteric trunk	0.00%	
10	IV(e)	Splenomesenteric trunk	0.09%	
11	IV(f)	Hepatosplenomesenteric trunk	0.38%	
12	IV(g)	Gatrosplenomesenteric trunk	0.00%	
13	V	Celiac-colic trunk	0.00%	0%
14	VI(a)	Coeliophrenic trunk (CT + CIPA)	11.33%	51.61%
15	VI(b)	Coeliophrenic trunk (CT + RIPA)	6.09%	
16	VI(c)	Coeliophrenic trunk (CT + LIPA)	18.09%	
17	VI(d)	Coeliophrenic trunk (CT + RIPA + LIPA)	16.09%	
18	Others	Additional branches	2.19	2.19%

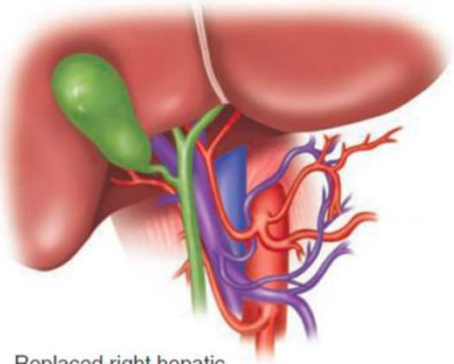
Anatomy of artery and variation



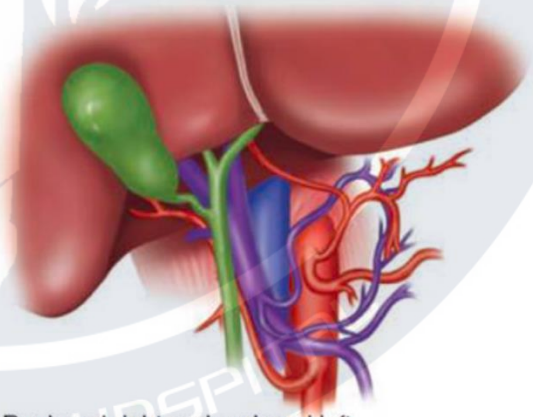
Classification 1 : Normal variation(75%)



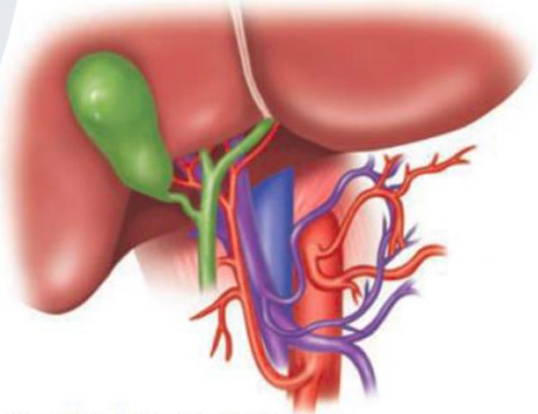
Replaced left hepatic artery
from left gastric artery (3%–10%)



Replaced right hepatic
artery from SMA (10%–15%)



Replaced right and replaced left
hepatic arteries (1%–2%)



Completely replaced common
hepatic artery from SMA (1%–2%)

Hiatt, Jonathan R. M.D.; Gabbay, Joubin; Busuttil, Ronald W. M.D., Ph.D.. Surgical Anatomy of the Hepatic Arteries in 1000 Cases. Annals of Surgery 220(1):50-52, July 1994.

The extent of mesopancreas dissection alongside the SMA

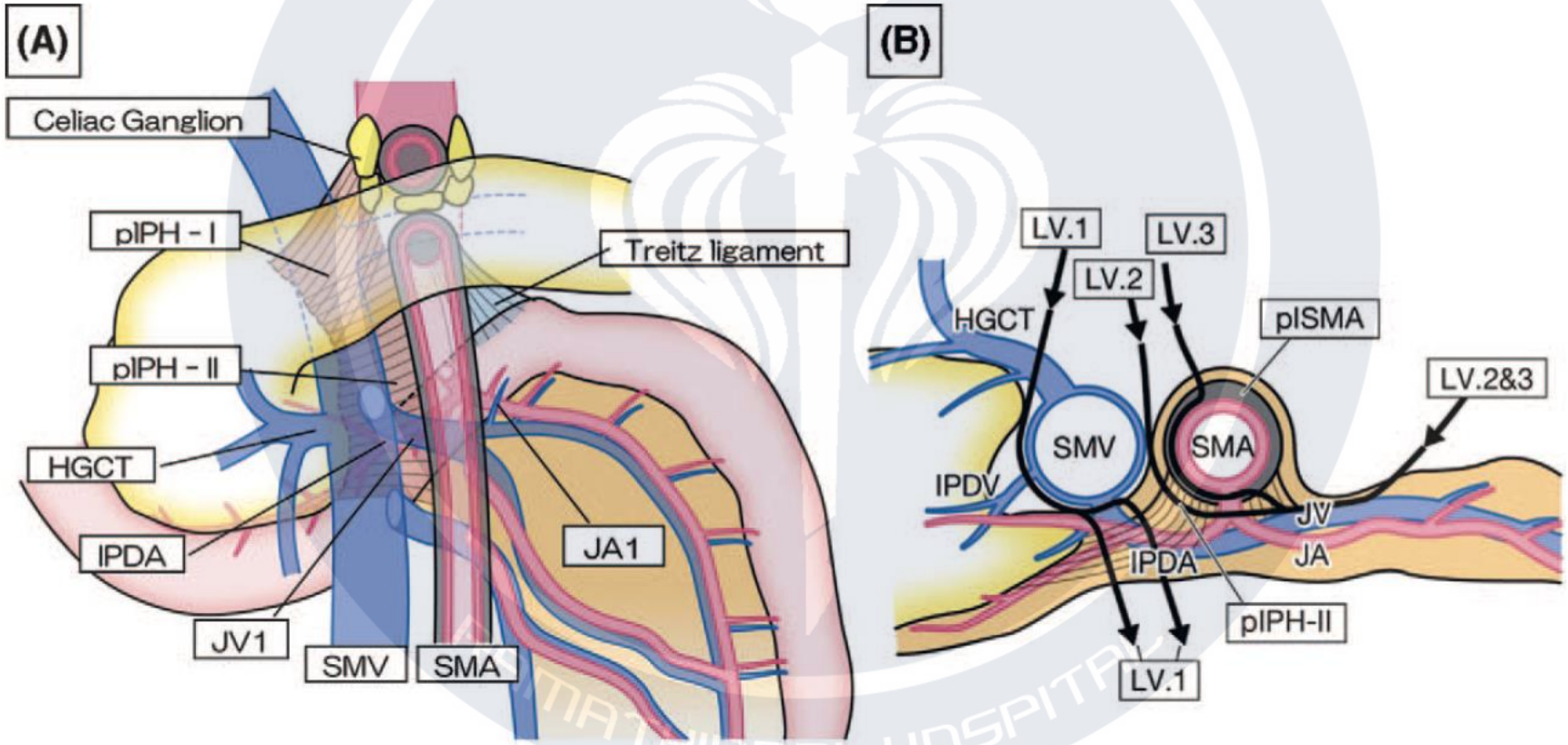
level 1 : dividing the mesopancreas while leaving nerve and lymphatic tissue surrounding the SMA intact

level 2 : systematically removing all lymph nodes adjacent to the SMA, with the inferior pancreaticoduodenal vessels severed at their origin

level 3 : entirely clearing the cuff of autonomous nerves from the right and posterior circumference of the SMA

Inoue Y, Saiura A, Yoshioka R, Ono Y, Takahashi M, Arita J et al. Pancreatoduodenectomy with systematic mesopancreas dissection using a supracolic anterior artery-first approach. Ann Surg 2015;262:1092–1101

The extent of mesopancreas dissection alongside the SMA



Inoue Y, Saiura A, Yoshioka R, Ono Y, Takahashi M, Arita J et al. Pancreatoduodenectomy with systematic mesopancreas dissection using a supracolic anterior artery-first approach. Ann Surg 2015;262:1092–1101

The extent of mesopancrease dissection alongside the SMA

TABLE 1. Aim and Indication of Each Dissection Level

	Dissection Level		
	Level 1	**Level 2**	**Level 3**
Aim of dissection			
1. Early inflow control	○	○	○
2. En bloc mesopancreas dissection		○	○
3. Gaining a cancer-free margin for invasive pancreatic cancer			○
Disease and indication			
1. Low-grade malignancy, CIS, IPMN	○		
2. Ampullary/lower bile duct/duodenal cancer		○	△*
3. Invasive pancreatic ductal cancer		△†	○

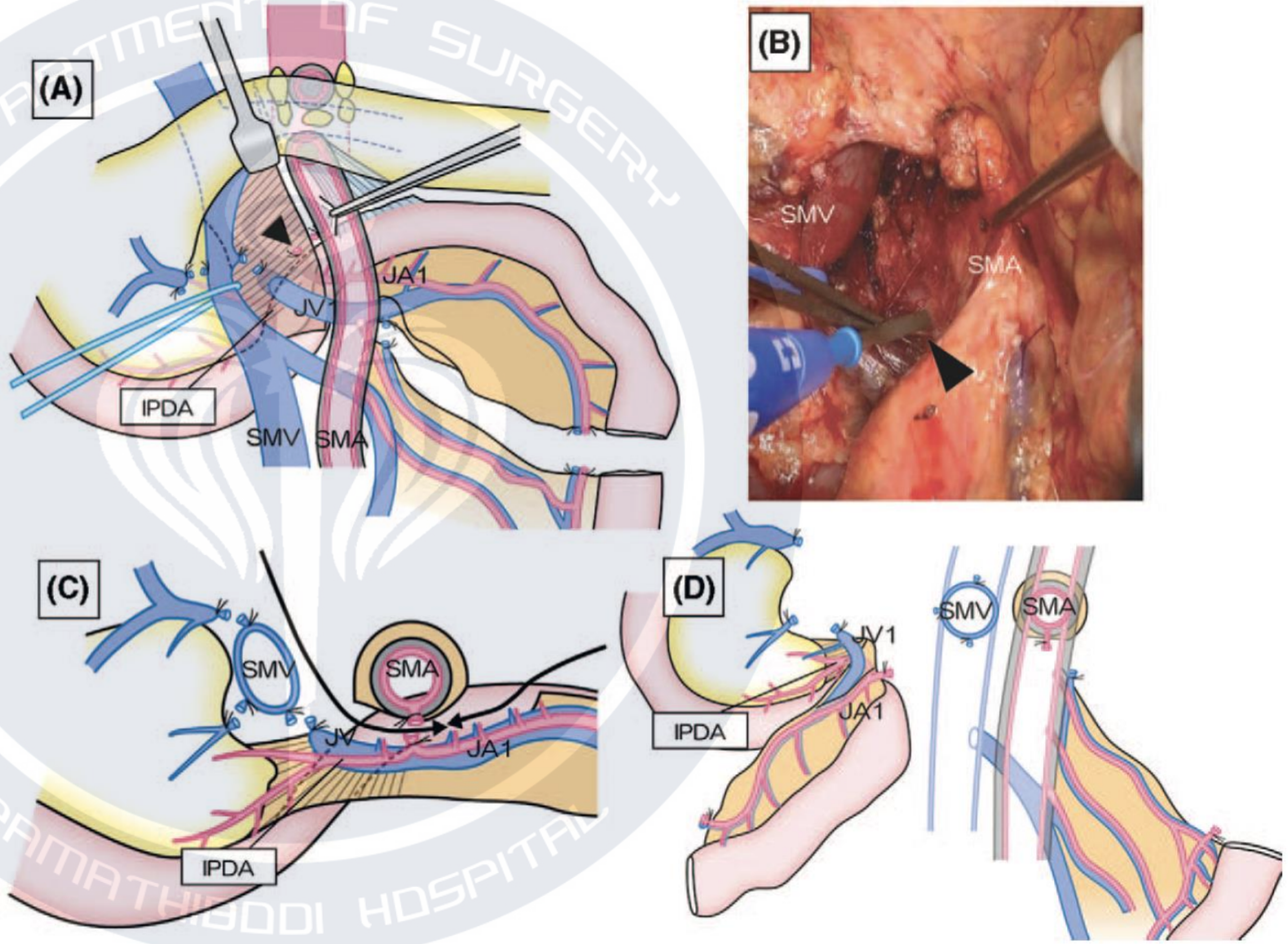
*Potentially indicative for nonpancreatic cancer suspected to have perineural invasion toward the SMA.

†Potentially indicative for pancreatic cancer apart from the SMA, or high-risk patients for extended surgical invasion.

