Surgical Planning For BR & LA PDAC in Open Surgery

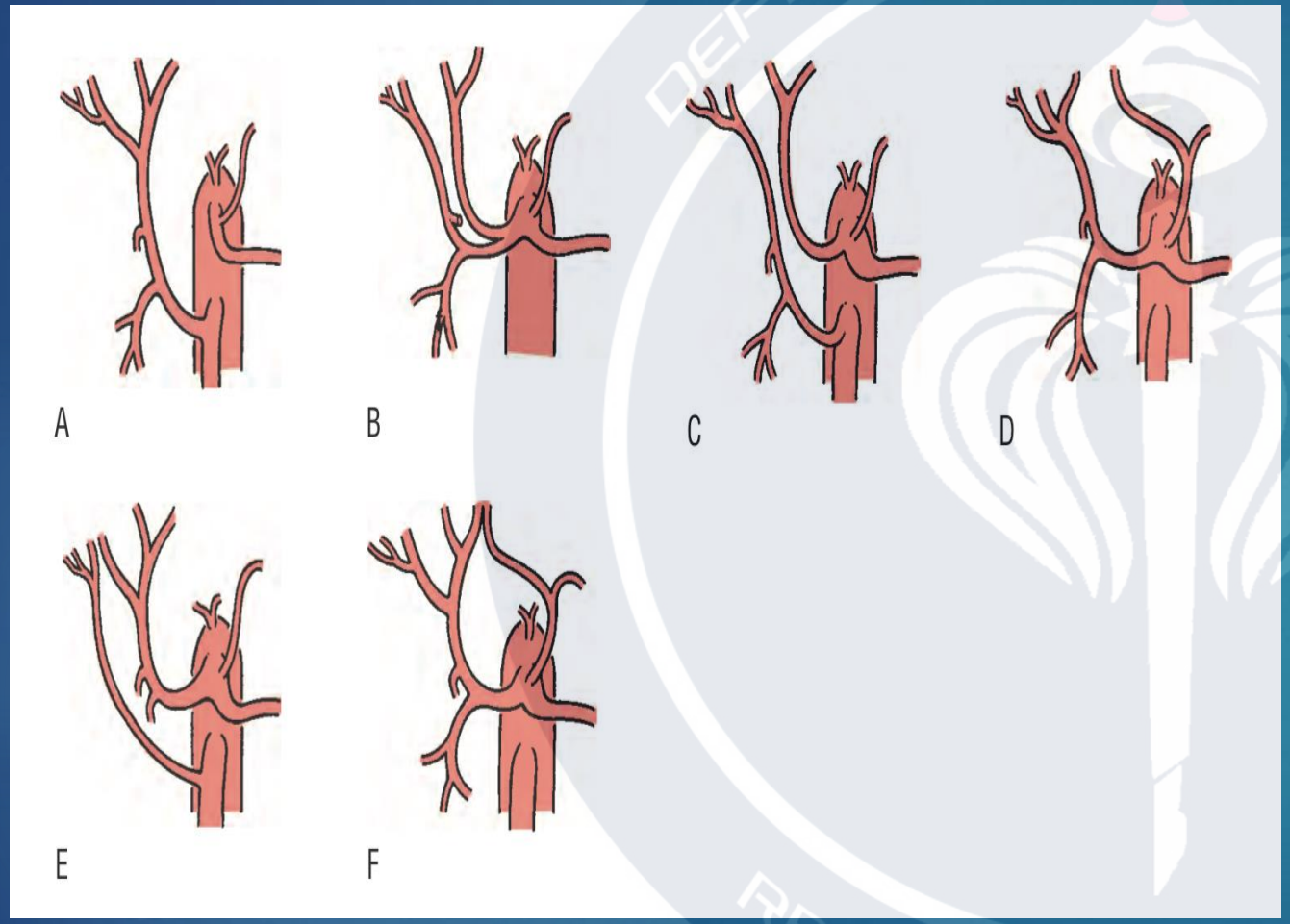
F1 CHUNLACHES CHAIJAREENONT

Outline

- Anatomy of the Peripancreatic Vessels and Nerves
- Definition of BR/LA PDAC
- Artery-First Approach
- Portomesecteric Vein Resection and Reconstruction
- Management of Arterial Involvement
- DP-CARS
- RAMPS vs DPS

Anatomy of the Peripancreatic Vessels and Nerve Plexuses

Celiac and SMA



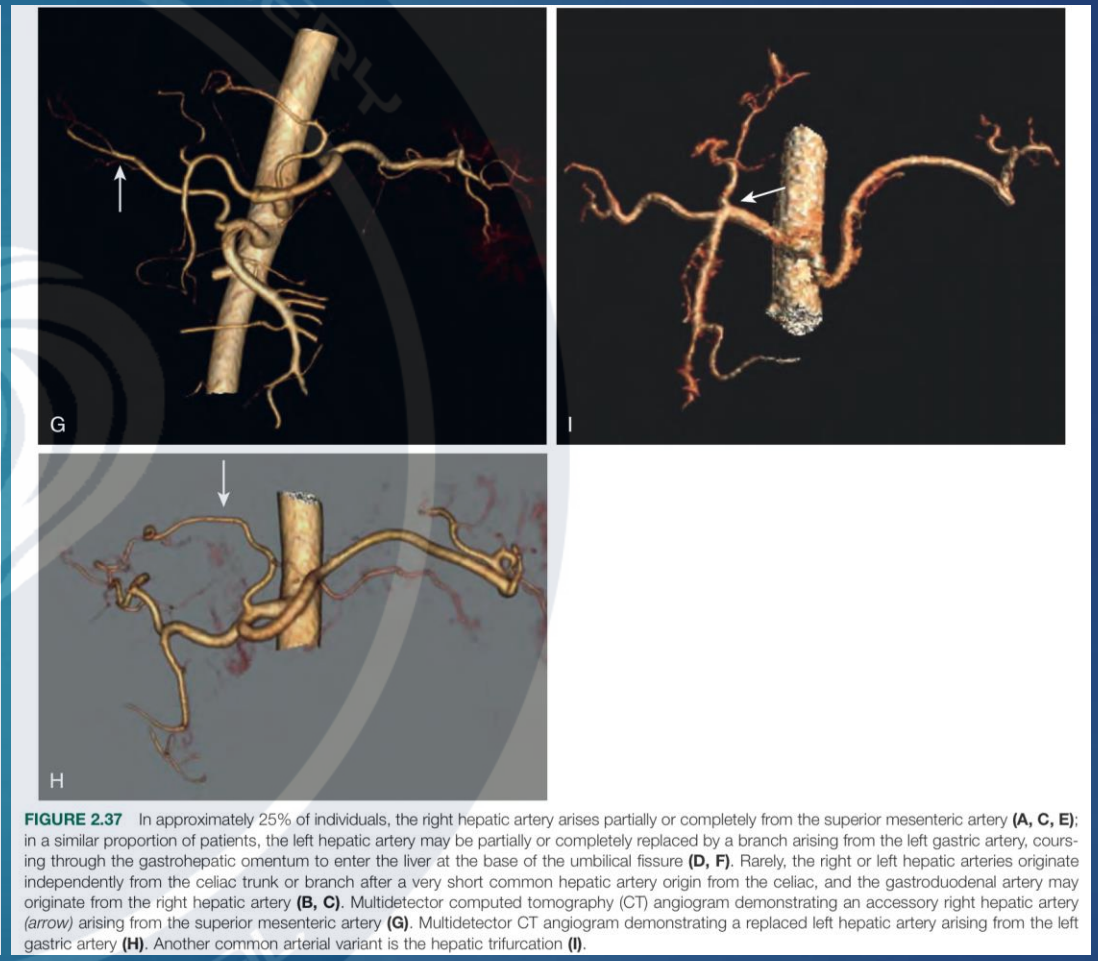


FIGURE 2.37 In approximately 25% of individuals, the right hepatic artery arises partially or completely from the superior mesenteric artery **(A, C, E)**; in a similar proportion of patients, the left hepatic artery may be partially or completely replaced by a branch arising from the left gastric artery, coursing through the gastrohepatic omentum to enter the liver at the base of the umbilical fissure **(D, F)**. Rarely, the right or left hepatic arteries originate independently from the celiac trunk or branch after a very short common hepatic artery origin from the celiac, and the gastroduodenal artery may originate from the right hepatic artery **(B, C)**. Multidetector computed tomography (CT) angiogram demonstrating an accessory right hepatic artery *(arrow)* arising from the superior mesenteric artery **(G)**. Multidetector CT angiogram demonstrating a replaced left hepatic artery arising from the left gastric artery **(H)**. Another common arterial variant is the hepatic trifurcation **(I)**.

SMA

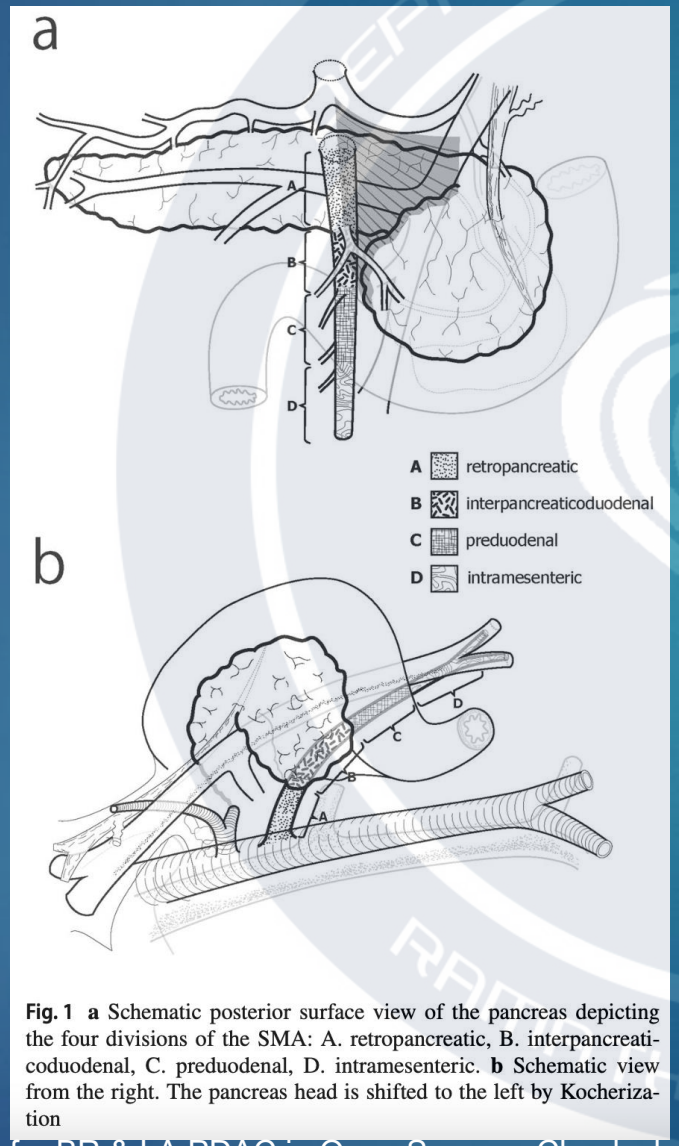


Fig. 1 **a** Schematic posterior surface view of the pancreas depicting the four divisions of the SMA: A. retropancreatic, B. interpancreaticoduodenal, C. preduodenal, D. intramesenteric. **b** Schematic view from the right. The pancreas head is shifted to the left by Kocherization

- French anatomists first divided the SMA into 4 segments:
  1. retropancreatic
  2. interpancreaticoduodenal
  3. preduodenal
  4. intramesenteric
- The right hepatic artery arises from the retropancreatic segment in 7.5–18% of cases, on which the pancreas body lies.
- The inferior pancreatoduodenal artery (IPDA) and first jejunal artery leave the interpancreaticoduodenal segment where the uncinate process closely abuts this artery.
- The middle colic artery and some jejunal arteries have their origins from the interpancreaticoduodenal to the preduodenal segment.