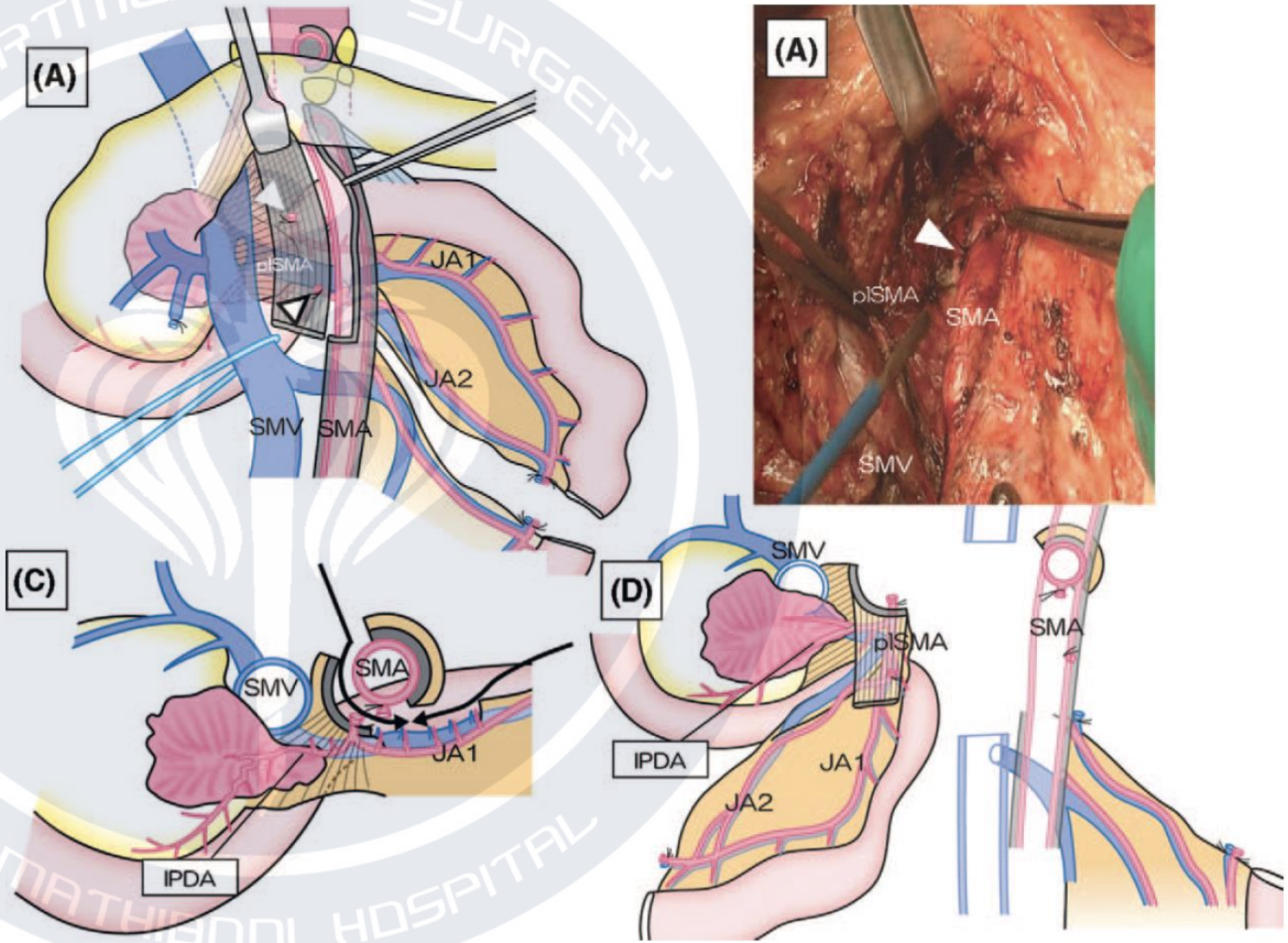
CIS indicates carcinoma in situ; IPMN, intraductal papillary mucinous neoplasm.

Inoue Y, Saiura A, Yoshioka R, Ono Y, Takahashi M, Arita J et al. Pancreatoduodenectomy with systematic mesopancreas dissection using a supracolic anterior artery-first approach. Ann Surg 2015;262:1092–1101

Mesopancrease dissection level 2



Mesopancrease dissection level 3

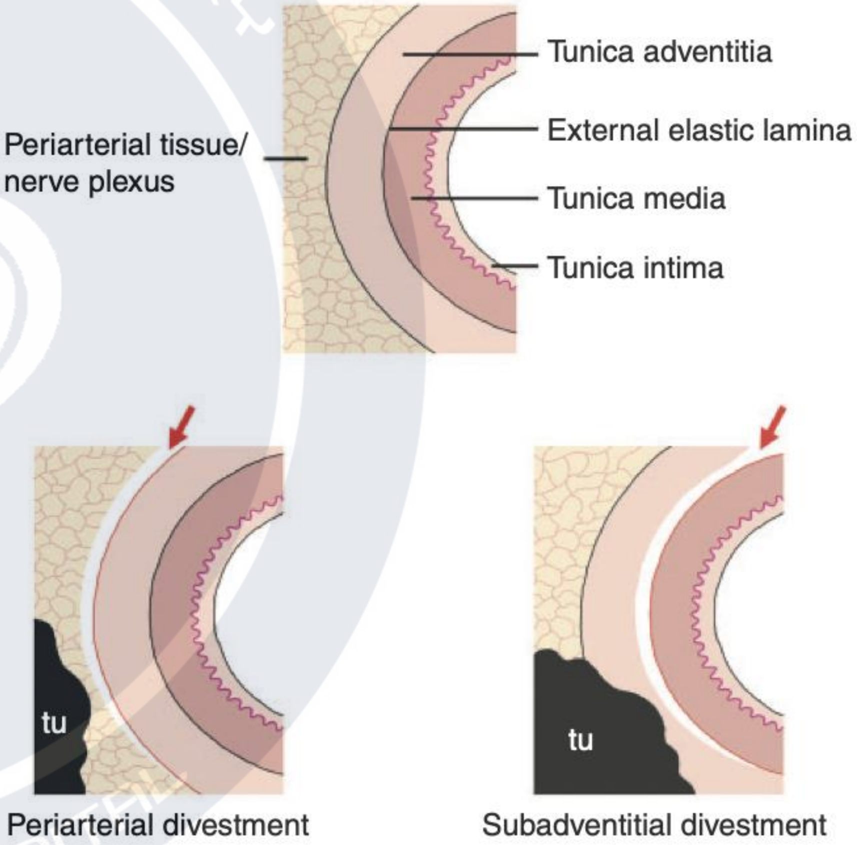


Inoue Y, Saiura A, Yoshioka R, Ono Y, Takahashi M, Arita J et al. Pancreatoduodenectomy with systematic mesopancreas dissection using a supracolic anterior artery-first approach. Ann Surg 2015;262:1092–1101

Artery divesment

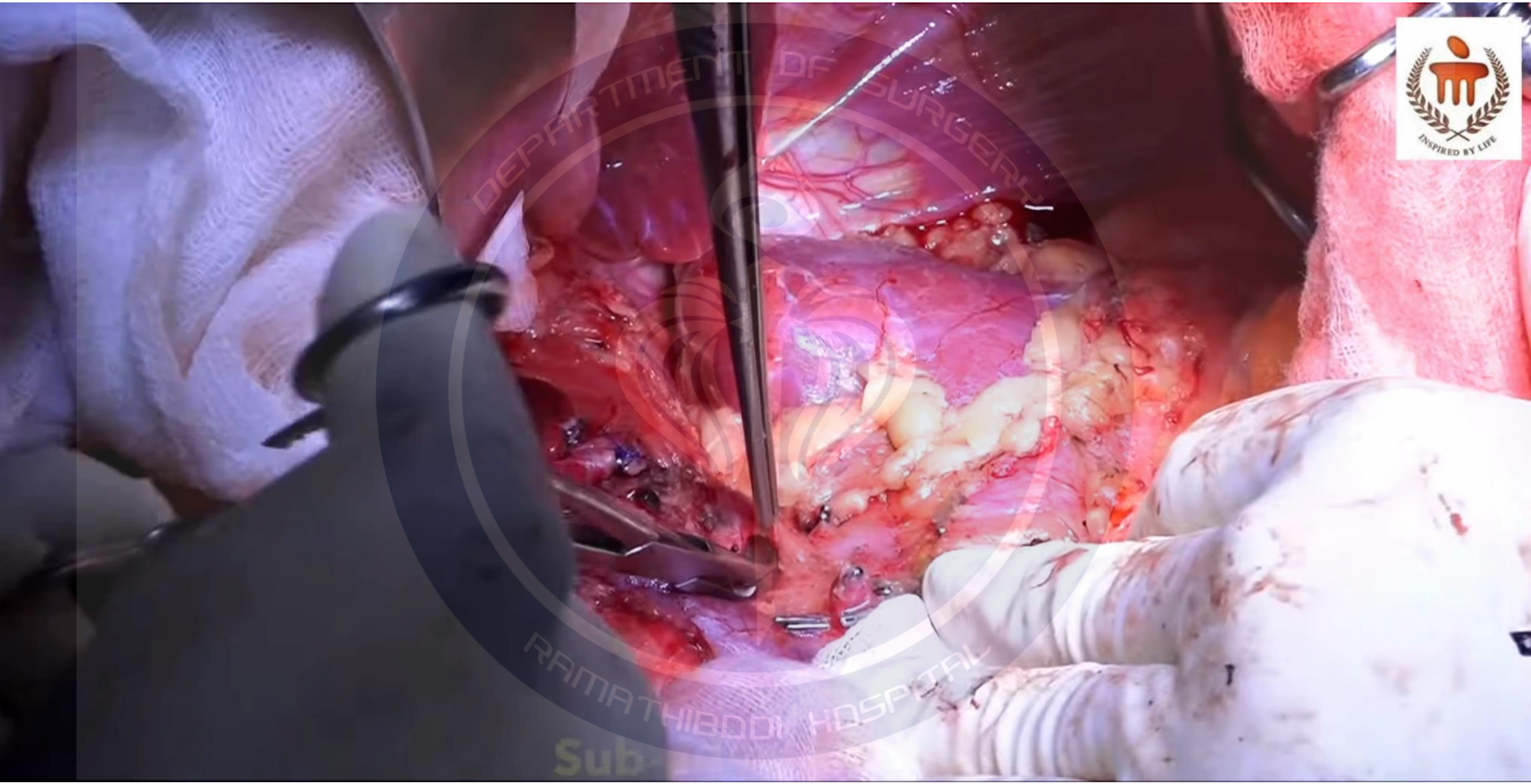
Further options for curative-intent resection in PDAC with extension to the coeliac axis and the SMA

Arterial clearance is obtained by entering a plane between the unaffected arterial wall and (remnant) tumor tissue, and sharp circumferential dissection of the tumor mass from the involved arterial segment is performed meticulously following this plane

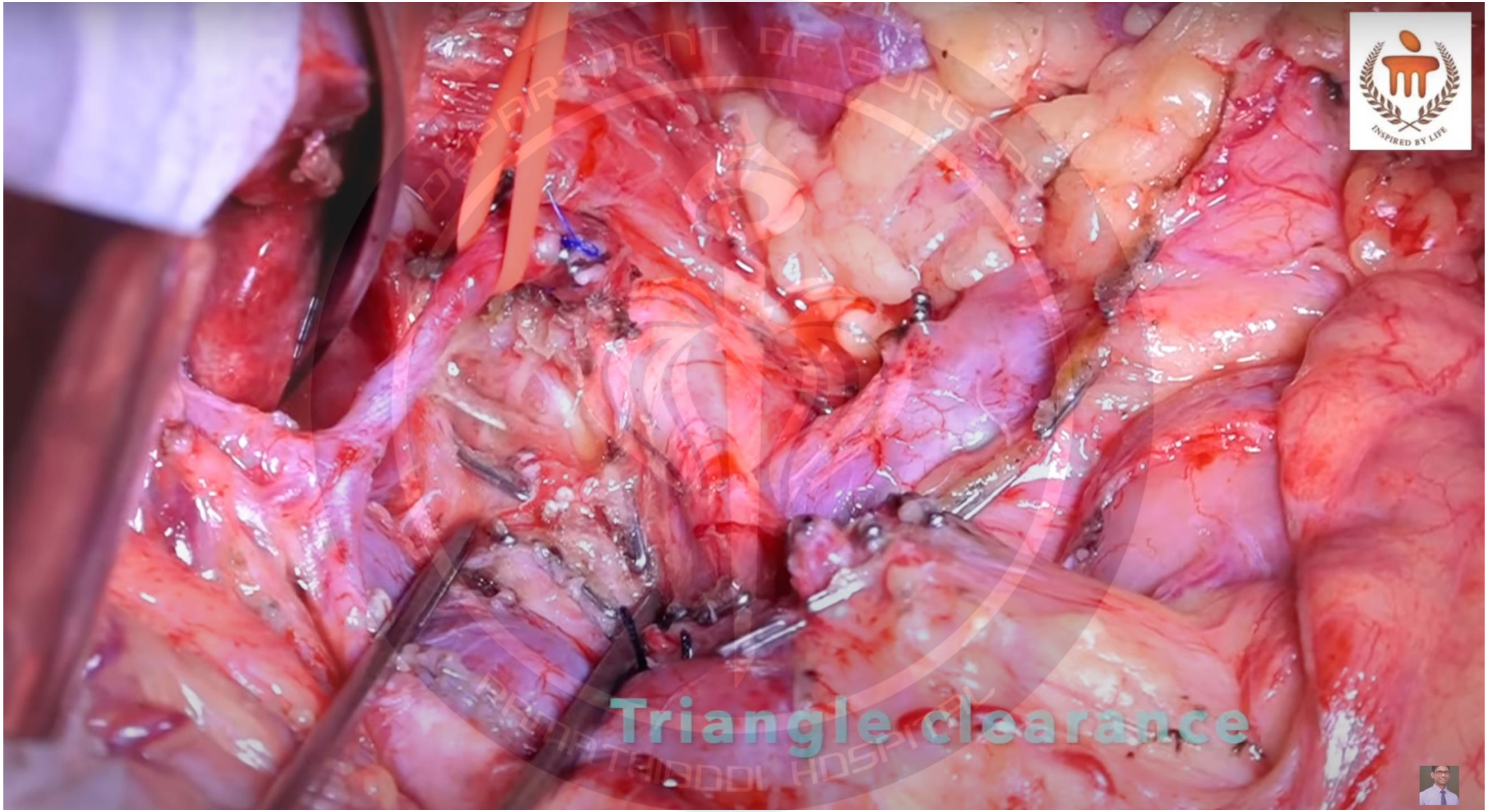


Sharp with scissor

Diener MK, Mihaljevic AL, Strobel O, Loos M, Schmidt T, Schneider M et al. Periarterial divestment in pancreatic cancer surgery. Surgery 2020 Oct 5;S0039-6060(20)30597-3. DOI: 10.1016/j.surg.2020.08.030
Ca[illegible] technique for resecting artery-involved pancreatic cancer: a retrospective cohort study. Langenbecks Arch Surg 2021 Jan 2[illegible] DOI: 10.1007/s00423-021-02080-5



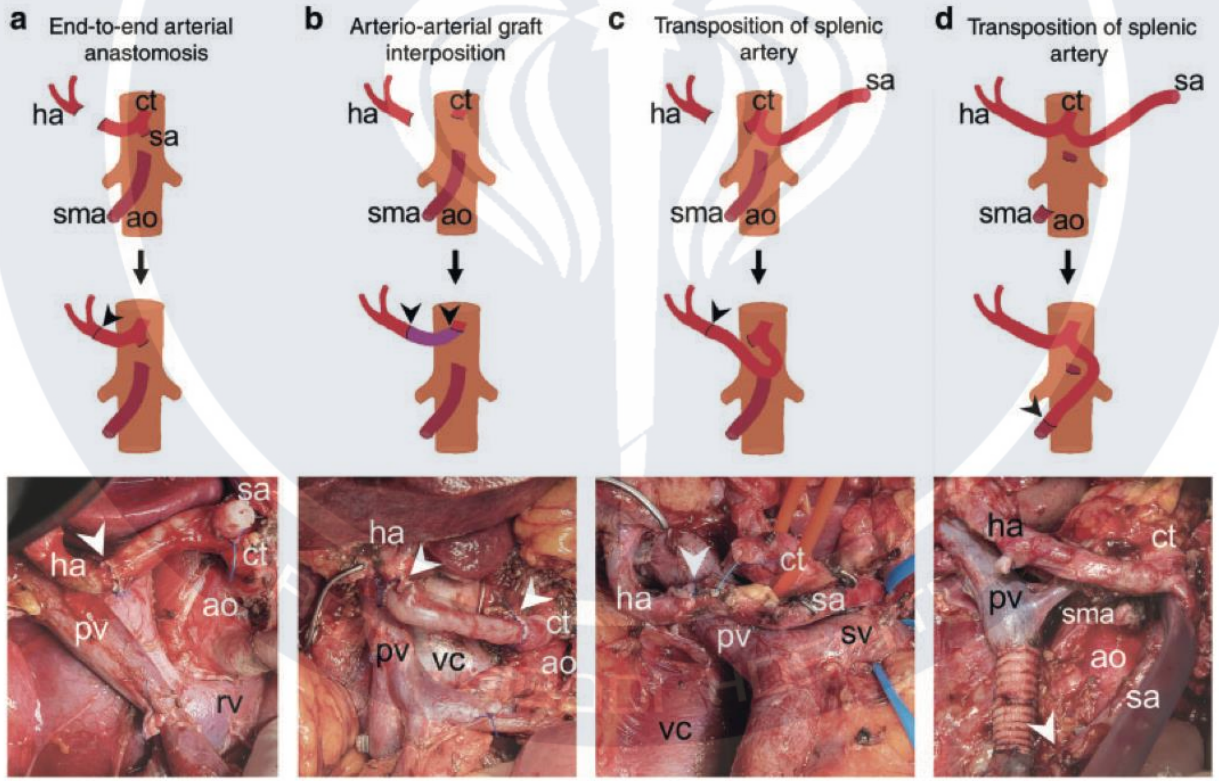
Kumar, N.A.N., Patodi, A., Usman, N. *et al.* Periarterial and Sub-adventitial Divestment Along with Triangle Operation and RAMPS for Pancreatic Body Cancer. *Ann Surg Oncol* 31, 4688–4690 (2024)



Kumar, N.A.N., Pakod, A., Usman, N. *et al.* Periarterial and Sub-adventitial Divestment Along with Triangle Operation and RAMPS for Pancreatic Body Cancer. *Ann Surg Oncol* **31**, 4688–4690 (2024)

Artery resection and reconstruction

If segmental tumor infiltration beyond the adventitial layer precludes arterial divestment, arterial resection should be considered.



Schneider M, Hackert T, Strobel O, Büchler MW. Technical advances in surgery for pancreatic cancer. Br J Surg. 2021 Jul 23;108(7):777-785. doi: 10.1093/bjs/znab133. PMID: 34046668.

Superior mesenteric artery

- Abutment < 180 degree
  - Borderline resectable
- Encasement more and equal 180 degree
  - Locally advanced
    - If response to Neoadjuvant CMT or stable disease > proceed to operation
    - If disease progression > deemed to be unresectable

Routine SMA resection and reconstruction is not considered acceptable

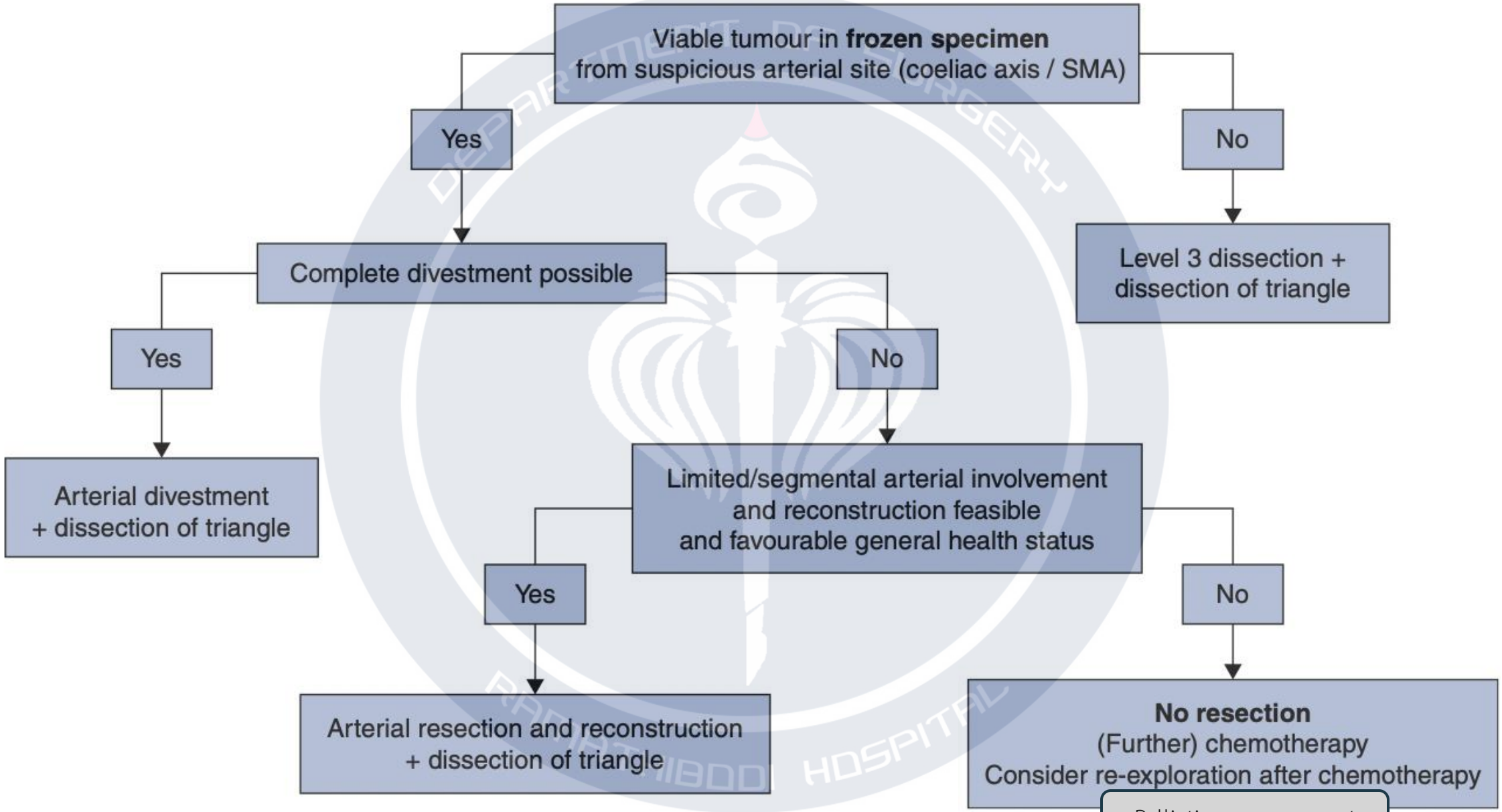
Habib JR, Kinny-Köster B, van Oosten F et al. Periadventitial dissection of the superior mesenteric artery for locally advanced pancreatic cancer: Surgical planning with the "halo sign" and "string sign". Surgery. 2021 May;169(5):1026-1031. Epub 2020 Oct 6. PMID: 33036782.

Yoon SS, Tseng JF, Lee DB, Chua A, Tanabe KK. Vascular Resection and Reconstruction in Pancreatic Cancer. Surg Clin North Am. 2006;86(6):1351-1370.

Celiac artery

- Celiac artery stenosis
  - Compression of median arcuate ligament
    - GDA clamp test before separation
    - Dissociated dense fibrous tissue at the right and upper edge
    - Reversed saphenous vein interposition graft is used to augment hepatic arterial flow
  - Atherosclerosis
    - Artery bypass graft
    - Arterial stent (In preoperative planning)
- Tumor invade celiac artery
  - Although it is common in pancreatic body/tail tumors
  - Appleby Procedure (Distal Pancreatectomy With Celiac Artery Resection)

Younan G, Tsai S, Evans DB, Christians KK. Techniques of Vascular Resection and Reconstruction in Pancreatic Cancer. Surg Clin North Am. 2016 Dec;96(6):1351-1370.
Jie Li, Zhikun Liu, Hao Xu, Jun Chen, The role of vascular resection and reconstruction in pancreaticoduodenectomy, Asian Journal of Surgery, Volume 47, Issue 1, 2024.



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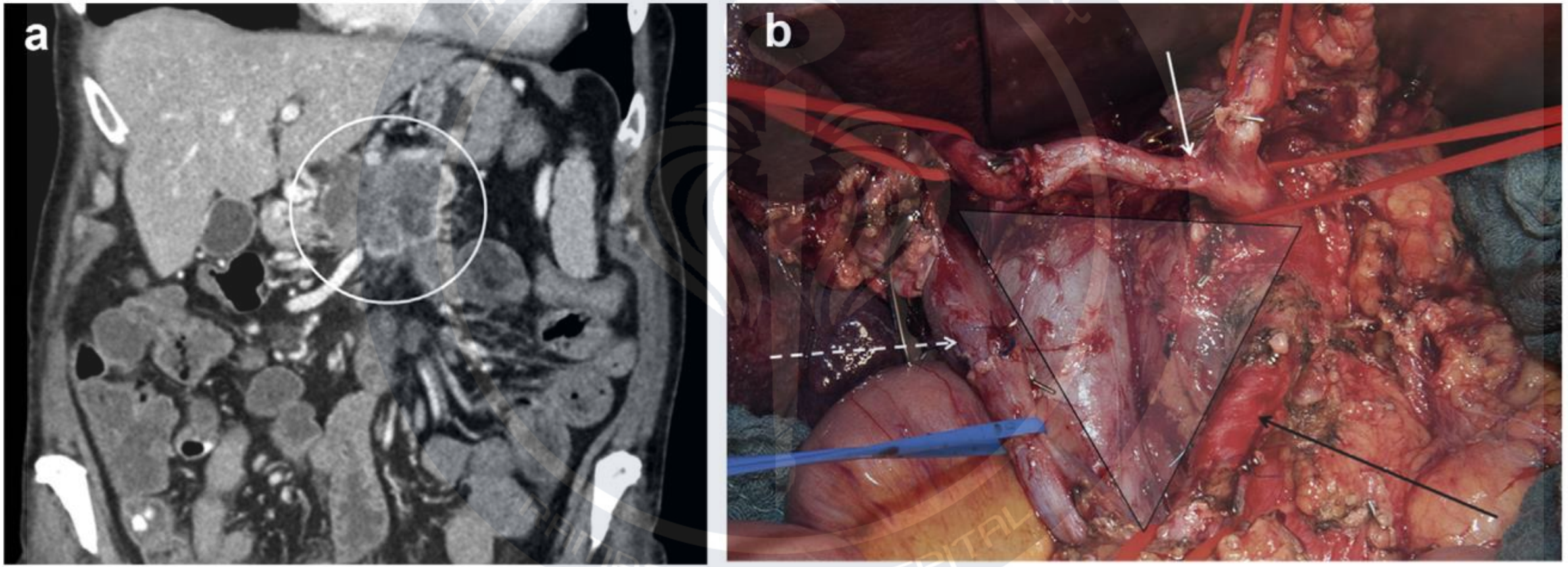
The Triangle operation : radical surgery after neoadjuvant treatment for advanced pancreatic cancer

Artery should be approached on the adventitial layer which opens longitudinally, once the adventitia has been reached. More extended lymph node dissection than usual to achieve clearance of the entire soft tissue.

Hackert T, Strobel O, Michalski CW, et al. The TRIANGLE operation - radical surgery after neoadjuvant treatment for advanced pancreatic cancer: a single arm observational study. HPB (Oxford) 2017;19:1001-7.

The Triangle operation : radical surgery after neoadjuvant treatment for advanced pancreatic cancer



The gray triangle, defined by PV/SMV, CA/HA and SMA

Hackert T, Strobel O, Michalski CW, et al. The TRIANGLE operation - radical surgery after neoadjuvant treatment for advanced pancreatic cancer: a single arm observational study. HPB (Oxford) 2017;19:1001-7.

The Triangle operation : radical surgery after neoadjuvant treatment for advanced pancreatic cancer

- 15 patients underwent the “TRIANGLE” operation between 03/ 2016 and 12/2016 following neoadjuvant therapy for LA-PDAC
- Median operation time was 320 min (range 180–488 min), median blood loss was 1000 ml (range 300 – 1600 ml), R0 resection was achieved in 6/15 patients, all R1 sites were located at peripancreatic soft tissue margins
- Lymph node yield ranged between 12 and 62 harvested lymph nodes and an N1 stage was found in 10 patients
- No postoperative mortality was observed
- Surgical morbidity occurred in 7/15 patients
  - fluid collection with percutaneous drainage (n = 1)
  - POPF grade B (n = 1)
  - wound infections or abdominal fascia dehiscence (n = 3)
  - chyle leak (n = 1)
  - one re-operation due to colon perforation

Hackert T, Strobel O, Michalski CW, et al. The TRIANGLE operation - radical surgery after neoadjuvant treatment for advanced pancreatic cancer: a single arm observational study. HPB (Oxford) 2017;19:1001-7.