IPDA, JA, JV

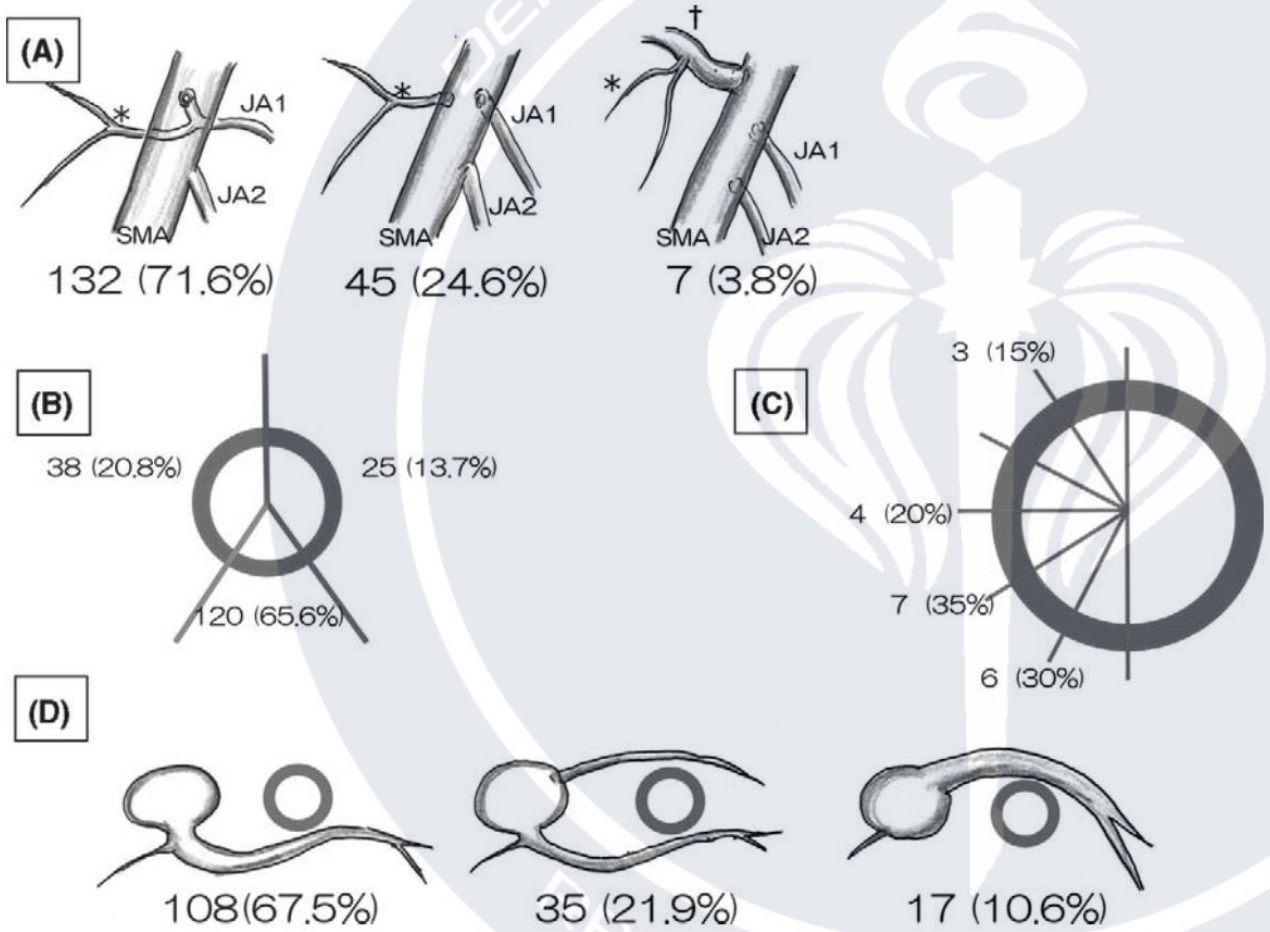


FIGURE 5. Imaging analysis. A, Patterns of the IPDA root. In total, 132 IPDAs branched from the common trunk with JA, whereas 45 came independently and 7 came from a replaced hepatic artery. * indicates IPDA. B, Most of IPDAs originate from the right dorsal aspect of the SMA. C, The point of SMA abutment by invasive tumor in 20 patients. D, Patterns of JV course in 160 patients.

SMV-PV

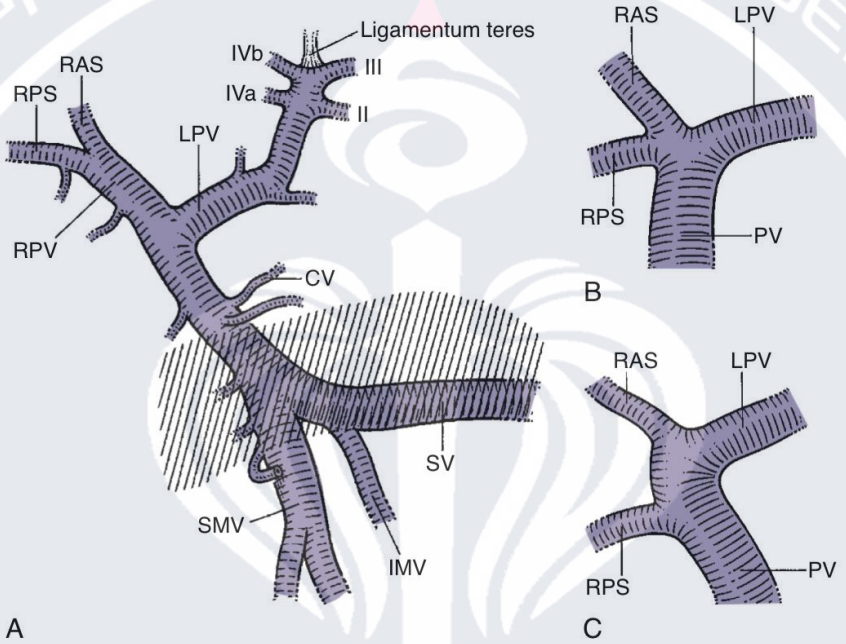


FIGURE 2.38 **A,** The superior mesenteric vein *(SMV)* at the root of the lesser omentum is usually a single trunk; two, or sometimes even three, branches may unite as the vessel enters the tunnel beneath the neck of the pancreas *(shaded)* to form a superior mesenteric trunk. This trunk ascends behind the neck of the pancreas and is joined by the splenic vein *(SV),* which enters it from the left to form the portal vein *(PV),* which emerges from the retroperitoneal upper border of the neck of the pancreas and ascends toward the liver within the free edge of the lesser omentum, lying behind the bile duct and the hepatic artery and surrounded by the lymphatics and nodes of the lesser omentum. During this course, it receives blood through the coronary vein *(CV),* which communicates with esophageal venous collaterals, which connect with the gastric vein and the esophageal plexus. Sometimes a separate right gastric vein enters the PV in this area. A superior pancreaticoduodenal vein often enters the PV just above the level of the pancreas, and several smaller veins enter the SMV and PV from the right side beneath the neck of the pancreas. As the PV ascends behind the common bile duct and common hepatic duct, it approaches the hilus of the liver and bifurcates into two branches, a larger right *(RPV)* and a smaller left portal vein *(LPV).* The branch on the left courses below the left hepatic duct to enter the umbilical fissure, in company with the left hepatic artery, and subsequently branches to supply the left liver segments (II-IV). Just before its entry into the umbilical fissure, it gives off a major caudate vein, segment I, which runs posteriorly and laterally to the left. Sometimes this vein consists of two or more branches; the right portal branch, which is much shorter in length before its entry into the liver, divides at the extremity of the hilus into the right anterior *(RAS)* and posterior *(RPS)* sectional branches and is accompanied by the respective arterial branches and biliary tributaries. **B,** The division of the portal vein may arise more proximally, however, and **C,** the right anterior and posterior sectional portal veins may arise independently from the portal venous trunk. *IMV,* Inferior mesenteric vein.

Nerve Plexus

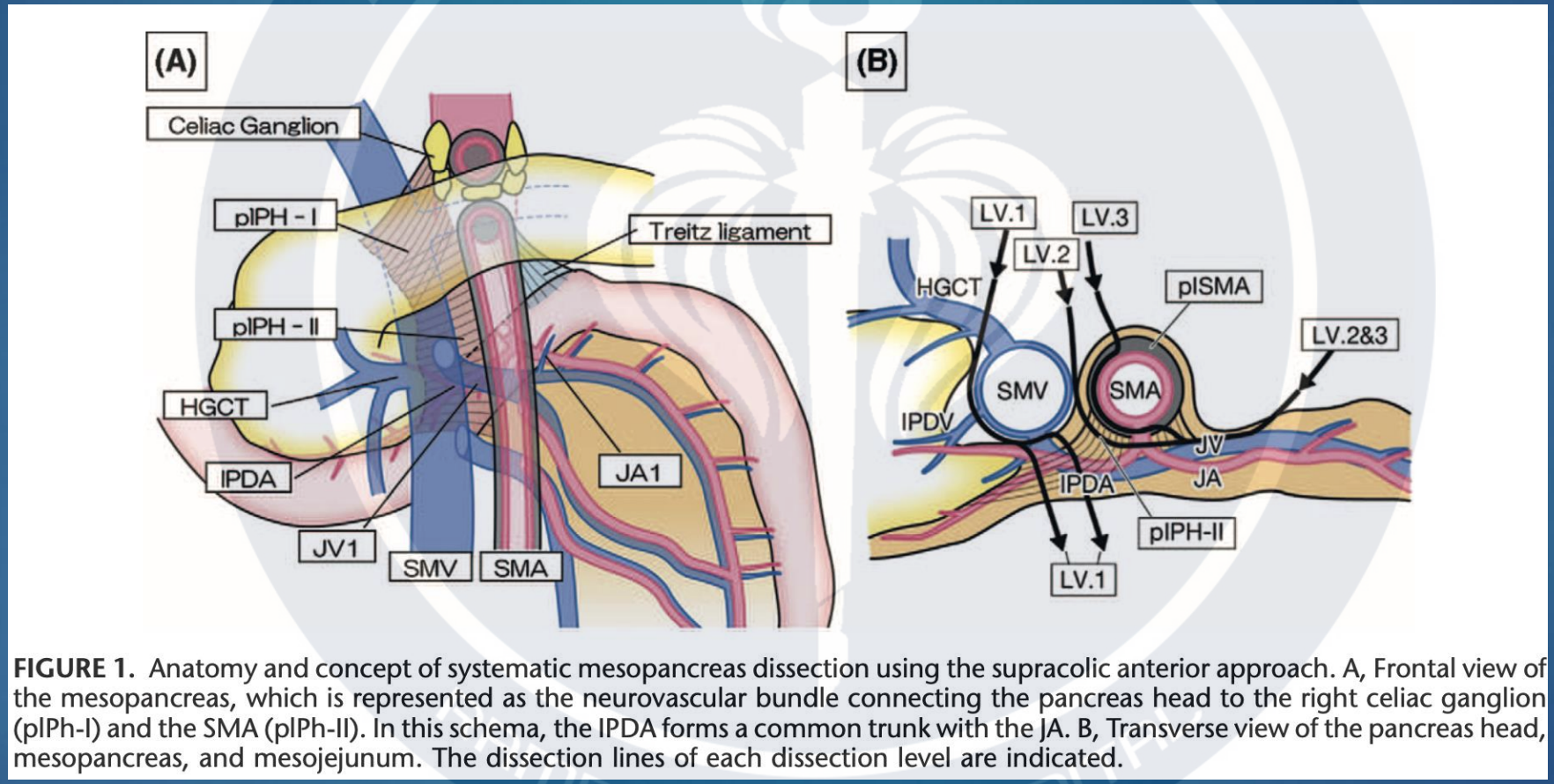


FIGURE 1. Anatomy and concept of systematic mesopancreas dissection using the supracolic anterior approach. A, Frontal view of the mesopancreas, which is represented as the neurovascular bundle connecting the pancreas head to the right celiac ganglion (plPh-I) and the SMA (plPh-II). In this schema, the IPDA forms a common trunk with the JA. B, Transverse view of the pancreas head, mesopancreas, and mesojejunum. The dissection lines of each dissection level are indicated.