ORIGINAL ARTICLE

The TRIANGLE operation for pancreatic head and body cancers: early postoperative outcomes

Rosa Klotz[1,2], Thilo Hackert[1], Patrick Heger[1,2], Pascal Probst[1,2], Ulf Hinz[1], Martin Loos[1], Christoph Berchtold[1], Arianeb Mehrabi[1], Martin Schneider[1], Beat P. Müller-Stich[1], Oliver Strobel[1], Markus K. Diener[1,2], André L. Mihaljevic[1,2,*] & Markus W. Büchler[1*]

[1]Department of General, Visceral and Transplantation Surgery, and [2]The Study Center of the German Surgical Society (SDGC), University of Heidelberg, Im Neuenheimer Feld 420, 69120 Heidelberg, Germany

- A total of 330 patients were included: Between March 2016 and October 2019, a total of 165 patients underwent $PD_{TRIANGLE}$ (n = 108) or $TP_{TRIANGLE}$ (n = 57)
- Operative time was significantly higher in the TRIANGLE
  - $PD_{STANDARD}$ vs $PD_{TRIANGLE}$: 322 (263–380) vs 359.5 (301.5–420.5) min, P = 0.0014
  - $TP_{STANDARD}$ vs $TP_{TRIANGLE}$: 367 (315–445) vs 434 (385–490) min, P = 0.0002.
- Intraoperative blood loss was significantly higher in the TRIANGLE than in the
  - $PD_{standard}$ vs $PD_{triangle}$ (600 (500 – 1000) vs 1000 (650 – 1600) ml), P < 0.0001
  - $Tp_{standard}$ vs $Pd_{triangle}$ (800 (500 – 1500) ml vs 1650 (1150–2550) ml), P < 0.0001
- No significant in morbidity and mortality
- In PD, Diarrhea was found in triangle group more than standard group(13(14.4%) vs 31(34.4%), p = 0.0029)

Klotz R, Hackert T, Heger P, et al. The TRIANGLE operation for pancreatic head and body cancers: early postoperative outcomes. HPB (Oxford). 2022 Mar;24(3):332-341.

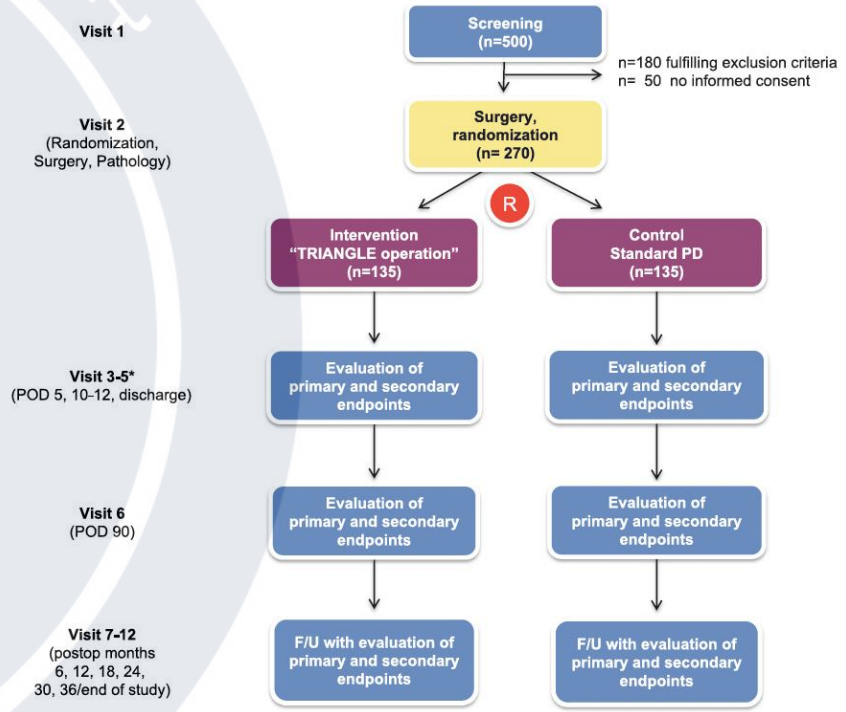
	PD			TP		
	Standard	Triangle	P-value	Standard	Triangle	P-value
	N = 70	N = 70		N = 39	N = 39	
CA 19-9 (U/mL)[a]	85.7 (22.5–508.5)	132.8 (27.5–661.6)	0.5709	124.2 (24.9–625.5)	159.0 (22.2–578.2)	0.7643
Neoadjuvant therapy	17 (24.3)	19 (27.1)	0.8469	14 (35.9)	19 (48.7)	0.3594
T status (8th)			0.8252			0.3611
T0	1 (1.4)	0 (0.0)		4 (10.3)	4 (10.3)	
T1	10 (14.3)	8 (11.4)		13 (33.3)	19 (48.7)	
T2	42 (60.0)	46 (65.7)		20 (51.3)	16 (41.0)	
T3	17 (24.3)	16 (22.9)		2 (5.1)	0 (0.0)	
N status (8th)			0.7429			0.2162
N0	23 (32.9)	19 (27.1)		10 (25.6)	6 (15.4)	
N1 (1–3 PLN)	15 (21.4)	18 (25.7)		9 (23.1)	16 (41.0)	
N2 (≥4 PLN)	32 (45.7)	33 (47.1)		20 (51.3)	17 (43.6)	
M status			0.2746			0.1153
M0	64 (91.4)	68 (97.1)		35 (89.7)	39 (100.0)	
M1	6 (8.6)	2 (2.9)		4 (10.3)	0 (0.0)	
Grading			0.5065			0.2732
1	0 (0.0)	1 (1.8)		18 (64.3)	14 (63.6)	
2	31 (55.4)	29 (52.7)		10 (35.7)	6 (27.3)	
3	23 (41.1)	25 (45.5)		0 (0.0)	2 (9.1)	
4	2 (3.6)	0 (0.0)		11	17	
X	14	15				
R classification			0.2721			0.0606
R0	20 (28.6)	20 (28.6)		4 (10.5)	12 (30.8)	
R1 (<1 mm)	20 (28.6)	28 (40.0)		11 (29.0)	12 (30.8)	
R1 (direct)	30 (42.9)	22 (31.4)		23 (60.5)	15 (38.5)	
Number of ELN	27.5 (21–35)	31.5 (24–40)	**0.0187**	33 (28–49)	44 (29–53)	0.3174

Klotz R, Hackert T, Heger P, et al. The TRIANGLE operation for pancreatic head and body cancers: early postoperative outcomes. HPB (Oxford). 2022 Mar;24(3):332-341.

STUDY PROTOCOL Open Access

Conventional partial pancreatoduodenectomy versus an extended pancreatoduodenectomy (triangle operation) for pancreatic head cancers—study protocol for the randomised controlled TRIANGLE trial

Patrick Heger[1,2,3], Thilo Hackert[2], Markus K. Diener[4], Manuel Feißt[5], Christina Klose[5], Colette Dörr-Harim[1,2], Friedhelm Möhlenbrock[6], Markus W. Büchler[2] and André L. Mihaljevic[1,2,3*]



Heger P, Hackert T, Diener MK, et al. Conventional partial pancreatoduodenectomy versus an extended pancreatoduodenectomy (triangle operation) for pancreatic head cancers-study protocol for the randomised controlled TRIANGLE trial. Trials. 2023 May 30;24(1):363.

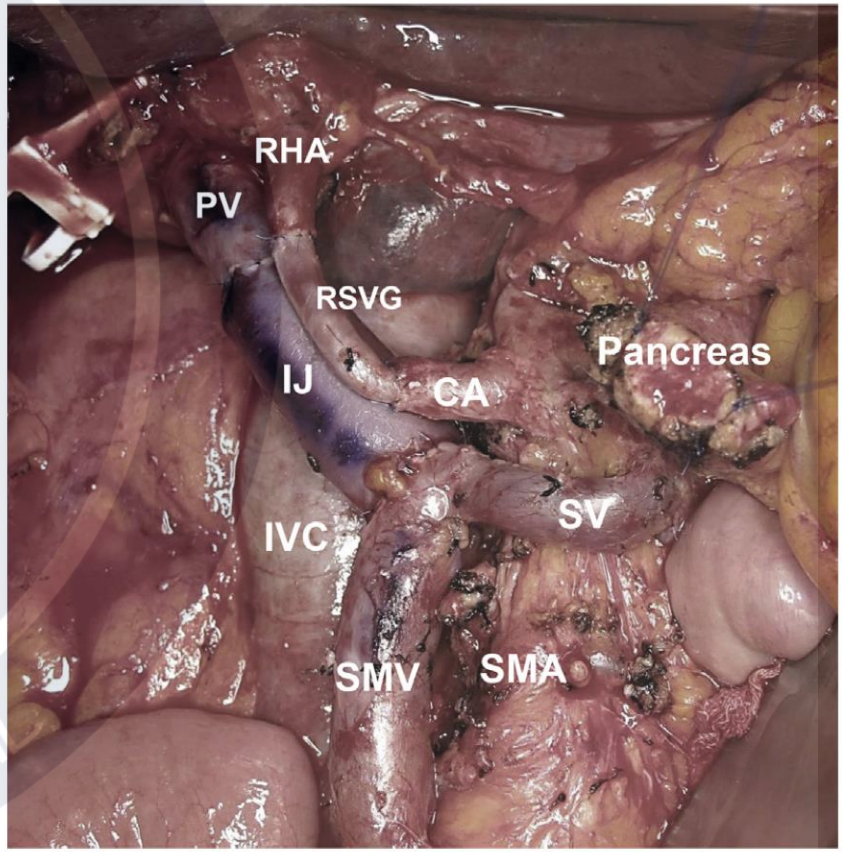
Common hepatic artery and hepatic artery proper

- Encasement of a short segment of the CHA is classified as borderline resectable disease
- Incidence hepatic artery injury during PD 0.5-2.7%
- postoperative peak transaminase levels < 500 U/l, 500—2000 U/l and > 2000 U/ were associated with mortality rates of 0.9%, 5% and 29%, respectively
- The fact that pancreaticoduodenal collaterals from the superior mesenteric artery have been sacrificed, leading to complete dearterialization of the liver and intra-hepatic biliary tree.

S. Landen, B. Ursalu, V. Delugeau et al, How to deal with hepatic artery injury during pancreaticoduodenectomy. A systematic review, Journal of Visceral Surgery, Volume 154, Issue 4, 2017, Pages 261-268, ISSN 1878-7886,

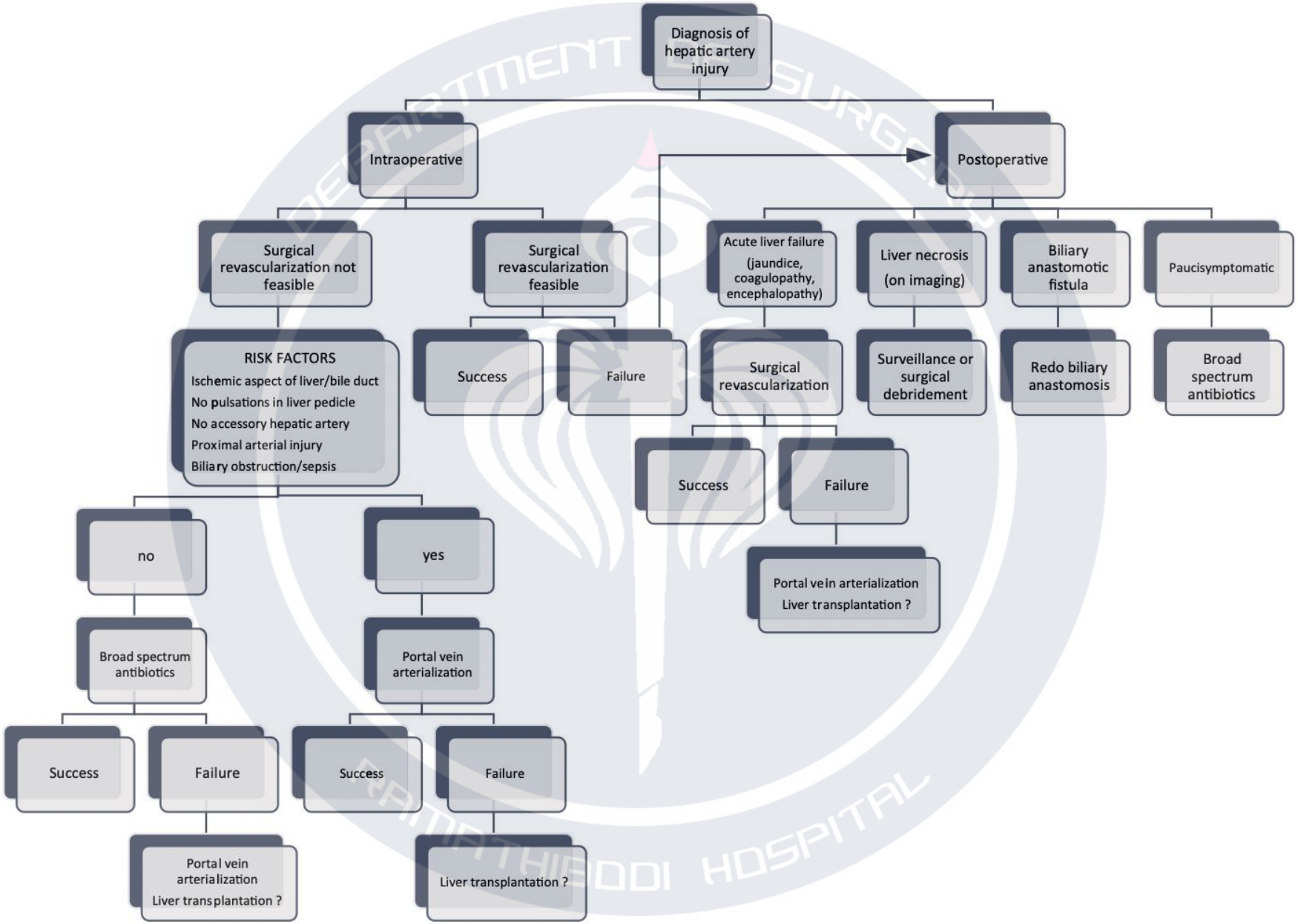
Common hepatic artery

- Options to reconstruction
  - Reverse saphenous vein graft
  - Right renal artery
  - Right gastroepiploic artery



Shindo Y, Tokumitsu Y, Matsukuma S et als, Hepatic artery resection and reconstruction using the right gastroepiploic artery during pancreaticoduodenectomy in advanced pancreatic cancer. Langenbecks Arch Surg. 2021 Sep;406(6):2075-2080Epub 2021 Apr 13. PMID: 33847784.

Younan G, Tsai S, Evans DB, Christians KK. Techniques of Vascular Resection and Reconstruction in Pancreatic Cancer. Surg Clin North Am. 2016 Dec;96(6):1351-1370.



S. Landen, B. Ursalu, V. Delugeau et al, How to deal with hepatic artery injury during pancreaticoduodenectomy. A systematic review, Journal of Visceral Surgery, Volume 154, Issue 4, 2017, Pages 261-268, ISSN 1878-7886,

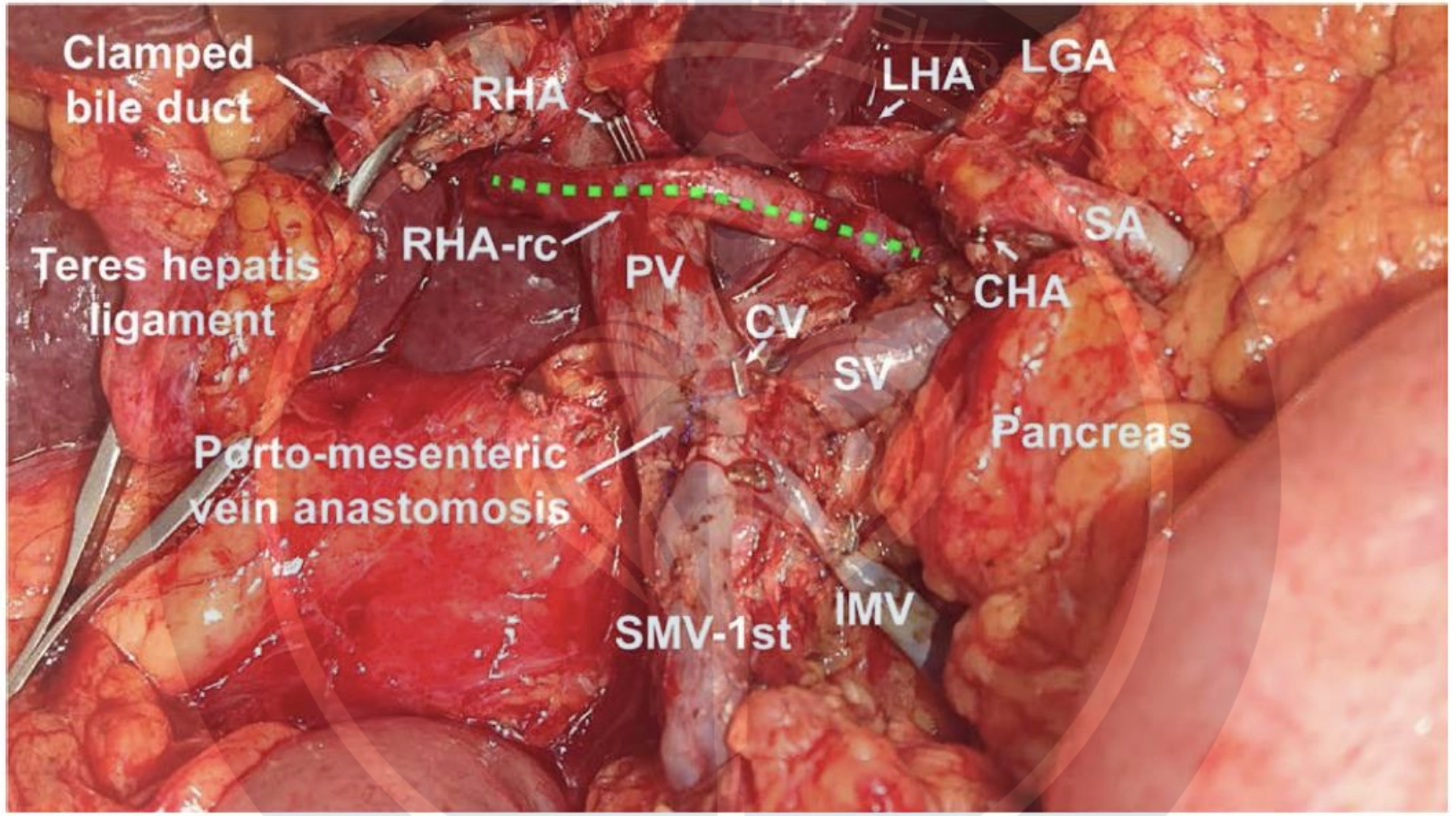


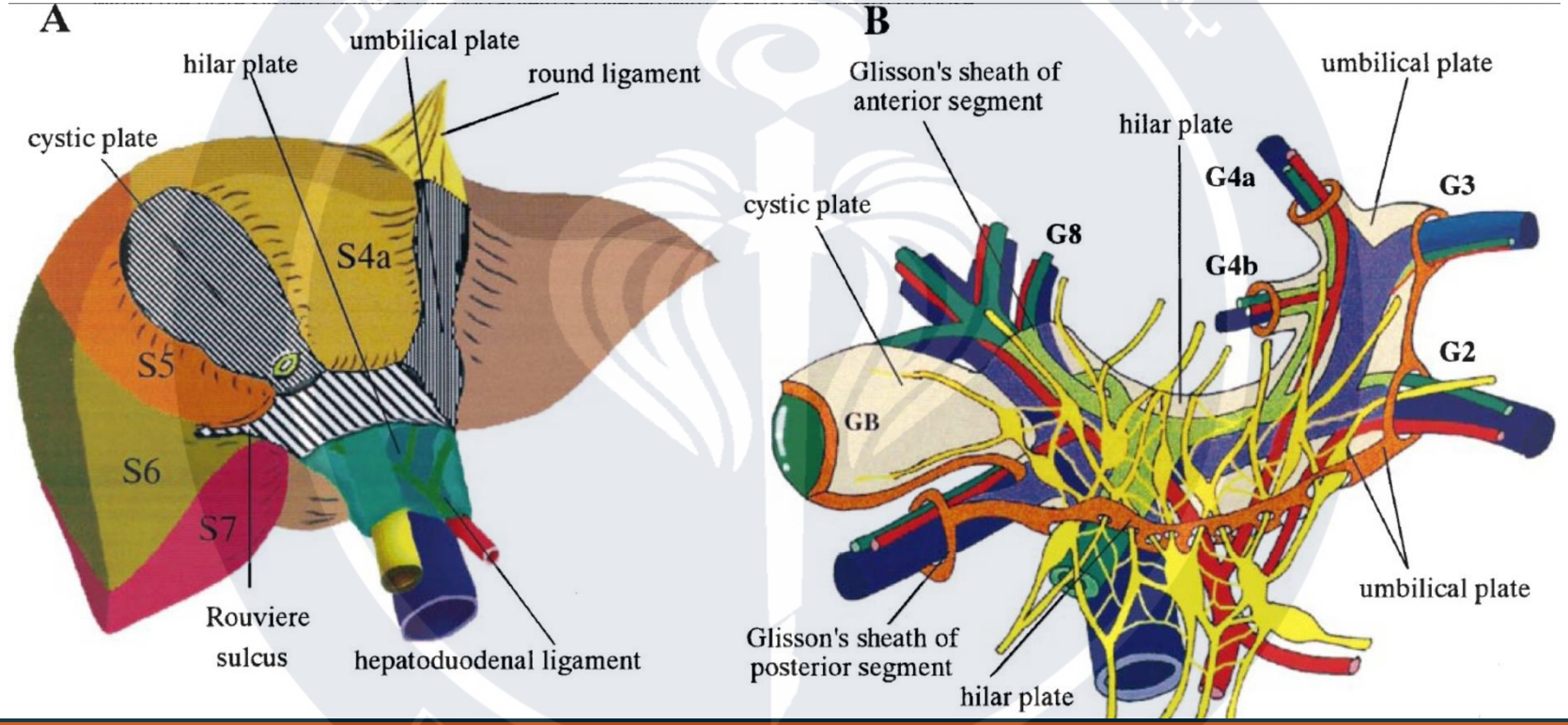
FIGURE 1. Ovarian vein graft in the course of the reconstructed right hepatic artery in pancreatic head cancer during pancreatoduodenectomy combined with hepatic artery resection. CV indicates coronary vein; IMV, inferior mesenteric vein; LGA, left gastric artery; LHA, left hepatic artery; PV, portal vein; RHA, right hepatic artery; RHA-rc, ovarian vein graft in the course of the reconstructed right hepatic artery; SA, splenic artery; SMV-1st, 1st order branch of superior mesenteric vein; SV, splenic vein.

Replaced RHA

- Replaced RHA is disconnected
  - Reduces the arterial blood flow to the right lobe of the liver
  - Increase the risk of abscess
  - Decrease the blood flow to the bile duct and the hepaticojejunostomy.
- Reconstruction should do in case by case

Shindo Y, Tokumitsu Y, Matsukuma S et als, Hepatic artery resection and reconstruction using the right gastroepiploic artery during pancreaticoduodenectomy in advanced pancreatic cancer. Langenbecks Arch Surg. 2021 Sep;406(6):2075-2080Epub 2021 Apr 13. PMID: 33847784.
Younan G, Tsai S, Evans DB, Christians KK. Techniques of Vascular Resection and Reconstruction in Pancreatic Cancer. Surg Clin North Am. 2016 Dec;96(6):1351-1370.

Replaced RHA



Hilar marginal artery can be retained

Blood supply of the liver and the biliary intestinal anastomosis are not effected

Y. Kawarada, B.C. Das, H. Taoka, Anatomy of the hepatic hilar area: the plate system, J Hepato-Biliary-Pancreatic Surg, 7 (6) (2000), pp. 580-586

Long-term impact of replaced right hepatic artery resection in pancreaticoduodenectomy

Naoko Sekiguchi[1,2] · Hidenori Takahashi[1,2] · Hirofumi Akita[2] · Daisaku Yamada[1] · Yoshito Tomimaru[1] · Takehiro Noda[1] · Yosuke Mukai[2] · Shinichiro Hasegawa[2] · Shogo Kobayashi[1] · Yuichiro Doki[1] · Hidetoshi Eguchi[1] · Hiroshi Wada[2]

Received: 20 November 2023 / Accepted: 4 March 2024 / Published online: 25 March 2024

	R group $n=7$	nR group $n=40$	p value
Post-operative complications+[a]	1 (14%)	4 (10%)	0.083
Liver abscess	0	0	
Liver infarction	0	0	
Biliary fistula	0	1 (2.5%)	
Postoperative bleeding	0	1 (2.5%)	
Intra-abdominal abscess	0	1 (2.5%)	
POPF	1 (14%)	2 (5%)	

	R group ($n=6$)	nR group ($n=28$)	p value
Preoperative liver volume, median [min–max]			
WL, ml	928 [873–1501]	1011 [736–1362]	0.946
LL, ml	332 [265–561]	328 [219–503]	0.572
RL, ml	620 [549–1091]	673 [448–911]	0.542
MS, ml	173 [102–307]	156 [67–237]	0.456
LS, ml	177 [126–253]	173 [71–300]	0.910
AS, ml	333 [226–549]	392 [289–540]	0.082
PS, ml	331 [265–541]	277 [150–419]	0.109
Liver volume at 6 months after surgery, median [min–max]			
WL, ml	914 [818–1440]	965 [664–1693]	0.600
LL, ml	305 [265–422]	335 [218–693]	0.635
RL, ml	609 [540–1018]	682 [330–1057]	0.635
MS, ml	169 [110–240]	151 [76.5–321]	0.822
LS, ml	170 [119–214]	167 [112–372]	0.822
AS, ml	344 [274–499]	396 [137–701]	0.382
PS, ml	288 [258–519]	287 [153–490]	0.438
Liver volume at 12 months after surgery, median [min–max]			
WL, ml	1022 [790–1791]	992 [661–1814]	0.452
LL, ml	320 [231–536]	325 [195–706]	0.917
RL, ml	702 [540–1254]	671 [355–1108]	0.452
MS, ml	144 [99.6–332]	158 [82.0–351]	0.736
LS, ml	170 [118–251]	157 [90.3–355]	0.697
AS, ml	407 [304–631]	381 [135–755]	0.312
PS, ml	299 [236–623]	302 [142–450]	0.392

Sekiguchi N, Takahashi H, Akita H et al. Long-term impact of replaced right hepatic artery resection in pancreaticoduodenectomy. Updates Surg. 2024 Aug;76(4):1257-1263

Long-term impact of replaced right hepatic artery resection in pancreaticoduodenectomy

Naoko Sekiguchi[1,2] · Hidenori Takahashi[1,2] · Hirofumi Akita[2] · Daisaku Yamada[1] · Yoshito Tomimaru[1] · Takehiro Noda[1] · Yosuke Mukai[2] · Shinichiro Hasegawa[2] · Shogo Kobayashi[1] · Yuichiro Doki[1] · Hidetoshi Eguchi[1] · Hiroshi Wada[2]

Received: 20 November 2023 / Accepted: 4 March 2024 / Published online: 25 March 2024

In this study, not dissect the lymph nodes or connective tissues at the hepatic hilum during PD for PC > ***preservation of the communicating arterial arcade*** between the right and left hepatic arterial systems at the hepatic hilum, leading to the retention of arterial blood flow to the right liver and the safety of PD with rRHA resection.

rRHA reconstruction should be performed on a case-by-case basis.