Inoue Y, et al. Pancreatoduodenectomy with systematic mesopancreas dissection using a supracolic anterior artery-first approach. Ann Surg. 2015; 262; 6: 1092-1101.

Definition

CRITERIA DEFINING RESECTABILITY STATUS AT DIAGNOSIS[a]

- **Decisions about resectability status should be made in consensus at multidisciplinary meetings/discussions.**

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]	Pancreatic head/uncinate process: • 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 (ex: 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. Pancreatic body/tail: • 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]	Head/uncinate process: • Solid tumor contact >180° with the SMA or CA. Pancreatic body/tail: • Solid tumor contact of >180° with the SMA or CA. • Solid tumor contact with the CA and aortic involvement.	• Unreconstructible SMV/PV due to tumor involvement or occlusion (can be due to tumor or bland thrombus).

[a] Al-Hawary MM, Francis IR, Chari ST, et al. Pancreatic ductal adenocarcinoma radiology reporting template: consensus statement of the Society of Abdominal Radiology and the American Pancreatic Association. Radiology 2014;270:248-260.
[b] Solid tumor contact may be replaced with increased hazy density/stranding of the fat surrounding the peri-pancreatic vessels (typically seen following neoadjuvant therapy); this finding should be reported on the staging and follow-up scans.
[c] Distant metastasis (including non-regional lymph node metastasis), regardless of anatomic resectability, implies disease that should not be treated with upfront resection.

Continued

Anatomy classification for BR-PDAC

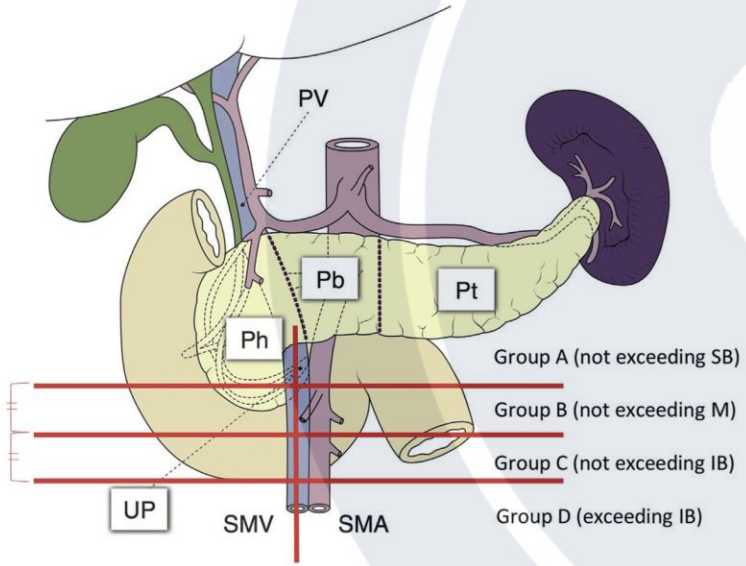


Fig. 2. Classification of the duodenal margin of SMV invasion. Group A: SMV invasion not exceeding the superior border of the duodenum (SB), Group B: SMV invasion not exceeding the middle of the duodenum (M), Group C: SMV invasion not exceeding the inferior border of the duodenum (IB), and Group D: SMV invasion exceeding the inferior border of the duodenum (IB). SMV: superior mesenteric vein, PV: portal vein, SMA: superior mesenteric artery, UP: uncinate process, Ph: pancreatic head, Pb: pancreatic body, Pt: pancreatic tail. Anatomical scheme of the pancreas in Japanese classification of pancreatic cancer 7th edition with modifications. (permission from Kanehara & Co., Ltd., Tokyo, Japan).

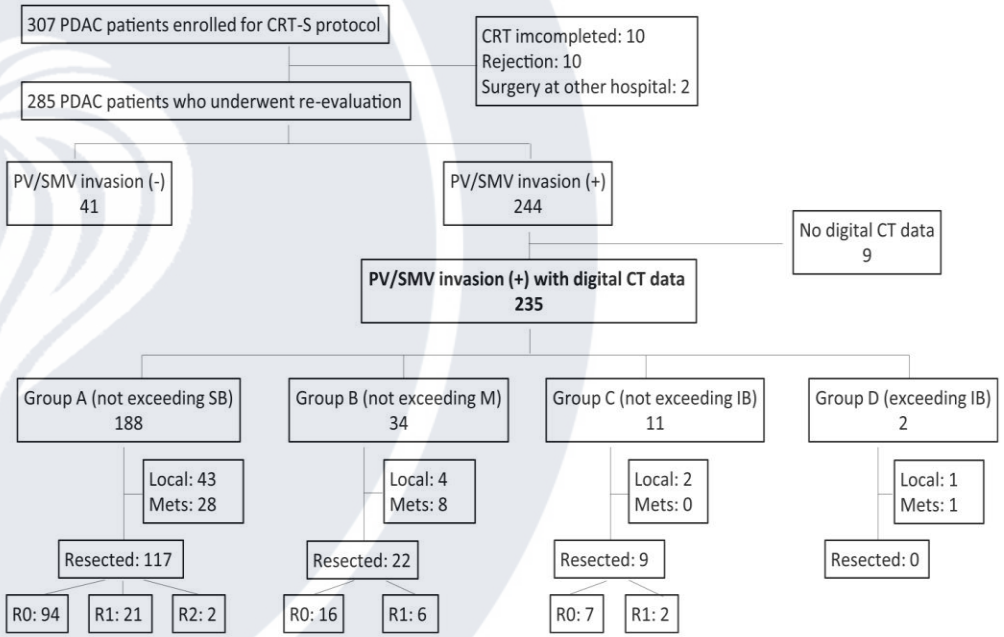


Fig. 3. Flow diagram of the 307 patients who had been enrolled for treatment of chemoradiotherapy (CRT) followed by surgery (CRT-S) at Mie University Hospital from February 2005 to December 2016, and surgical outcomes in the subjects of 235 patients according to classification of duodenal margin of SMV invasion (Groups A, B, C and D). Invasion (-): invasion negative, invasion (+): invasion positive, Local: unresected due to local factors such as major artery invasion, Mets: unresected due to the development of distant metastases.

8TH ed. AJCC

Table 1. **Definitions for T, N, M**
American Joint Committee on Cancer (AJCC) TNM Staging of Pancreatic Cancer (8th ed., 2017)

T	**Primary Tumor**
TX	Primary tumor cannot be assessed
T0	No evidence of primary tumor
Tis	Carcinoma *in situ* This includes high-grade pancreatic intraepithelial neoplasia (PanIn-3), intraductal papillary mucinous neoplasm with high-grade dysplasia, intraductal tubulopapillary neoplasm with high-grade dysplasia, and mucinous cystic neoplasm with high-grade dysplasia
T1	Tumor ≤2 cm in greatest dimension
T1a	Tumor ≤0.5 cm in greatest dimension
T1b	Tumor >0.5 cm and <1 cm in greatest dimension
T1c	Tumor 1–2 cm in greatest dimension
T2	Tumor >2 cm and ≤4 cm in greatest dimension
T3	Tumor >4 cm in greatest dimension
T4	Tumor involves the celiac axis, superior mesenteric artery, and/or common hepatic artery, regardless of size

N	**Regional Lymph Nodes**
NX	Regional lymph nodes cannot be assessed
N0	No regional lymph node metastases
N1	Metastasis in one to three regional lymph nodes
N2	Metastasis in four or more regional lymph nodes
M	**Distant Metastasis**
M0	No distant metastasis
M1	Distant metastasis

Table 2. **AJCC Prognostic Groups**

	T	N	M
Stage 0	Tis	N0	M0
Stage IA	T1	N0	M0
Stage IB	T2	N0	M0
Stage IIA	T3	N0	M0
Stage IIB	T1, T2, T3	N1	M0
Stage III	T1, T2, T3	N2	M0
	T4	Any N	M0
Stage IV	Any T	Any N	M1

Artery-First Approach

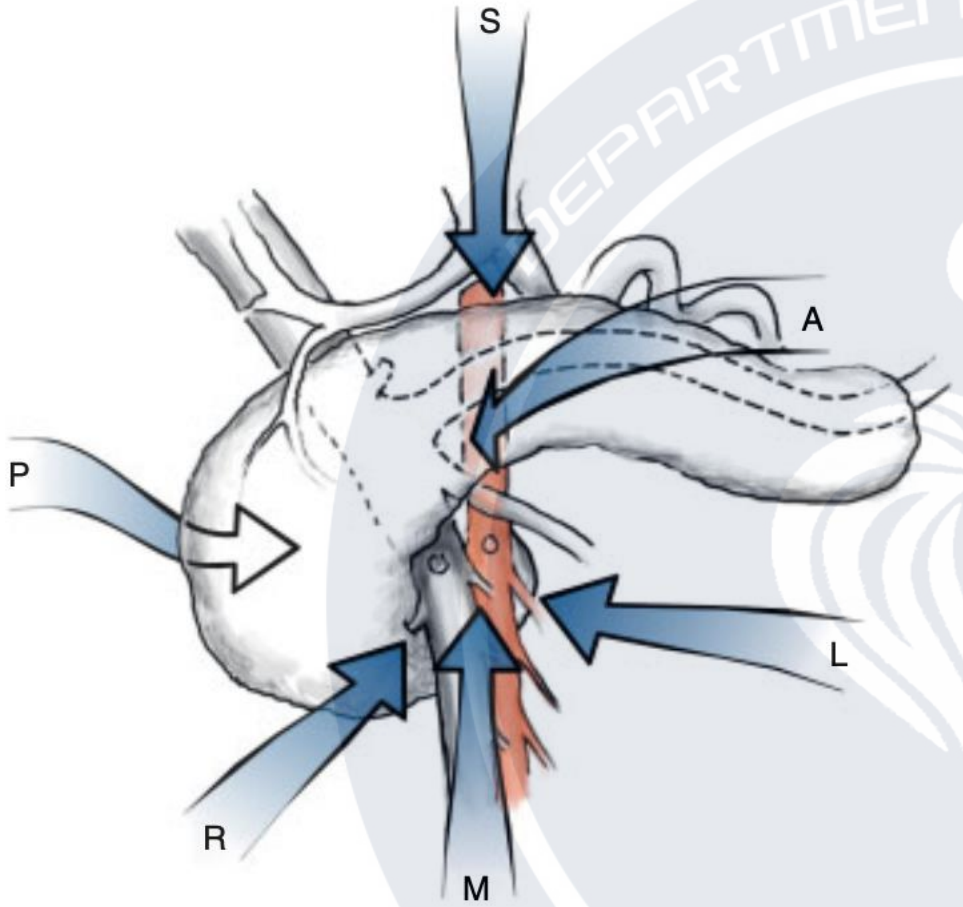


Fig. 1 Diagram showing the six approaches to the superior mesenteric artery: S, superior approach; A, anterior approach; P, posterior approach; L, left posterior approach; R, right/medial uncinate approach; M, mesenteric approach