Sekiguchi N, Takahashi H, Akita H et al. Long-term impact of replaced right hepatic artery resection in pancreaticoduodenectomy. Updates Surg. 2024 Aug;76(4):1257-1263

Author	Mortality, n [%]			Morbidity, n [%]			Blood loss (mL)*			Hemorrhage, n [%]			Fistula, n [%]			DGE, n [%]			Length of hospital stay**		
	RHA	No RHA	P	RHA	No RHA	P	RHA	No RHA	P	RHA	No RHA	P	RHA	No RHA	P	RHA	No RHA	P	RHA	No RHA	P
Stauffer *et al.* (9)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lee *et al.* (10)	0	0	–	3 [20]	10 [11]	ns	–	–	–	–	–	–	0	4	–	1	0	–	0	1	–
Eschuis *et al.* (11)	2 [1]	13 [2]	0.58	80 [56]	303 [49]	0.15	299	300	0.96	1,100	1,050	0.88	11 [8]	44 [7]	0.82	18 [12]	87 [14]	0.63	48 [33]	193 [31]	0.61
Perwaiz *et al.* (12)	1 [2]	3 [2]	1	16 [30]	43 [30]	1	414±37	370±38	<0.001	450±54	415±61	<0.001	1 [2]	2 [2]	1	5 [13]	12 [8]	0.77	3 [8]	11 [7]	0.76
Jah *et al.* (13)	0	2 [2]	ns	9 [32]	31 [29]	ns	400	400	0.58	1,400	1,200	0.27	–	–	–	5 [19]	16 [15]	0.43	4 [14]	15 [14]	0.47
Turrini *et al.* (14)	1 [2]	1 [3]	ns	17 [36]	11 [35]	ns	361	310	ns	573	697	ns	–	–	–	–	–	–	–	–	–
Sulpice *et al.* (16)	0	1 [0.5]	1	9 [24]	88 [42]	0.04	479±85	439±128	0.05	950	650	0.5	1 [3]	16 [7]	0.5	1 [3]	13 [6]	0.7	4 [11]	16 [7]	0.5
Ram *et al.* (17)	3 [10]	5 [9]	0.44	14 [48]	32 [58]	0.52	334±84	341±106	0.98	–	–	–	4 [8]	9 [16]	1	3 [10]	9 [16]	0.53	10 [25]	24 [46]	0.56
Okada *et al.* (18)	1 [2]	3 2]	ns	26 [60]	111 [61]	ns	480±44	420±45	<0.05	390±45	360±52	ns	1 [2]	4 [2]	ns	2 [5]	9 [5]	ns	23 [5]	98 [5]	ns

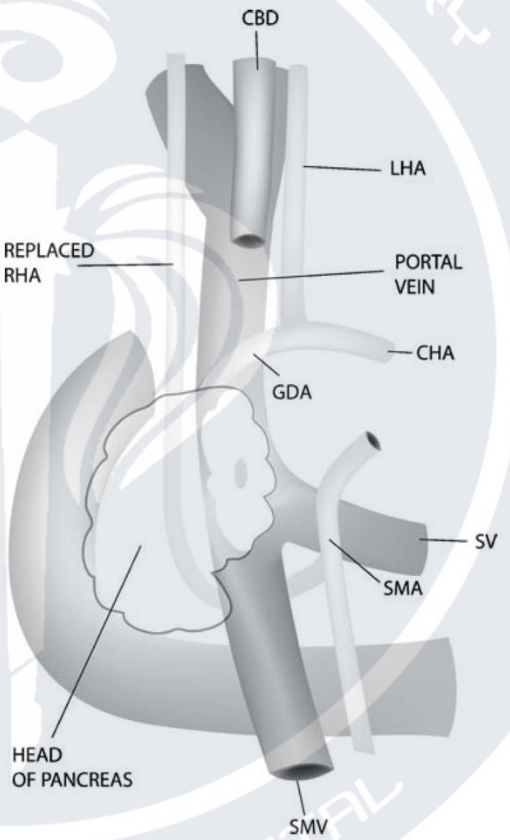
*, mean; **, median. PD, pancreaticoduodenectomy; RHA, right hepatic artery; DGE, delayed gastric emptying; ns, not significant.

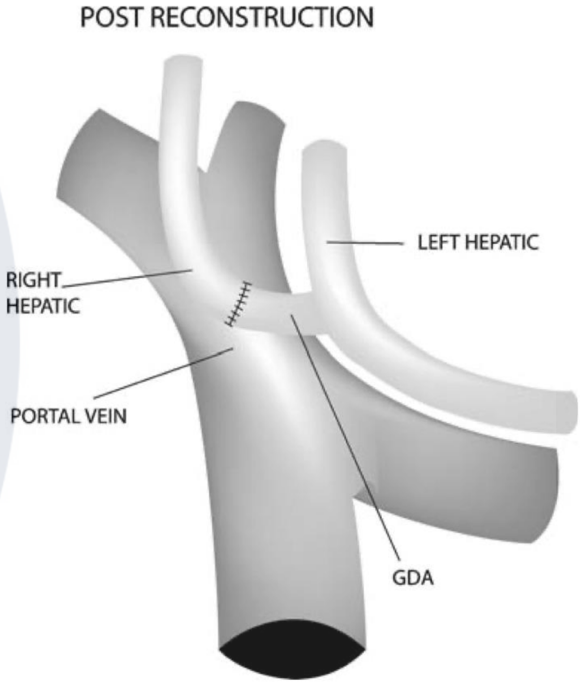
Postoperative and oncological outcomes seemed unaffected by the RHA in PD

21. Arvanitakis M, Pluvot FR, Truant S. Management of the right hepatic artery in pancreaticoduodenectomy: a systematic review. J Gastrointest Oncol. 2016 Apr;7(2):298-305.

Replaced RHA

- If distant <= 2 cm
  - Direct anastomosis
- If Direct anastomosis cannot performed
  - Artery transposition
    - From GDA to distal remnant





J.D. Allendorf, S. Bellemare. Reconstruction of the replaced right hepatic artery at the time of pancreaticoduodenectomy J Gastrointest Surg : official journal of the Society for Surgery of the Alimentary Tract, 13 (3)(2009),
Younan G, Tsai S, Evans DB, Christians KK. Techniques of Vascular Resection and Reconstruction in Pancreatic Cancer. Surg Clin North Am. 2016 Dec;96(6):1351-1370.

RESEARCH ARTICLE Open Access

Arterial resection and reconstruction in pancreatectomy: surgical technique and outcomes

Qiyi Zhang[1†], Jingjin Wu[3†], Yang Tian[1], Jixuan Duan[2], Yi Shao[2], Sheng Yan[1*] and Weilin Wang[1*]

21 patients that underwent a pancreatectomy combined with arterial resection and reconstruction

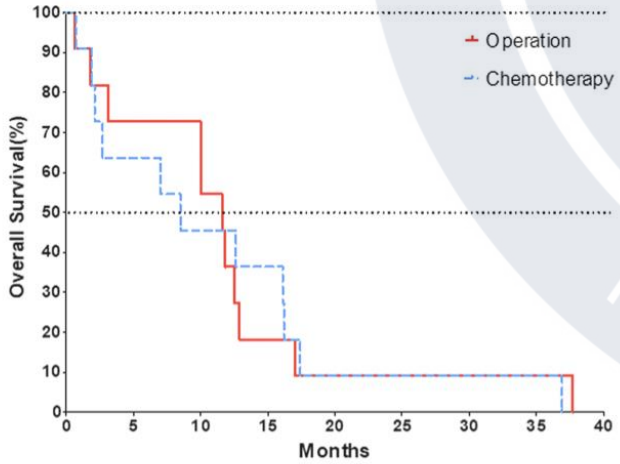


Fig. 4 The median survival time was 11.6 months in operative group vs. 8.5 months in the chemotherapy group, $p > 0.05$

Table 2 Surgical Outcomes

Case	Surgery	Invaded artery	Arterial reconstruction	Venous reconstruction	Arterial anatomy
1	PD	ARHA	ARHA-CHA	PV-SMV	ARHA from SMA
2	PD	RHA	RHA-GDA	No	LHA from LGA; RHA from SMA
3	PD	RHA	RHA-LHA	No	LHA from LGA; RHA from SMA
4	TP	CHA & PHA	PHA-CHA	SMV-SMV	Normal
5	PD	RHA	RHA-GDA	No	RHA from GDA
6	PD	CHA & PHA	PHA-CHA	SV + SMV- "Y" graft- PV	Normal
7	PD	CHA	CHA-CHA	No	SMA from Celiac axis, SA from aorta
8	TP	RHA	RHA-RHA	PV-PV	RHA from CHA
9	PD	PHA	PHA-LGA	SV + SMV- "Y" graft- PV	Normal
10	PD	CHA	CHA-CHA	No	Normal
11	PD	RHA	RHA-RHA	No	Normal
12	PD	PHA	PHA-CHA	PV-PV; SMV- "Y" graft-SMV	Normal
13	PD	PHA	PHA-CHA	No	Normal
14	PD	RHA	RHA-GDA	No	RHA from SMA
15	PD	CHA & PHA	PHA-CHA	PV-PV	Normal
16	PD	SMA	SMA-graft-SMA	No	SMA from Celiac axis; LGA from aorta
17	PD	CHA & PHA	PHA-CHA	PV-PV	Normal
18	PD	RHA	RHA-GDA	PV-PV	Normal
19	PD	SMA	SMA-GSV-SMA	No	Normal
20	PD	SMA	SMA-GSV-SMA	No	Normal
21	PD	CHA & SMA	CHA-CHA; SMA-GSVSMA	No	Normal

PD pancreaticoduodenectomy, *TP* total pancreatectom, *DP* distal pancreatectomy, *ARHA* accessory right hepatic artery, *CHA* common hepatic artery, *PHA* proper hepatic artery, *RHA* right hepatic artery, *LHA* left hepatic artery, *GDA* gastroduodenal artery, *LGA* left gastric artery, *SMA* superior mesenteric artery, *SA* splenic artery, *PV* portal vein, *SMV* superior mesenteric vein, *GSV* great saphenous vein. Graft: allogeneic frozen iliac vessel

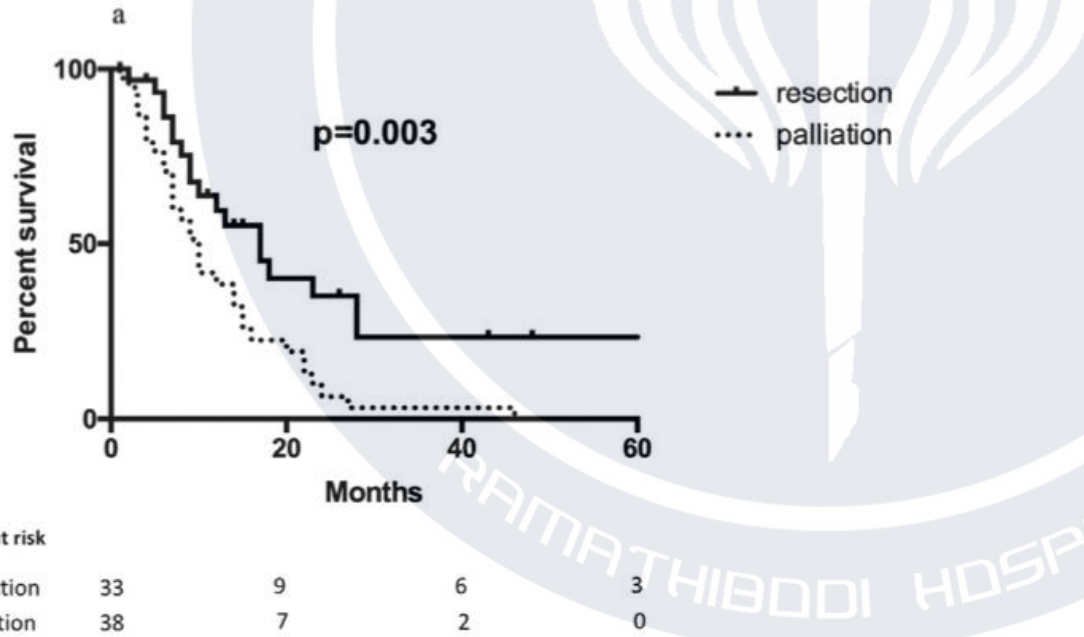
Zhang Q, Wu J, Tian Y, Duan J, Shao Y, Yan S, Wang W. Arterial resection and reconstruction in pancreatectomy: surgical technique and outcomes. BMC Surg. 2019 Oct 10;19(1):141.

ORIGINAL ARTICLE

Pancreatectomy with arterial resection is superior to palliation in patients with borderline resectable or locally advanced pancreatic cancer

Marco Del Chiaro[1], Elena Rangelova[1], Asif Halimi[1], Zeeshan Ateeb[1], Chiara Scandavini[1], Roberto Valente[1], Ralf Segersvärd[1], Urban Arnelo[1] & Caroline S. Verbeke[2,3]

[1]Pancreatic Surgery Unit, Division of Surgery, Department of Clinical Science, Intervention and Technology (CLINTEC), Karolinska Institute at Center for Digestive Diseases, Karolinska University Hospital, K53, 14186, [2]Department of Pathology & Cytology, Karolinska University Hospital, Stockholm, Sweden, and [3]Institute of Clinical Medicine, Oslo University, Norway



Group 1 – Resection Group (n = 34)	n (%)
Type of resection performed	
- Total pancreatectomy	23 (68)
- Pancreatoduodenectomy	9 (26)
- Distal pancreatectomy	2 (5.9)
Type of vascular resection performed	
- Artery-alone resection	11 (32)
- Combined artery-vein resection	23 (68)
Number of vessels resected	
- 1	11 (32)
- 2	22 (65)
- 3	1 (3.0)
Type of vessel resected (overall n = 58)	
- Hepatic artery/celiac trunk	32 (55)
- Superior mesenteric artery	3 (5.2)
- Superior mesenteric/portal vein	23 (40)
Type of vascular reconstruction	
Hepatic artery/celiac trunk (n = 32)	
- End-to-end anastomosis	15 (47)
- Anastomosis on GDA stump	2 (6.3)
- Rotation of splenic artery	10 (31)
- Autologous graft interposition	3 (9.5)
- PTFE graft interposition	1 (3.0)
- Legature without reconstruction (Appelby procedure)	1 (3.0)
Superior mesenteric artery (n = 3)	
- End-to-end anastomoses	3 (100)
Superior mesenteric/portal vein (n = 23)	
- End-to-end anastomoses	23 (100)
Group 2 – Palliation Group (n = 39)	**N (%)**
Type of operation performed	
- Double bypass	20 (51)
- Gastroenteric anastomosis	2 (5.1)
- Explorative laparotomy only	17 (44)

Del Chiaro M, Rangelova E, Halimi A, et al. Pancreatectomy with arterial resection is superior to palliation in patients with borderline resectable or locally advanced pancreatic cancer. HPB (Oxford). 2019 Feb;21(2):219-225.

Group 1 – Resection Group (n = 34)	n (%)
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Group 2 – Palliation Group (n = 39)	N (%)
Type of operation performed	
- Double bypass	20 (51)
- Gastroenteric anastomosis	2 (5.1)
- Explorative laparotomy only	17 (44)

	Resection group (n = 34) n (%)	Palliative Group (n = 39) n (%)	p
Mean operation time (minutes)	426 ± 14	171 ± 11	<0.0001
Mean intraoperative blood loss (ml)	613 ± 72	188 ± 21	<0.0001
Postoperative mortality (in hospital)	1 (2.9)	1 (2.6)	0.9
Postoperative overall morbidity	21 (62)	17 (44)	0.1
Postoperative overall surgical complications	13 (38)	10 (26)	0.2
Severe postoperative complications (Clavien-Dindo ≥ 3b)	4 (12)	2 (5.1)	0.3
Reoperation	3 (8.8)	–	0.06
Need for ICU stay	3 (8.8)	–	0.06
Mean length of hospital stay (days)	18 ± 2.4	9.3 ± 0.8	0.0005

Superior mesenteric artery (n = 3)	
- End-to-end anastomoses	3 (100)
Superior mesenteric/portal vein (n = 23)	
- End-to-end anastomoses	23 (100)

Del Chiaro M, Rangelova E, Halimi A, et al. Pancreatectomy with arterial resection is superior to palliation in patients with borderline resectable or locally advanced pancreatic cancer. HPB (Oxford). 2019 Feb;21(2):219-225.

Arterial resections in pancreatic cancer – Systematic review and meta-analysis

Piotr Małczak[1,2], Marek Sierżęga[3], Tomasz Stefura[1], Artur Kacprzyk[1], Jakub Droś[1], Oksana Skomarovska[1], Marta Krzysztofik[1], Piotr Major[1,2] & Michał Pędziwiatr[1,2]

[1]2nd Department of General Surgery, Jagiellonian University Medical College, [2]Centre for Research, Training and Innovation in Surgery (CERTAIN Surgery), and [3]1st Department of Surgery, Jagiellonian University Medical College, Krakow, Poland

Study or Subgroup	Vascular resection Events	Total	Standard resection Events	Total	Weight	Risk Ratio M-H, Random, 95% CI	Year
Tamura	1	7	1	8	2.8%	1.14 [0.09, 15.08]	1989
Klempnauer	3	16	7	114	11.8%	3.05 [0.88, 10.63]	1991
Kinoshita	2	6	0	32	2.1%	23.57 [1.27, 439.14]	2001
Shimada	0	12	0	76		Not estimable	2006
Nakao	5	14	5	186	14.8%	13.29 [4.36, 40.49]	2006
Wang	1	19	0	61	1.8%	9.30 [0.39, 219.35]	2008
Yekebas	1	13	22	572	4.9%	2.00 [0.29, 13.74]	2008
Martin	0	5	0	31		Not estimable	2009
Boggi	1	26	13	281	4.6%	0.83 [0.11, 6.11]	2009
Hartwig	3	14	7	202	11.9%	6.18 [1.79, 21.35]	2009
Bockhorn	4	29	18	449	17.8%	3.44 [1.25, 9.51]	2010
Wu	0	9	2	36	2.1%	0.74 [0.04, 14.21]	2010
Sperti	0	5	1	39	1.9%	2.22 [0.10, 48.52]	2010
Ouaissi	1	8	1	82	2.6%	10.25 [0.71, 148.76]	2010
Bachelier	2	26	1	26	3.4%	2.00 [0.19, 20.72]	2011
Gong	4	16	4	103	11.2%	6.44 [1.79, 23.20]	2013
Perinel	0	14	2	66	2.1%	0.89 [0.05, 17.66]	2016
Podda	0	4	4	72	2.4%	1.62 [0.10, 26.09]	2017
Loveday	1	20	0	11	1.9%	1.71 [0.08, 38.86]	2018
Total (95% CI)		**263**		**2447**	**100.0%**	**4.09 [2.66, 6.27]**	
Total events	29		88				

Heterogeneity: Tau² = 0.00; Chi² = 15.74, df = 16 (P = 0.47); I² = 0%
Test for overall effect: Z = 6.44 (P < 0.00001)

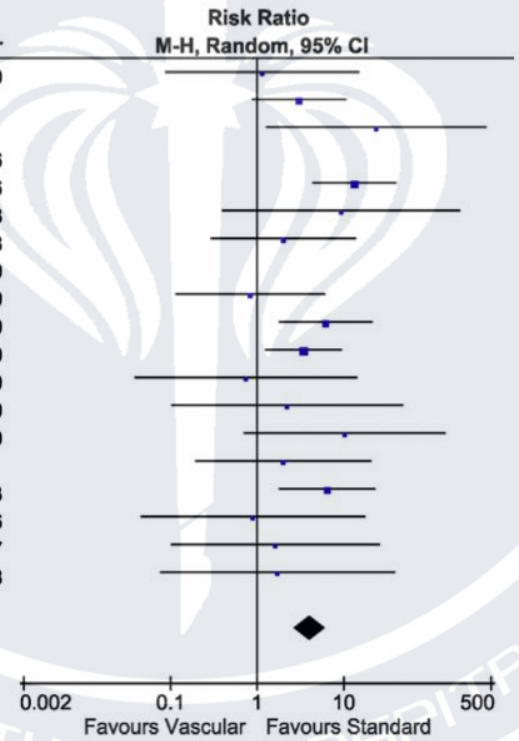

Figure 2 Postoperative mortality

Mortality rates related to arterial resections (29/263, 11.02%) compared to a standard pancreatic resection (88/2447, 3.6%).

The relative risk associated with arterial resection was about 4- fold higher than standard procedures (RR: 4.09; 95%CI 2.66 – 6.27; p < 0.001.).

Małczak P, Sierżęga M, Stefura T, Kacprzyk A, Droś J, Skomarovska O, Krzysztofik M, Major P, Pędziwiatr M. Arterial resections in pancreatic cancer - Systematic review and meta-analysis. HPB (Oxford). 2020 Jul;22(7):961-968

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Study or Subgroup	Vascular resection Events	Total	Standard resection Events	Total	Weight	Risk Ratio M-H, Random, 95% CI	Year
Kinoshita	4	6	14	32	9.8%	1.52 [0.77, 3.03]	2001
Wang	7	19	14	61	9.1%	1.61 [0.76, 3.39]	2008
Martin	0	5	14	31	1.3%	0.18 [0.01, 2.68]	2009
Boggi	9	26	106	281	11.8%	0.92 [0.53, 1.59]	2009
Hartwig	9	14	49	202	13.2%	2.65 [1.67, 4.20]	2009
Sperti	4	5	13	49	10.5%	3.02 [1.59, 5.72]	2010
Ouaissi	6	8	46	82	13.4%	1.34 [0.86, 2.08]	2010
Bachelier	14	26	10	26	11.0%	1.40 [0.77, 2.56]	2011
Gong	4	16	22	103	7.1%	1.17 [0.46, 2.95]	2013
Loveday	13	20	8	11	12.8%	0.89 [0.55, 1.45]	2018
Total (95% CI)		**145**		**878**	**100.0%**	**1.45 [1.05, 1.99]**	
Total events	70		296				

Heterogeneity: Tau² = 0.14; Chi² = 22.35, df = 9 (P = 0.008); I² = 60%

Test for overall effect: Z = 2.28 (P = 0.02)

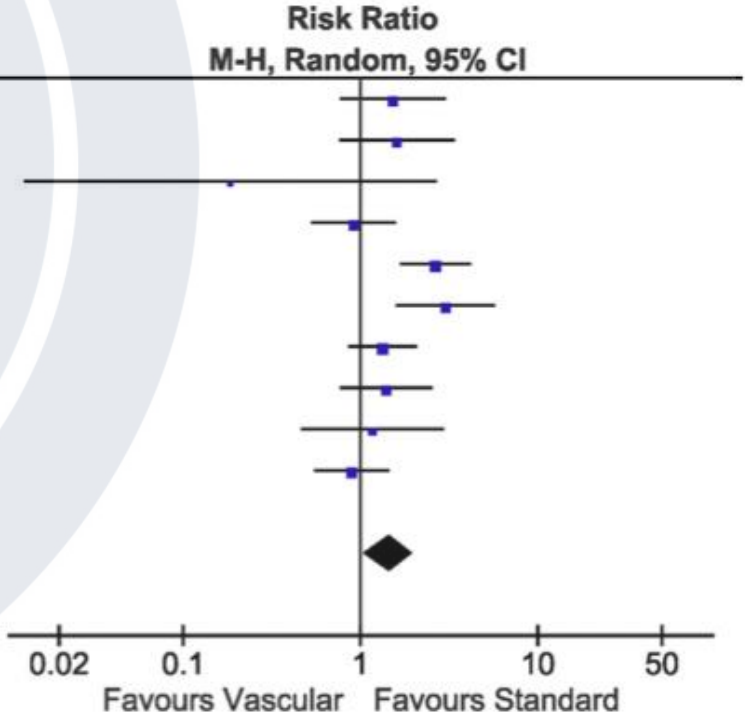

Figure 3 Overall morbidity

Systematic review and/or Meta-analysis

INTERNATIONAL JOURNAL OF SURGERY

OPEN

Perioperative and long-term survival outcomes of pancreatectomy with arterial resection in borderline resectable or locally advanced pancreatic cancer following neoadjuvant therapy: a systematic review and meta-analysis

Kang Xue, MS, Xing Huang, MD, Pengcheng Zhao, MS, Yi Zhang, MD*, Bole Tian, MD* Published online : 21 September 2023

Table 1

Characteristics of included studies on patients undergoing pancreatectomy with neoadjuvant therapy and arterial resection.

Reference	Year	Inclusion period	Sample size	Country	Study type	Study design	Study quality
Yoshitomi[21]	2019	2010–2016	31	Japan	Reotrospect.	Controlled	8
Stitzenberg[22]	2008	1996–2007	12	America	Reotrospect.	One-arm	6
Yoshiya[23]	2019	2008–2018	11	Japan	Reotrospect.	Controlled	7
Murakami[24]	2020	2008–2019	32	Japan	Reotrospect.	Controlled	8
Christians[25]	2014	2011–2013	10	America	Reotrospect.	One-arm	6
Kwon[16]	2019	2000–2017	38	Korean	Reotrospect.	Controlled	6
Amano[26]	2015	2013–2015	13	Japan	Reotrospect.	One-arm	6
Baumgartner[33]	2012	2007–2010	11	America	Reotrospect.	One-arm	6
Addeo[34]	2020	2010–2018	57	France	Reotrospect.	Controlled	8

Systematic review and/or Meta-analysis

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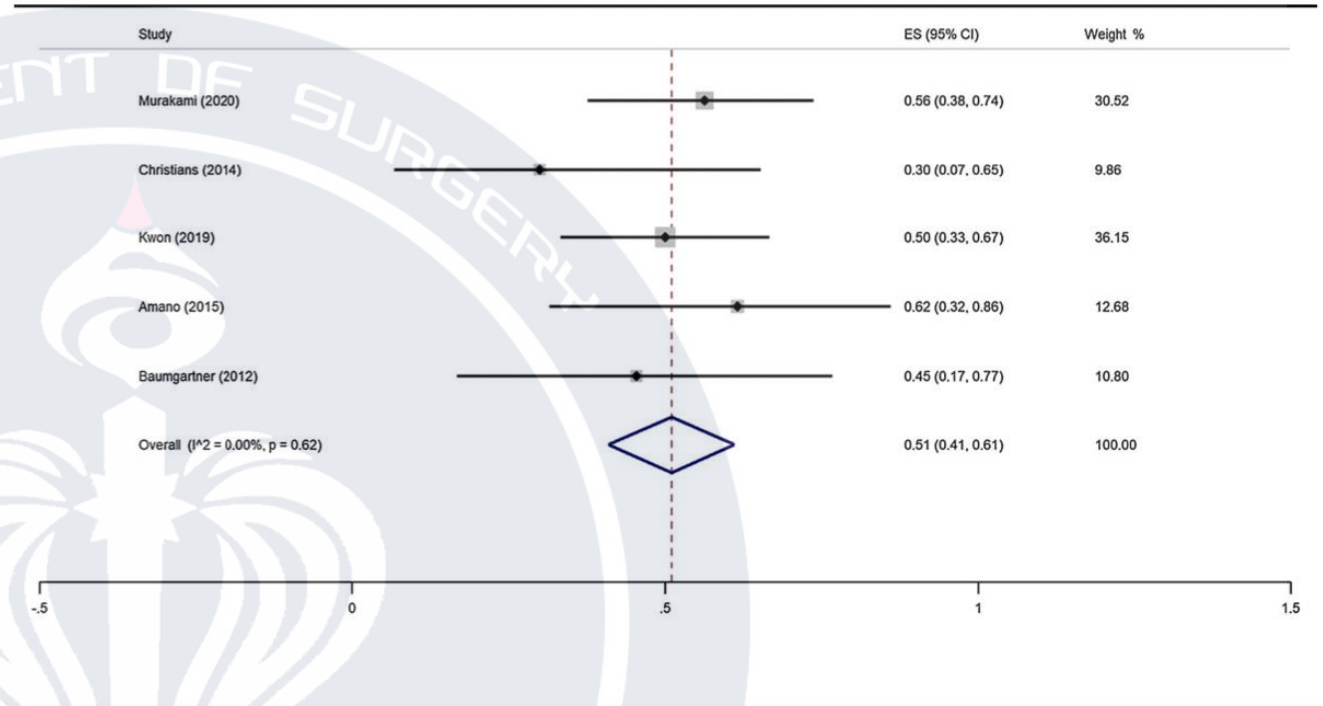
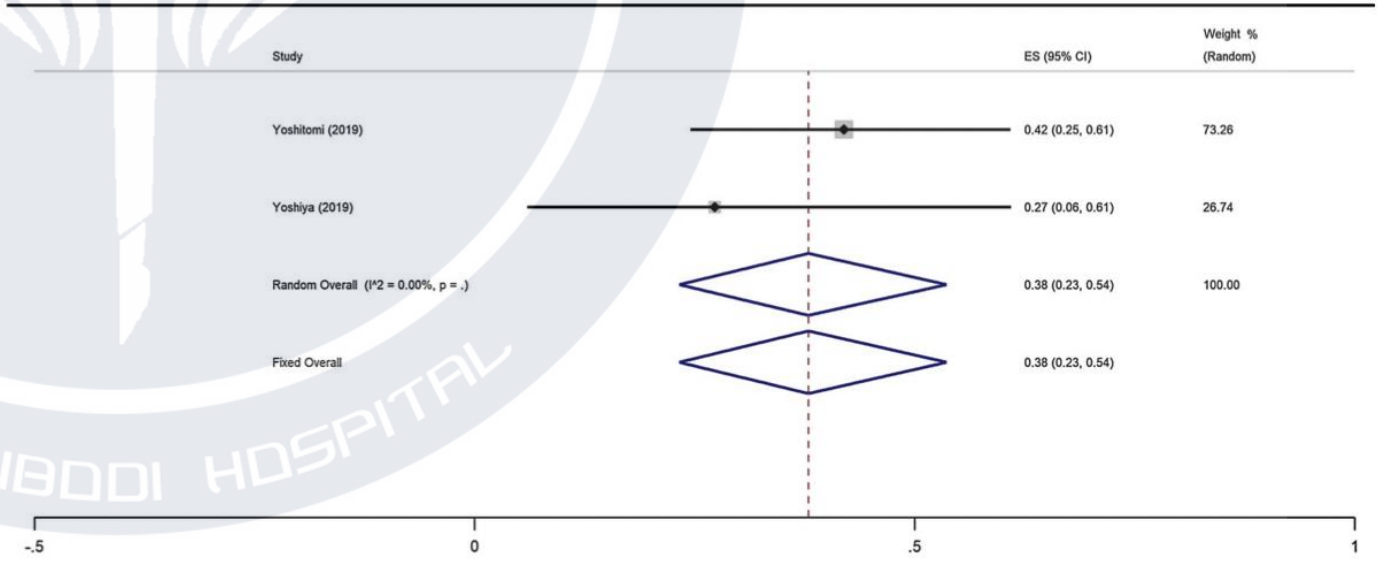
- R0 rates ranged from 50 to 92% (median 81%)
- The median 1-, 2-, 3-, and 5-year survival rates of patients who had AR were 92.3% (range: 72.7–100%), 64.8% (range: 25–78.8%), 51.6% (range: 16.7–63.6%), and 14% (range: 0–41.1%), respectively.
- The 1-, 2-, and 5-year recurrence-free survival rates were 72.7, 49.9, and 18.7%, respectively
- Mortality rate was 2%

Xue K, Huang X, Zhao P, Zhang Y, Tian B. Perioperative and long-term survival outcomes of pancreatectomy with arterial resection in borderline resectable or locally advanced pancreatic cancer following neoadjuvant therapy: a systematic review and meta-analysis. Int J Surg. 2023 Dec 1;109(12):4309-4321.