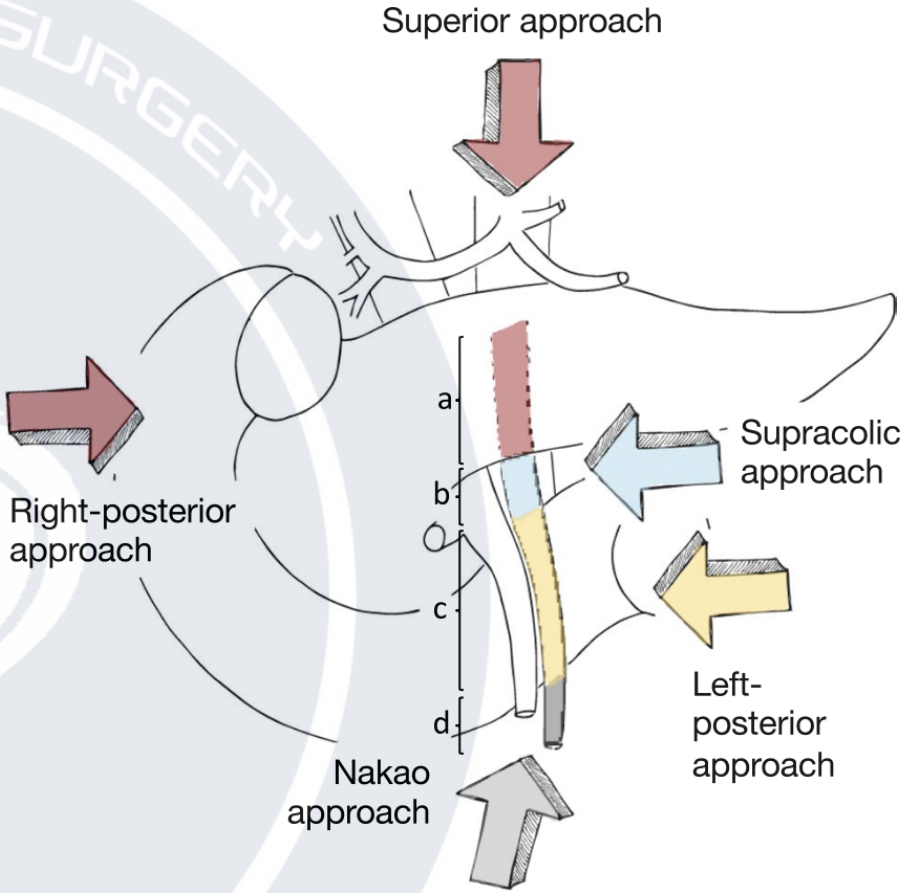


Fig. 1 Schematic representation of the four segments of the SMA (**a** retropancreatic, **b** interpancreaticoduodenal, **c** preduodenal, **d** intramesenteric) and different artery-first approaches. Please note that every type of artery-first allows the early identification of one specific segment of the vessel [2-column fitting image]

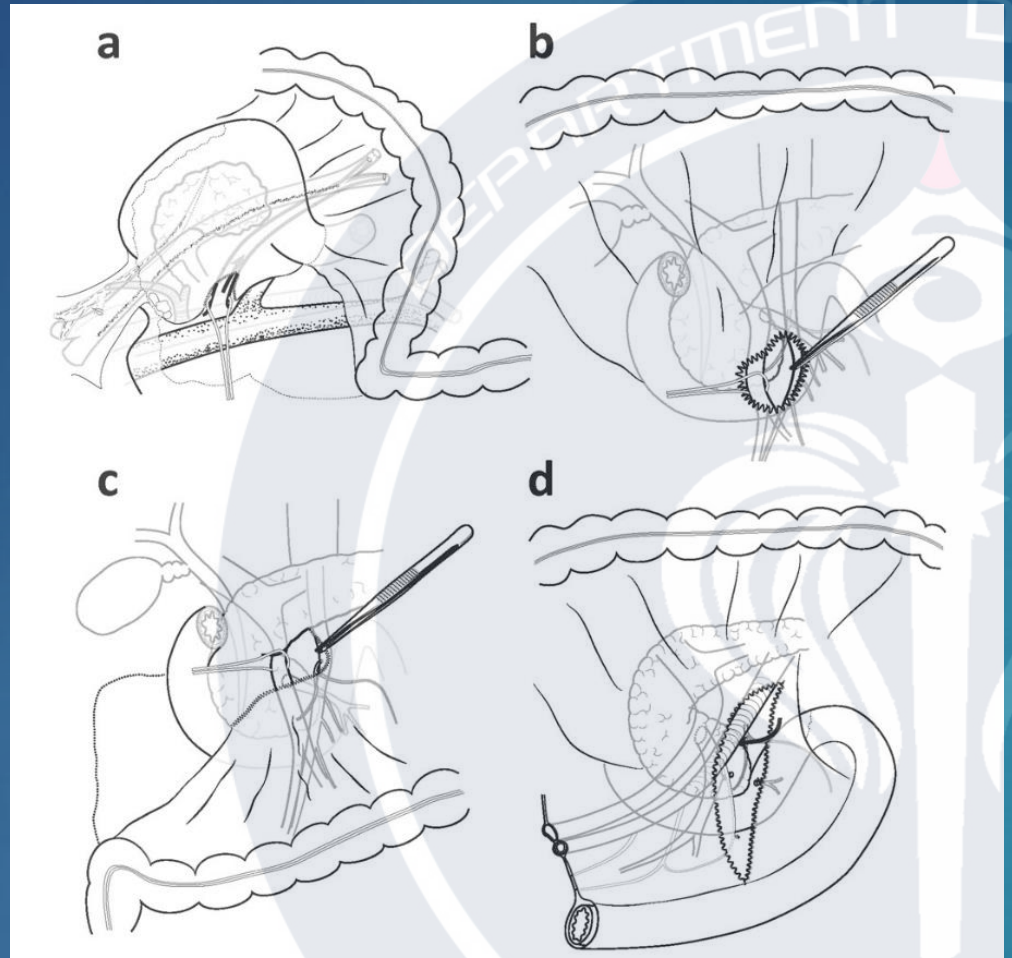


Fig. 2 Schematic presentations of the four approaches. **a** Supracolic right posterior approach. The retropancreatic portion of the SMA is taped. The arrow indicates the dissection site and direction. **b** Infracolic anterior approach. The SMV is taped, and the SMA is retracted by tweezers. **c** Supracolic anterior approach. The SMV is taped, and the SMA is retracted by tweezers. **d** Infracolic left posterior approach. The arrow indicates the direction of the dissection

A. Supracolic right posterior approach
B. Infracolic anterior approach (Nakao)
C. Supracolic anterior approach (Medial uncinate)
D. Infracolic left posterior approach

Table 1 Order of pancreatoduodenectomoy procedures according to a timeline

Category	Author	Year	Order of procedures					
			Dissection of		Division of			
			Kocherization	SMA	Jejunum	Stomach	CBD[a]	Pancreas
Supracolic right posterior	Pessaux	2006	1	2	4	5	3	6
	Varty	2005	1	3	4[b]	5	2	6
	Popescu	2007	1	3	5[b]	4	2	6
	Shah	2013	1	2	6	3	4	5
	Zimmitti	2016	1	2	4	3	6	5
	Pędziwiatr	2017	1	2	5	4	3	6
	Vallance	2017	1	2	4	5	3	6
Infracolic anterior	Nakao	1993	6	1	4	3	2	5
	Horiguchi	2007	3	4	5	2	1	6
	Weitz	2010	1[c]	2	4	5	3	6
	Mizuno	2014	6	1	5[b]	2	3	4
	Zhu J	2016	6	1	5	2	4	3
Supracolic anterior	Hackert	2010	1	4	3[b]	5	2	6
	Inoue	2015	1	2	3	4	5	6
	Zhang	2017	1	3	2	4	6	5
Infracolic left posterior	Kurosaki	2011	1[d]	2	4[b]	3	6	5
	Kawabata	2012	1[d]	2	5	4	3	6

ND not described

[a]Including dissection of the hepatoduodenal ligament, division of the common bile duct (CBD) and exposition of the portal vein

[b]Division of the ligament of Treitz is described before or after division of the jejunum

[c]Including the Cattel–Braasch maneuver d: reversed Kocher maneuver

Table 1 Summary of indications, advantages and disadvantages of various artery-first approaches

Approach	Indication(s)	Advantages	Disadvantages
Posterior[12]	Posteromedial tumour in head/neck, especially involving PV–SMV Periampullary tumour extending from body to head	Early identification of SMA involvement Identification of replaced RHA Enables adequate retropancreatic lymphadenectomy Early identification of SMV involvement and facilitates *en bloc* resection	Difficult in patients with peripancreatic inflammation and adhesions around head of pancreas
Medial uncinate[18,22]	Malignant tumours of uncinate process	Early identification of SMA involvement at uncinate Early ligation of IPDA minimizes bleeding Useful approach in peripancreatic inflammation with difficulty tunnelling above PV Useful approach for total pancreatectomy as mobilization can be achieved without transecting gland	Late identification of replaced RHA
Inferior infracolic (mesenteric)[19]	Locally advanced tumours with questionable infiltration of SMA at its origin from aorta Malignant tumours of uncinate and ventral pancreas	Early identification of replaced RHA Allows better exposure and dissection of region posterior to SMA Early ligation of IPDA minimizes bleeding	Difficult in morbidly obese patients Difficult exposure in patients with high origin of SMA
Left posterior[20]	Tumours along uncinate and ventral pancreas	Facilitates skeletonization of SMA in retroperitoneum without kocherization of duodenum Early ligation of IPDA	Extensive dissection of SMA requiring antidiarrhoeals
Inferior supracolic (anterior)[21]	Tumours along inferior border of pancreas	Facilitates better retroperitoneal dissection, especially with locally advanced tumours with neoadjuvant treatment 'No-touch' technique with *en bloc* kocherization theoretically prevents tumour cell dissemination	Early division of stomach and neck of pancreas
Superior	Malignant tumours of superior border of pancreas	Early identification of CHA, coeliac and SMA involvement	Difficult exposure in patients with low origin of SMA

PV, portal vein; SMV, superior mesenteric vein; SMA, superior mesenteric artery; RHA, right hepatic artery; IPDA, inferior pancreatoduodenal artery; CHA, common hepatic artery.

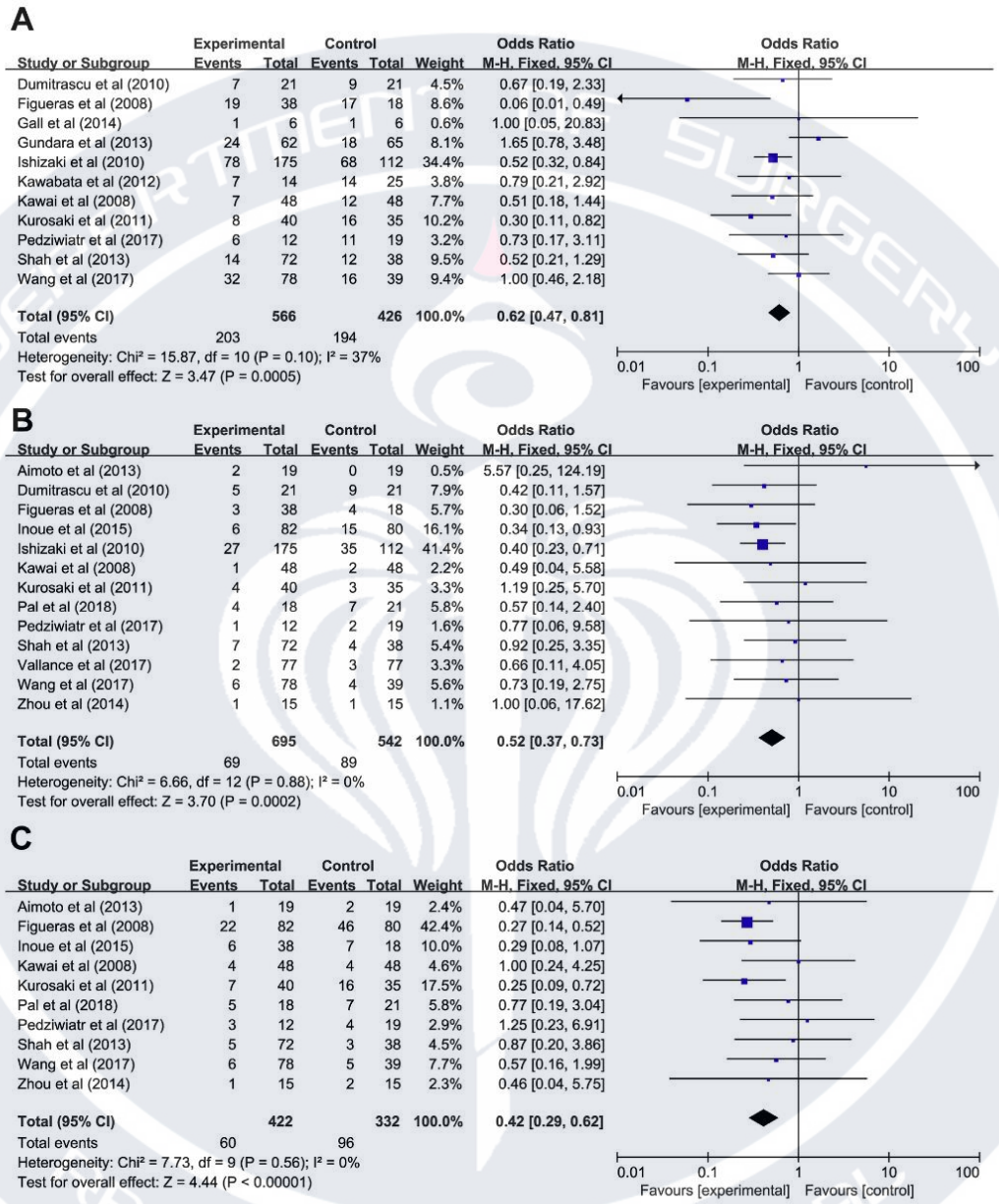


Fig. 2. Forest plot of overall complication rate (A), pancreatic fistula (B) and delayed gastric emptying rate (C) in patients who received SMA-PD compared with S-PD.