Perioperative mortality



Perioperative mortality (Clavien-Dindo >= 3)

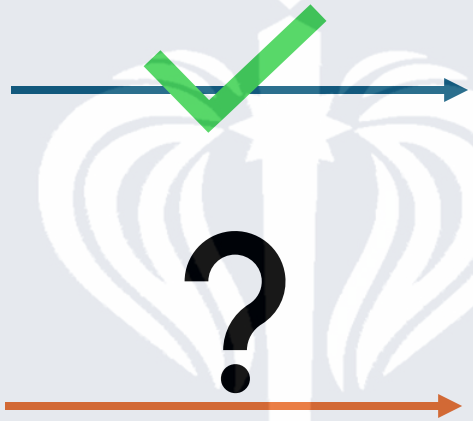


Xue K, Huang X, Zhao P, et al. Perioperative and long-term survival outcomes of pancreatectomy with arterial resection in borderline resectable or locally advanced pancreatic cancer following neoadjuvant therapy: a systematic review and meta-analysis. Int J Surg. 2023 Dec 1;109(12):4309-4321.

Introduction

Venous resection

Technical options of reconstruction are given

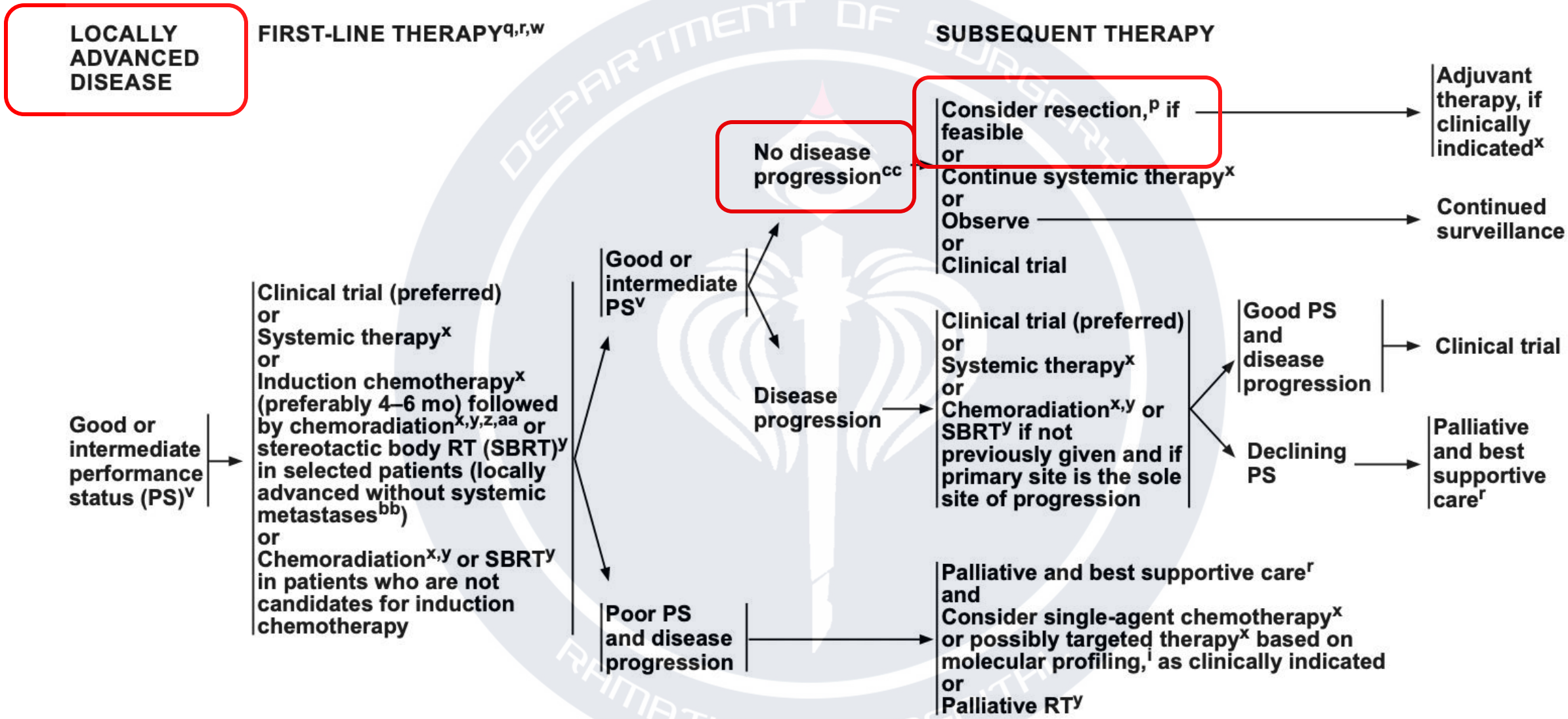


Artery resection

Not recommend for routine
Highly selected patients

How to selection

Maximilian Bockhorn, Falk G. Uzunoğlu, Mustapha Adham et al. Borderline resectable pancreatic cancer: A consensus statement by the International Study Group of Pancreatic Surgery (ISGPS), Surgery, Volume 155, Issue 6, 2014


LOCALLY ADVANCED DISEASE
FIRST-LINE THERAPY[q,r,w]
SUBSEQUENT THERAPY
Good or intermediate performance status (PS)[v]
Clinical trial (preferred) or Systemic therapy[x] or Induction chemotherapy[x] (preferably 4–6 mo) followed by chemoradiation[x,y,z,aa] or stereotactic body RT (SBRT)[y] in selected patients (locally advanced without systemic metastases[bb]) or Chemoradiation[x,y] or SBRT[y] in patients who are not candidates for induction chemotherapy
Good or intermediate PS[v]
Poor PS and disease progression
No disease progression[cc]
Consider resection,[p] if feasible or Continue systemic therapy[x] or Observe or Clinical trial
Adjuvant therapy, if clinically indicated[x]
Continued surveillance
Disease progression
Clinical trial (preferred) or Systemic therapy[x] or Chemoradiation[x,y] or SBRT[y] if not previously given and if primary site is the sole site of progression
Good PS and disease progression
Clinical trial
Declining PS
Palliative and best supportive care[r]
Palliative and best supportive care[r] and Consider single-agent chemotherapy[x] or possibly targeted therapy[x] based on molecular profiling,[i] as clinically indicated or Palliative RT[y]

In the present...

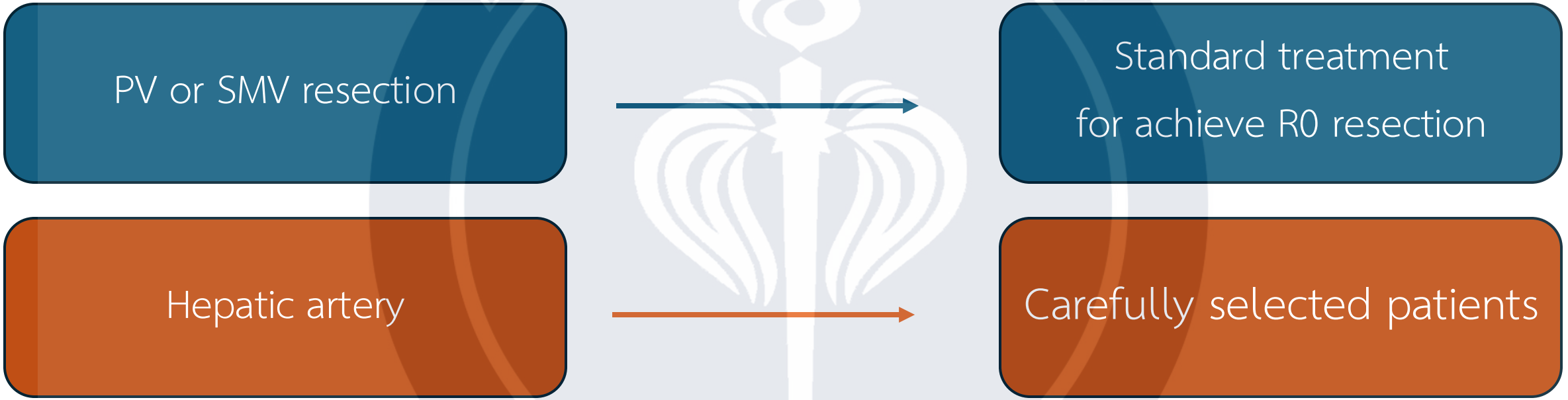
- Need Multidisciplinary team
- No standard selection criteria
- But very selected case in
  - Fit patient
  - No disease progression after NACT
  - CA 19-9 < 100

Compared between survival gain and negative consequence

Jabłońska B, Król R, Mrowiec S. Vascular Resection in Pancreatectomy-Is It Safe and Useful for Patients with Advanced Pancreatic Cancer? Cancers (Basel). 2022 Feb 25;14(5):1193

Bratlie SO, Wennerblom J, Vilhav C, Persson J, Rangelova E. Resectable, borderline, and locally advanced pancreatic cancer-"the good, the bad, and the ugly" candidates for surgery? J Gastrointest Oncol. 2021 Oct;12(5):2450-2460. PMID: 34790406; PMCID: PMC8576252.

Summary


PV or SMV resection
Standard treatment
for achieve R0 resection
Hepatic artery
Carefully selected patients

Summary

SMA/Celiac

Artery divesment

Resection/Reconstruction

Not routine recommend

Our institution experience(Ramathibodi hospital)

- Pancreaticoduodenectomy with or without vascular reconstruction 225 patients, between January 2012 and August 2024
- 188 patients performed pancreaticoduodenectomy alone(PD)
- 37 patients performed pancreaticoduodenectomy with vascular resection and reconstruction
  - 15 lateral venography
  - 14 end-to-end anastomoses
  - 5 resections with GSV panel graft position
  - 1 primary repair hepatic artery
  - 1 artery and venous resection and reconstruction

Our institution experience

Variable	Non vascular resection(n=188)	Vascular resection(n=37)	P-value
Gender			0.978
Male	91(48.4)	18(48.6)	
Female	97(51.6)	19(51.4)	
Age, mean±SD	62.7+12.2	63.0+11.2	0.916
Clinical presentation, n(%)			0.345
Incidental findings	22(11.7)	1(2.7)	
Jaundice	116(61.7)	28(75.7)	
Abdominal pain/discomfort	29(15.4)	7(18.9)	
Palpable mass	1(0.5)	0	
Weight loss	8(4.3)	0	
Others	12(6.4)	1(2.7)	

Our institution experience

Variable	Non vascular resection(n=188)	Vascular resection(n=37)	P-value
Patho, n(%) n=225			
pancreatic cancer	33(17.6)	24(64.9)	
distal CCA	19(10.1)	2(5.4)	
ampullary cancer	57(30.3)	2(5.4)	
duodenal cancer	11(5.8)	0	
MD-IPMN	11(5.8)	2(5.4)	
BD-IPMN	4(2.1)	0	
Combine-IPMN	3(1.6)	0	
PNET	14(7.5)	4(10.8)	
Chronic pancreatitis	8(4.3)	0	

Our institution experience

Variable	Non vascular resection(n=188)	Vascular resection(n=37)	P-value
Pre-Op SMV_invasion, n(%) n=210			<0.001
grade1	151(86.3)	9(25.7)	
grade2	18(10.3)	11(31.4)	
grade3	6(3.4)	10(28.6)	
grade4	0	5(14.3)	

Our institution experience

Variable	Non vascular resection(n=188)	Vascular resection(n=37)	P-value
Blood loss(ml), median(IQR)	600(400, 800)	1200(500, 2200)	<0.001
Operative time (mins), mean+SD	447+-103	541+-126	<0.001
LOS(day), median(IQR) n=213	19(12, 31)	14(11, 37)	0.843
ICU stay(day), median(IQR) n=220	3(2, 5)	3(2, 5)	0.804

Our institution experience

Variable	Non vascular resection(n=188)	Vascular resection(n=37)	P-value
POPF, n(%)			
No	67(35.6)	30(81.1)	<0.001
Yes	121(64.4)	7(18.9)	
Grade			
BL	83(68.6)	2(28.6)	0.042
B+C	38(31.4)	5(71.4)	
PPH, n(%)			
No	172(91.5)	32(86.5)	0.339
Yes	16(8.5)	5(13.5)	
DGE, n(%)			
No	148(78.7)	30(81.1)	0.747
Yes	40(21.3)	7(18.9)	

Variable	Non vascular resection(n=188)	Vascular resection(n=37)	P-value
Vascular complication, n(%) n=184			
No	146(96.7)	19(57.5)	<0.001
Yes	5(3.3)	14(42.5)	
Thrombosis	0	7(21.2)	
Stenosis	1(0.7)	6(18.2)	
Bleed	4(2.6)	3(9.0)	
90-day morbidity, n(%) n=209			
No	37(19.7)	11(29.7)	0.173
Yes	151(80.3)	26(70.3)	
90-day mortality, n(%) n=209			
No	173(99.4)	33(94.3)	0.073
Yes			

1-year Patency 100%(Autogenous FV/GSV graft)

Thank you