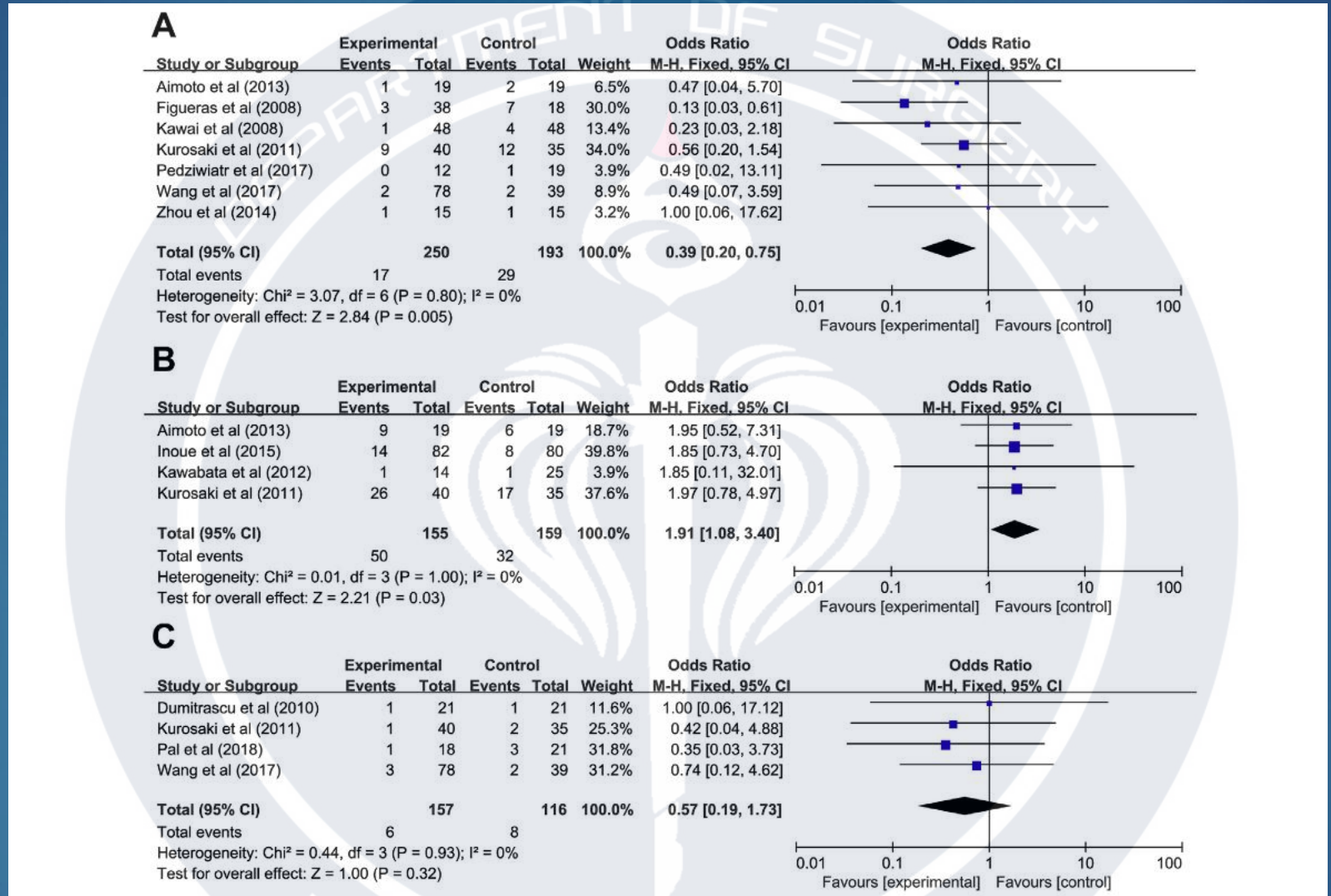
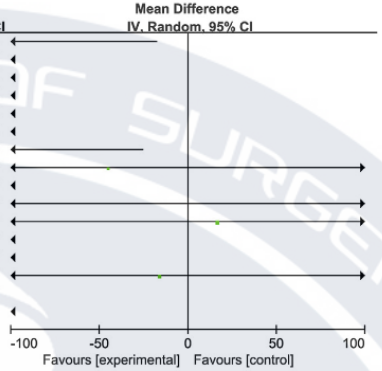


Fig. 3. Forest plot of intraabdominal infections (A), diarrhea (B) and postoperative haemorrhage rate (C) in patients who received SMA-PD compared with S-PD.

A

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Dumitrascu et al (2010)	292.86	195.12	21	435.71	219.17	21	7.7%	-142.85 [-268.35, -17.35]
Gundara et al (2013)	385	31	25	627	41	17	10.1%	-242.00 [-264.97, -219.03]
Horiguchi et al (2007)	678	329	18	1,225	375	18	4.9%	-547.00 [-777.46, -316.54]
Inoue et al (2015)	435	174.8	82	642.5	164.4	80	9.7%	-207.50 [-259.74, -155.26]
Ishizaki et al (2010)	446	302	175	1,062	605	112	7.9%	-616.00 [-736.65, -495.35]
Kawabata et al (2012)	1,070	170.1	14	1,330	340	25	6.7%	-260.00 [-420.32, -99.68]
Kawai et al (2008)	728	222.9	48	867	334.8	48	8.1%	-139.00 [-252.78, -25.22]
Kurosaki et al (2011)	1,307	823	40	1,352	823	35	2.7%	-45.00 [-418.35, 328.35]
Nagakawa et al (2015)	162.7	18.5	10	463.8	97.9	22	9.8%	-301.10 [-343.59, -258.61]
Pal et al (2018)	855.6	607.3	18	973.8	783.5	21	2.1%	-118.20 [-555.24, 318.84]
Pedziwiatr et al (2017)	408.3	166.3	12	391.7	180.7	19	7.8%	16.60 [-107.72, 140.92]
Shah et al (2013)	601	250.3	72	1,371.5	471.8	38	6.7%	-770.50 [-931.26, -609.74]
Wang et al (2017)	534	81.5	78	756	220.7	39	9.2%	-222.00 [-293.59, -150.41]
Zhou et al (2014)	407	202	15	423	253	15	6.6%	-16.00 [-179.84, 147.84]
Total (95% CI)			**628**			**510**	**100.0%**	**-264.84 [-336.10, -193.58]**

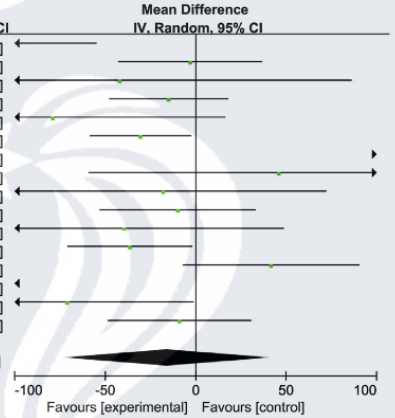
Heterogeneity: Tau² = 12987.26; Chi² = 124.63, df = 13 (P < 0.00001); I² = 90%
Test for overall effect: Z = 7.28 (P < 0.00001)



B

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Dumitrascu et al (2010)	228.57	75.78	21	332.38	85.84	21	6.5%	-103.81 [-152.78, -54.84]
Figueras et al (2008)	380	79	38	383	67	18	6.6%	-3.00 [-42.86, 36.86]
Gall et al (2014)	198	88.9	6	240	133.3	6	5.0%	-42.00 [-170.20, 86.20]
Gundara et al (2013)	380	55.56	25	395	51.85	17	6.6%	-15.00 [-47.89, 17.89]
Horiguchi et al (2007)	451	89	18	530	186	18	5.7%	-79.00 [-174.26, 16.26]
Inoue et al (2015)	453.5	35.93	14	484	53.04	25	6.7%	-30.50 [-58.54, -2.46]
Ishizaki et al (2010)	578	112	175	360	108	112	6.7%	218.00 [192.01, 243.99]
Kawabata et al (2012)	614	289.5	82	568	385.9	80	5.5%	46.00 [-59.25, 151.25]
Kawai et al (2008)	339	225.2	48	357	225.9	48	5.8%	-18.00 [-108.24, 72.24]
Kurosaki et al (2011)	516	95	40	526	95	35	6.5%	-10.00 [-53.10, 33.10]
Nagakawa et al (2015)	522.5	89.6	10	562.2	164.8	22	5.8%	-39.70 [-128.17, 48.77]
Pal et al (2018)	321.1	54	18	357.6	55.8	21	6.6%	-36.50 [-71.02, -1.98]
Pedziwiatr et al (2017)	466.7	53.8	12	425	85.1	19	6.5%	41.70 [-7.20, 90.60]
Shah et al (2013)	208.1	46.3	72	322	33.8	38	6.8%	-113.90 [-129.06, -98.74]
Wang et al (2017)	313	162.2	78	384	190.3	39	6.2%	-71.00 [-140.73, -1.27]
Zhou et al (2014)	255	57	15	264	54	15	6.6%	-9.00 [-48.73, 30.73]
Total (95% CI)			**672**			**534**	**100.0%**	**-15.82 [-72.49, 40.85]**

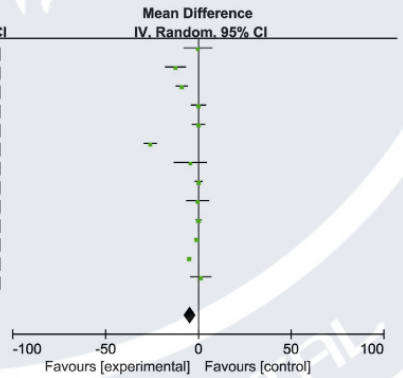
Heterogeneity: Tau² = 12311.17; Chi² = 492.95, df = 15 (P < 0.00001); I² = 97%
Test for overall effect: Z = 0.55 (P = 0.58)



C

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Dumitrascu et al (2010)	19.57	12.89	21	19.9	12.87	21	5.8%	-0.33 [-8.12, 7.46]
Figueras et al (2008)	16.2	10	38	28.6	10	18	7.0%	-12.40 [-18.01, -6.79]
Gall et al (2014)	16.2	2	6	25.2	3.5	6	8.3%	-9.00 [-12.23, -5.77]
Gundara et al (2013)	12	9.63	25	12	3.7	17	7.9%	0.00 [-4.16, 4.16]
Inoue et al (2015)	27	4.67	14	27	6.74	25	8.2%	0.00 [-3.60, 3.60]
Kawabata et al (2012)	30	7	82	56	14.5	80	8.2%	-26.00 [-29.52, -22.48]
Kurosaki et al (2011)	45.4	24	40	49.8	15	35	5.1%	-4.40 [-13.34, 4.54]
Nagakawa et al (2015)	19.5	2.4	10	19.4	3.7	22	8.8%	0.10 [-2.05, 2.25]
Pal et al (2018)	13.78	12.2	18	14.29	6.2	21	6.7%	-0.51 [-6.74, 5.72]
Pedziwiatr et al (2017)	9	1.3	12	9	3	19	9.0%	0.00 [-1.54, 1.54]
Shah et al (2013)	8.46	2.06	72	9.47	3.59	38	9.1%	-1.01 [-2.25, 0.23]
Wang et al (2017)	14	1.4	78	19	2.4	39	9.1%	-5.00 [-5.81, -4.19]
Zhou et al (2014)	16.8	8.2	15	15.6	7.8	15	6.9%	1.20 [-4.53, 6.93]
Total (95% CI)			**431**			**356**	**100.0%**	**-4.49 [-7.54, -1.43]**

Heterogeneity: Tau² = 26.48; Chi² = 247.54, df = 12 (P < 0.00001); I² = 95%
Test for overall effect: Z = 2.88 (P = 0.004)



SMA first for PD: blood loss (A), operation time (B) and postoperative stay (C).

Fig. 4. Forest plot of blood loss (A), operative time (B) and postoperative stay (C) in patients who received SMA-PD compared with S-PD.

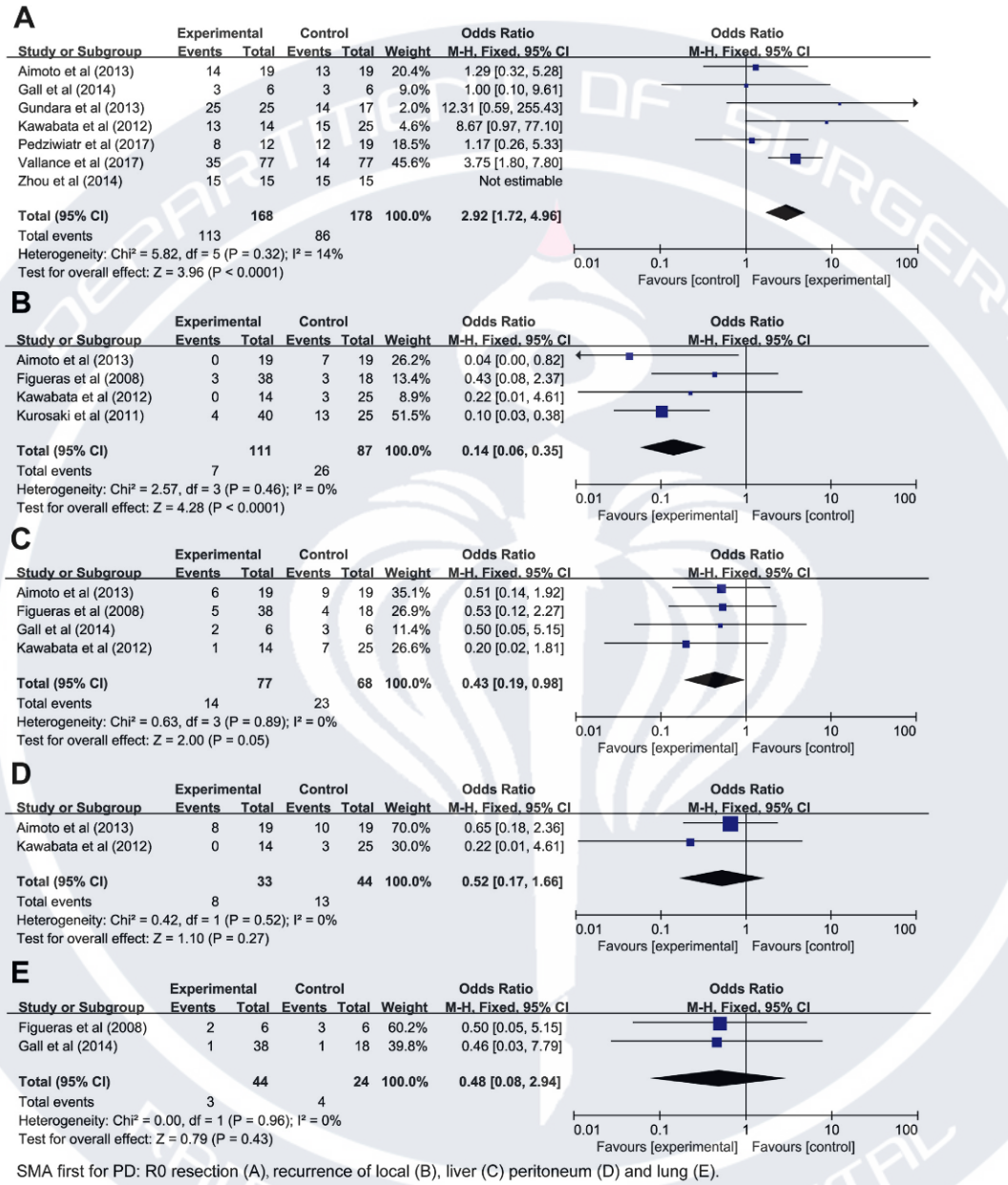


Fig. 5. Forest plot of R0 resection rate (A), local recurrence rate (B), liver recurrence rate (C), peritoneum recurrence rate (D) and lung recurrence rate (E) in patients who received SMA-PD compared with S-PD.

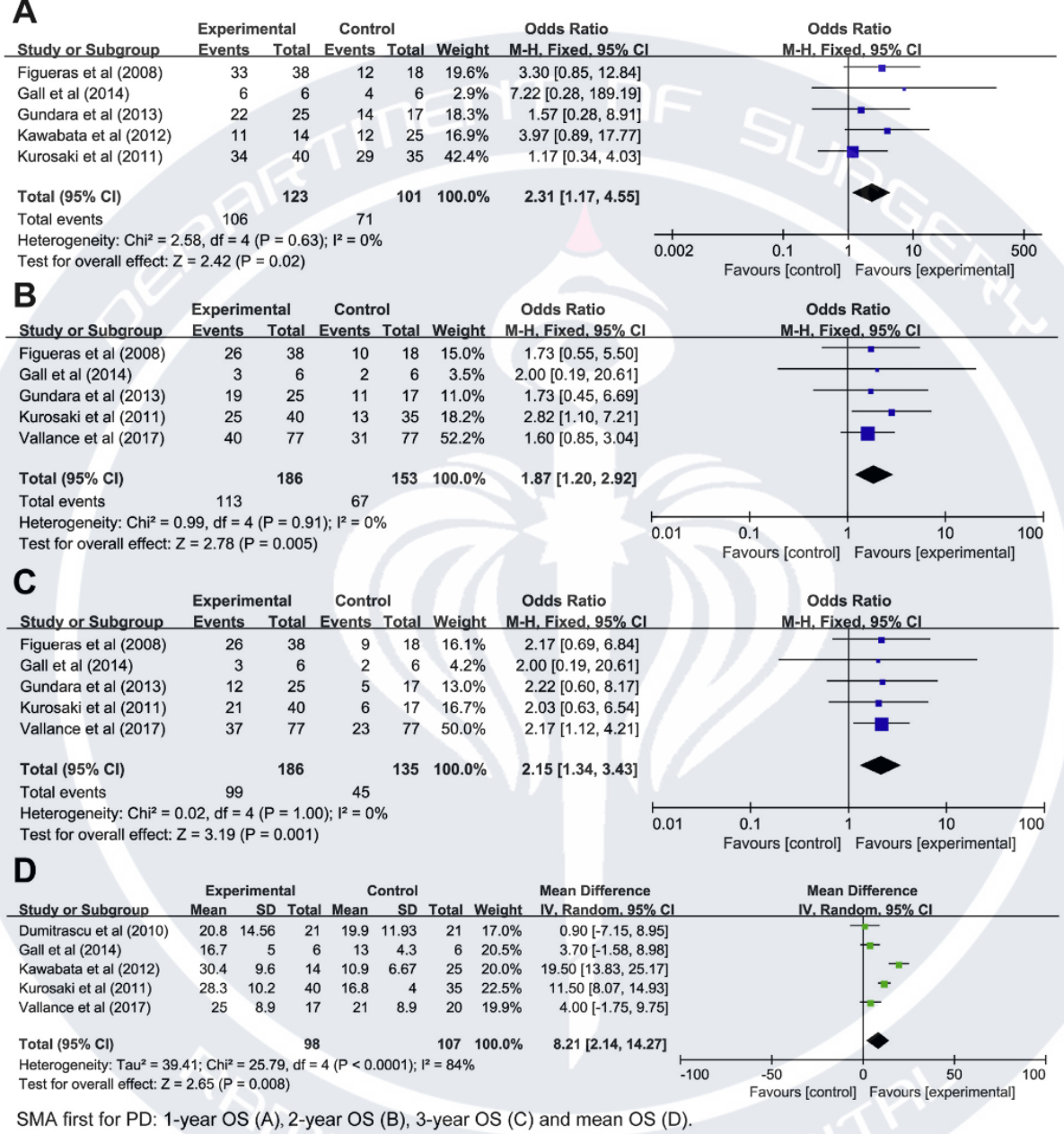


Fig. 6. Forest plot of one-year OS (A), two-year OS (B), three-year OS (C) and mean OS (D) in patients who received SMA-PD compared with S-PD.

Table 2
Subgroup analysis of complications stratified by SMA approach type.

Outcomes or Subgroup	studies	participants (case/control)	OR (95%CI)	*P*-value
Overall complications				
Left posterior	1	40/35	0.30 (0.11–0.82)	**0.02**
Anterior	4	291/231	0.70 (0.49–1.02)	0.06
Posterior	3	73/64	0.38 (0.18–0.82)	**0.01**
Mesenteric	2	90/58	0.93 (0.47–1.85)	0.84
Superior	1	72/38	0.52 (0.21–1.29)	0.16
Pancreatic fistula				
Left posterior	3	77/75	1.05 (0.40–2.70)	0.93
Anterior	2	223/160	0.41 (0.23–0.71)	**0.002**
Posterior	3	136/116	0.39 (0.16–0.93)	**0.03**
Mesenteric	3	172/138	0.47 (0.22–0.98)	0.05
Superior	1	72/38	0.92 (0.25–3.35)	0.89
Medical uncinate	1	15/15	1.00 (0.06–17.62)	1.00
Delayed gastric emptying				
Left posterior	3	77/75	0.39 (0.18–0.85)	**0.02**
Anterior	1	48/48	1.00 (0.24–4.25)	1.00
Posterior	1	38/18	0.24 (0.06–0.90)	**0.04**
Mesenteric	3	172/138	0.37 (0.21–0.63)	**< 0.001**
Superior	1	72/38	0.87 (0.20–3.86)	0.86
Medical uncinate	1	15/15	0.46 (0.04–5.75)	0.55
Intraabdominal infections				
Left posterior	2	59/54	0.54 (0.21–1.39)	0.20
Anterior	1	48/48	0.23 (0.03–2.18)	0.20
Posterior	1	38/18	0.13 (0.03–0.61)	**0.009**
Mesenteric	2	90/58	0.49 (0.09–2.71)	0.41
Medical uncinate	1	15/15	1.00 (0.06–17.62)	1.00
Diarrhea				
Left posterior	2	59/54	1.96 (0.92–4.19)	0.08
Anterior	1	14/25	1.85 (0.11–32.01)	0.67
Mesenteric	1	82/80	1.85 (0.73–4.70)	0.19
Postoperative haemorrhage				
Left posterior	2	58/56	0.38 (0.07–2.09)	0.27
Posterior	1	21/21	1.00 (0.06–17.12)	0.75
Mesenteric	1	78/39	0.74 (0.12–4.62)	1.00

The bold means P < 0.05.

Table 4
Subgroup analysis of survival outcomes in pancreatic cancer patients stratified by SMA approach type.

Outcomes	studies	participants (case/control)	Effect Estimate OR/WMD (95%CI)	P-value
R0 resection				
Left posterior	1	19/19	OR: 1.29 (0.32–5.28)	0.72
Anterior	1	6/6	OR: 1.00 (0.10–9.61)	1.00
Posterior	2	102/94	OR: 4.00 (1.96–8.16)	**< 0.001**
Mesenteric	2	26/44	OR: 2.72 (0.38–19.59)	0.32
Medial uncinate	1	15/15	Not estimable	/
Local recurrence				
Left posterior	2	59/44	OR: 0.08 (0.03–0.27)	**< 0.0001**
Posterior	1	38/18	OR: 0.43 (0.08–2.37)	0.33
Mesenteric	1	14/25	OR: 0.22 (0.01–4.61)	0.33
1-year OS				
Left posterior	1	40/35	OR: 1.17 (0.34–4.03)	0.80
Anterior	2	39/42	OR: 2.72 (0.90–8.26)	0.08
Posterior	2	44/24	OR: 3.81 (1.10–13.18)	**0.03**
2-year OS				
Left posterior	1	40/35	OR: 2.82 (1.10–7.21)	**0.03**
Anterior	1	25/17	OR: 1.73 (0.45–6.69)	0.43
Posterior	3	121/101	OR: 1.65 (0.96–2.84)	0.07
3-year OS				
Left posterior	1	40/17	OR: 2.03 (0.63–6.54)	0.24
Anterior	1	25/17	OR: 2.22 (0.60–8.17)	0.23
Posterior	3	121/101	OR: 2.16 (1.24–3.77)	**0.007**
Mean OS				
Left posterior	1	40/35	WMD: 11.50 (8.07–14.93)	**< 0.001**
Anterior	1	82/80	WMD: 19.50 (16.96–22.04)	**< 0.001**
Posterior	3	108/100	WMD: 6.58 (0.72–12.44)	**0.03**

The bold means P < 0.05.

RCT

TABLE 1. Patient Characteristics and Surgical Procedures.

Variable	Category	ST-PD (n=75)	AFA-PD (n=78)	Total (n= 153)
Age (yr)		67.7 ± 10.2	67.9 ± 67.9	67.8 ± 9.7
Sex	Male	45 (60%)	44 (57%)	89 (58%)
	Female	30 (40%)	34 (43%)	64 (42%)
Diabetes Mellitus		23 (35%)	24 (32%)	47 (33%)
ASA III		42 (56.0%)	39 (50%)	81 (53%)
Preop biliary drainage		44 (59%)	43 (55%)	87 (56%)
Pathological Diagnosis	Pancreatic cancer	38 (50.6%)	51 (65.4%)	89 (58%)
	Ampullary cancer	26 (34.7%)	22 (28.2%)	48 (31.4%)
	BileDuct Cancer	9 (12%)	5 (6.4%)	14 (9.2%)
	Duodenal Cancer	2 (2.7%)	0 (0%)	2 (1.3%)
Whipple /PP	Whipple	70 (93%)	76 (97%)	146 (95.4%)
	Pylorus-preserving	5 (7%)	2 (3%)	7 (4.6%)
Pancreatic anastomosis	PJ	56 (81%)	59 (86%)	115 (83%)
	PG	13 (19%)	9 (14%)	22 (17%)
Completion pancreatectomy		6 (8.0%)	10 (12.8%)	16 (10.5%)
Vascular resection		12 (16.0%)	18 (23.1%)	30 (19.6%)

Continuous variables expressed as mean ± standard deviation, and categorical expressed as n and frequencies (%).
PP indicates pylorus-preserving; PJ, pancreatojejunostomy; PG, pancreatogastrostomy; ASA, American Society of Anesthesiologists.

TABLE 2. Primary and Secondary End-point: R0 Resection Rate, Margin Invasion, and Postoperative Outcomes.

Variable	Category	ST-PD (n=75)	AFA-PD (n=78)	Total (n= 153)	*P* Value
R0 n (%)	Pancreatic and periampullary tumors	58 (77.3%)	53 (67.9%)	111 (72.6%)	0.194
R0 n (%)	Pancreatic cancer	22 (57.9%)	30 (58.8%)	52 (58.3%)	0.930
At least 1 margin affected		17 (22.7%)	25 (32.1%)	42 (27.4%)	0.806
Margin affected (1 or more simultaneously)	Transection	2 (12%)	7 (28%)	9 (21%)	0.167
	Medial	15 (88%)	18 (72%)	33 (78%)	0.776
	Posterior	15 (88%)	14 (56%)	29 (69%)	0.069
Isolated lymph nodes		18 ± 8	18 ± 8	18 ± 8	0.969
Operation time (min) median [IQR]		330 [285–390]	360 [300–420]	340 [300–395]	0.430
Blood loss (mL)		303 ± 408	344 ± 304	324 ± 359	0.525
Intraoperative Blood Transfusion		9 (12.2%)	14 (18.2%)	23 (15.2%)	0.249
Complications	Yes	55 (73.3%)	53 (67.9%)	108 (70.6%)	0.484
	Clavien-Dindo ≥3	18 (24%)	16 (20.5%)	34 (22.2%)	0.699
	CCI (mean ± SD)	26 ± 19.5	29.7 ± 24.3	27.8 ± 21	0.390
Hemorrhage		8 (10.7%)	8 (10.3%)	16 (10.5%)	1.000
Pancreatic fistula (A/B/C)		23 (31%) 11 (15%)/ 9 (12%)/3 (4%)	16 (21%) 7 (9%)/ 7 (9%)/2 (3%)	39 (25%) 18 (12%)/ 16 (10%/5 (3%)	0.194
DGE		13 (17.3%)	14 (17.9%)	27 (17.6%)	1.000
GI fistula		3 (4.0%)	3 (3.8%)	6 (3.9%)	1.000
Biliary fistula		4 (5.3%)	3 (3.8%)	7 (4.6%)	0.714
Abdominal abscess		17 (22.7%)	17 (21.8%)	34 (22.2%)	1.000
Chylous fistula		5 (6.7%)	6 (7.7%)	11 (7.2%)	1.000
Diarrhea		3 (4.0%)	6 (7.7%)	9 (5.9%)	0.495
Postop. transfusion		21 (28.0%)	18 (23.1%)	39 (25.5%)	0.578
Reoperation		5 (6.7%)	5 (6.4%)	10 (6.5%)	1.000
Readmission		12 (16.0%)	5 (6.4%)	17 (11.1%)	0.073
Hospital stay (d) (median, range)		15 (11-22)	17 (13-25)	16 (11-23)	0.182
30-d Mortality		3 (4.0%)	5 (6.4%)	8 (5.2%)	0.721
90-d Mortality		3 (4.0%)	6 (7.7%)	9 (5.8%)	0.267

Continuous variables are expressed as mean ± standard deviation or median and range; categorical variables as n (%) and [IQR].
DGE indicates delayed gastric emptying; GI, gastrointestinal.

On going trial

- **MAPLE-PD trial: Mesenteric Approach vs. Conventional Approach for Pancreatic Cancer during Pancreaticoduodenectomy: study protocol for a multicenter randomized controlled trial of 354 patients with pancreatic ductal adenocarcinoma.**
- **PancER trial: Conventional partial pancreatoduodenectomy versus an extended pancreatoduodenectomy (triangle operation) for pancreatic head cancers—study protocol for the randomised controlled TRIANGLE trial.**

Portomesenteric vein resection and reconstruction

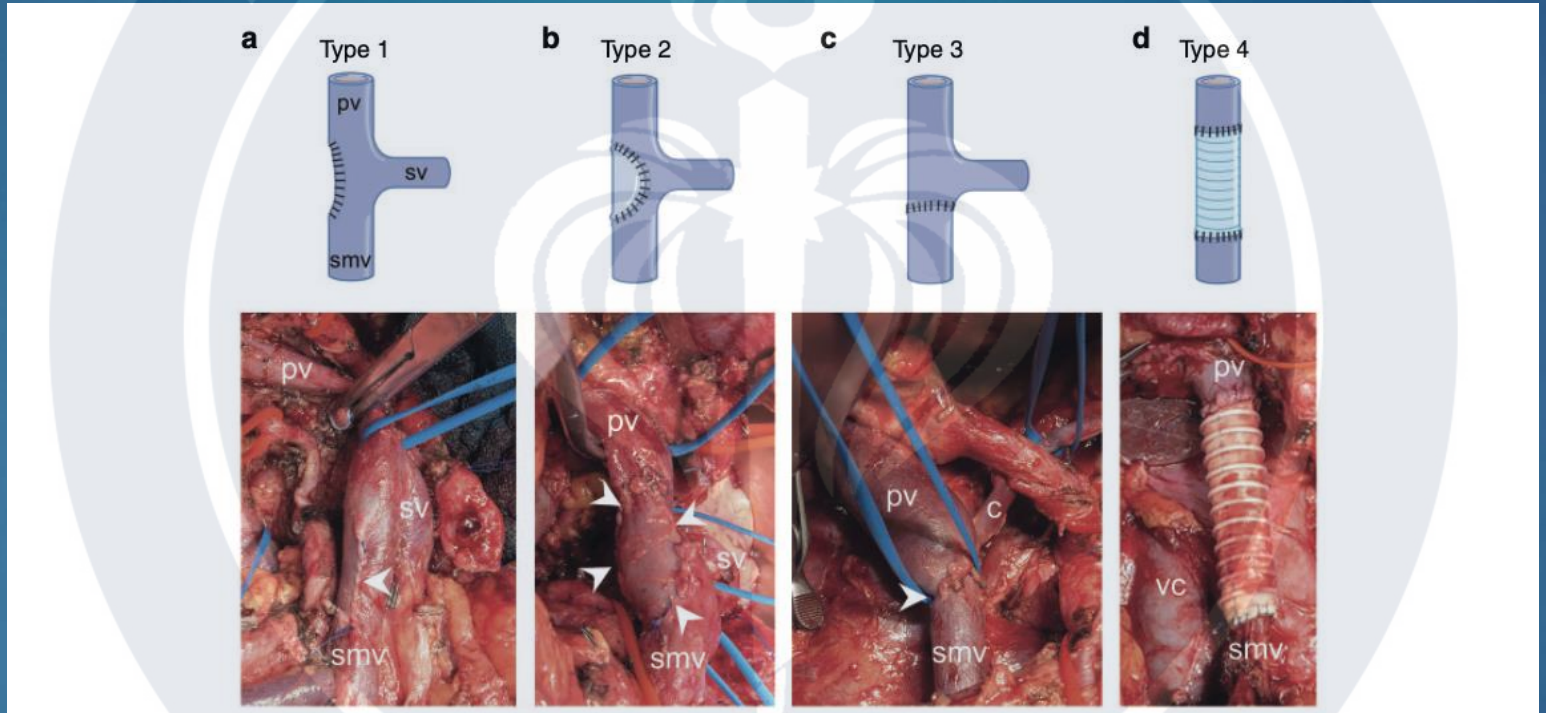


Fig. 2 Resection and reconstruction of the mesenteric–portal vein axis

Sketches representing types of venous resection according to the International Study Group of Pancreatic Surgery (ISGPS)[21] and representative operative fields. **a** ISGPS type 1: partial venous excision with direct suture closure (arrowhead). **b** ISGPS type 2: partial venous excision using a peritoneal patch (arrowheads). **c** ISGPS type 3: segmental resection with primary venovenous anastomosis (arrowhead). **d** ISGPS type 4: segmental resection with interposed prosthesis and two anastomoses. c, coronary vein; pv, portal vein; smv, superior mesenteric vein; sv, splenic vein; vc, vena cava.

Gastric venous

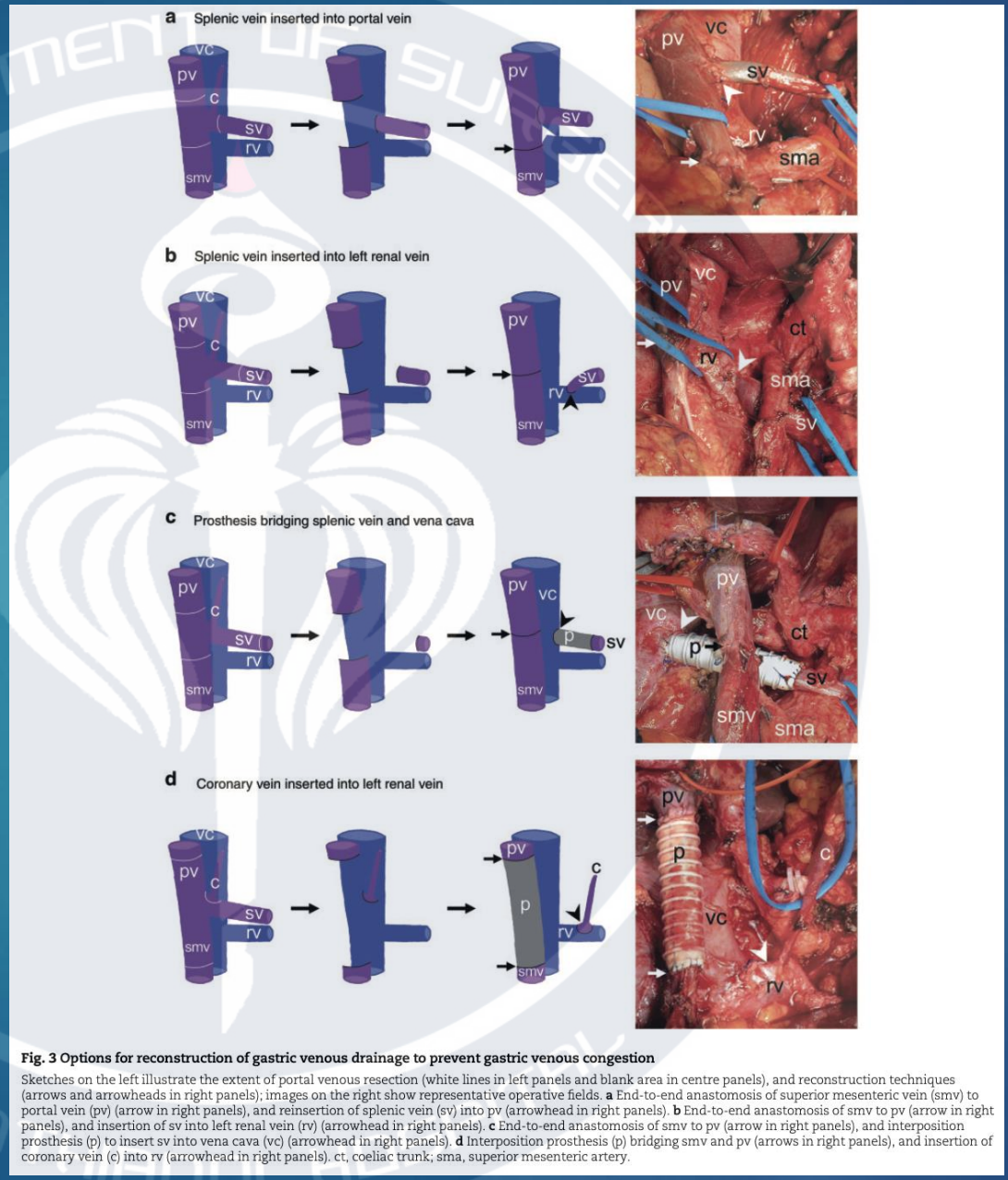


Fig. 3 Options for reconstruction of gastric venous drainage to prevent gastric venous congestion

Sketches on the left illustrate the extent of portal venous resection (white lines in left panels and blank area in centre panels), and reconstruction techniques (arrows and arrowheads in right panels); images on the right show representative operative fields. **a** End-to-end anastomosis of superior mesenteric vein (smv) to portal vein (pv) (arrow in right panels), and reinsertion of splenic vein (sv) into pv (arrowhead in right panels). **b** End-to-end anastomosis of smv to pv (arrow in right panels), and insertion of sv into left renal vein (rv) (arrowhead in right panels). **c** End-to-end anastomosis of smv to pv (arrow in right panels), and interposition prosthesis (p) to insert sv into vena cava (vc) (arrowhead in right panels). **d** Interposition prosthesis (p) bridging smv and pv (arrows in right panels), and insertion of coronary vein (c) into rv (arrowhead in right panels). ct, coeliac trunk; sma, superior mesenteric artery.

Management of Arterial Involvement

Arterial resection and reconstruction

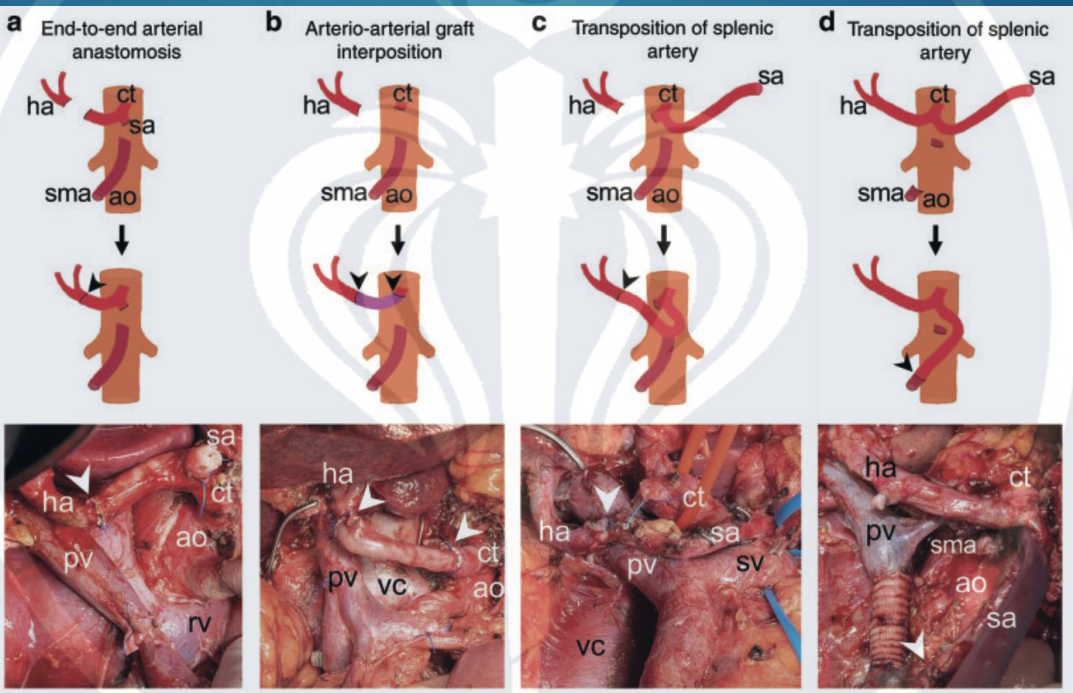


Fig. 5 Options for arterial resection and reconstruction

Sketches illustrating extent of arterial resection (blank area in top panels), and reconstruction techniques (arrowheads in bottom panels), and representative operative fields. **a** Segmental resection of common hepatic artery, and end-to-end anastomosis of common hepatic artery to proper hepatic artery (ha) (arrowhead in bottom panels). **b** Segmental resection of coeliac trunk (ct) and common hepatic artery, and interposition of autologous arterial graft between common hepatic artery and ha (arrowheads in bottom panels). **c** Segmental resection of common hepatic artery, and transposition of splenic artery (sa) to ha (arrowhead in bottom panels). **d** Segmental resection of superior mesenteric artery (sma), and transposition of splenic artery (sa) to sma (arrowhead in bottom panels). ao, aorta; pv, portal vein; rv, left renal vein; sv, splenic vein; vc, vena cava.

Arterial divesment

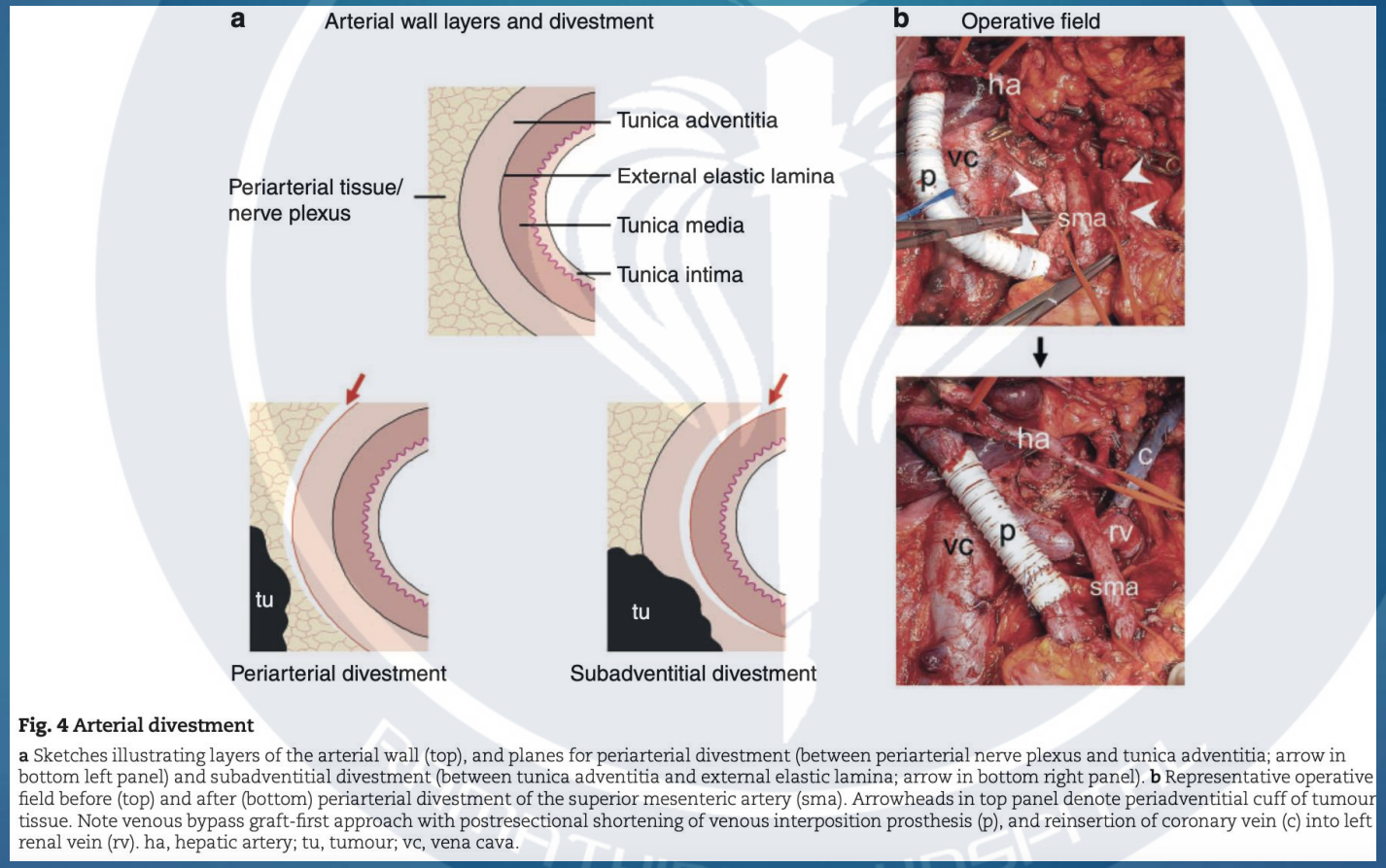


Fig. 4 Arterial divestment

a Sketches illustrating layers of the arterial wall (top), and planes for periarterial divestment (between periarterial nerve plexus and tunica adventitia; arrow in bottom left panel) and subadventitial divestment (between tunica adventitia and external elastic lamina; arrow in bottom right panel). **b** Representative operative field before (top) and after (bottom) periarterial divestment of the superior mesenteric artery (sma). Arrowheads in top panel denote periadventitial cuff of tumour tissue. Note venous bypass graft-first approach with postresectional shortening of venous interposition prosthesis (p), and reinsertion of coronary vein (c) into left renal vein (rv). ha, hepatic artery; tu, tumour; vc, vena cava.

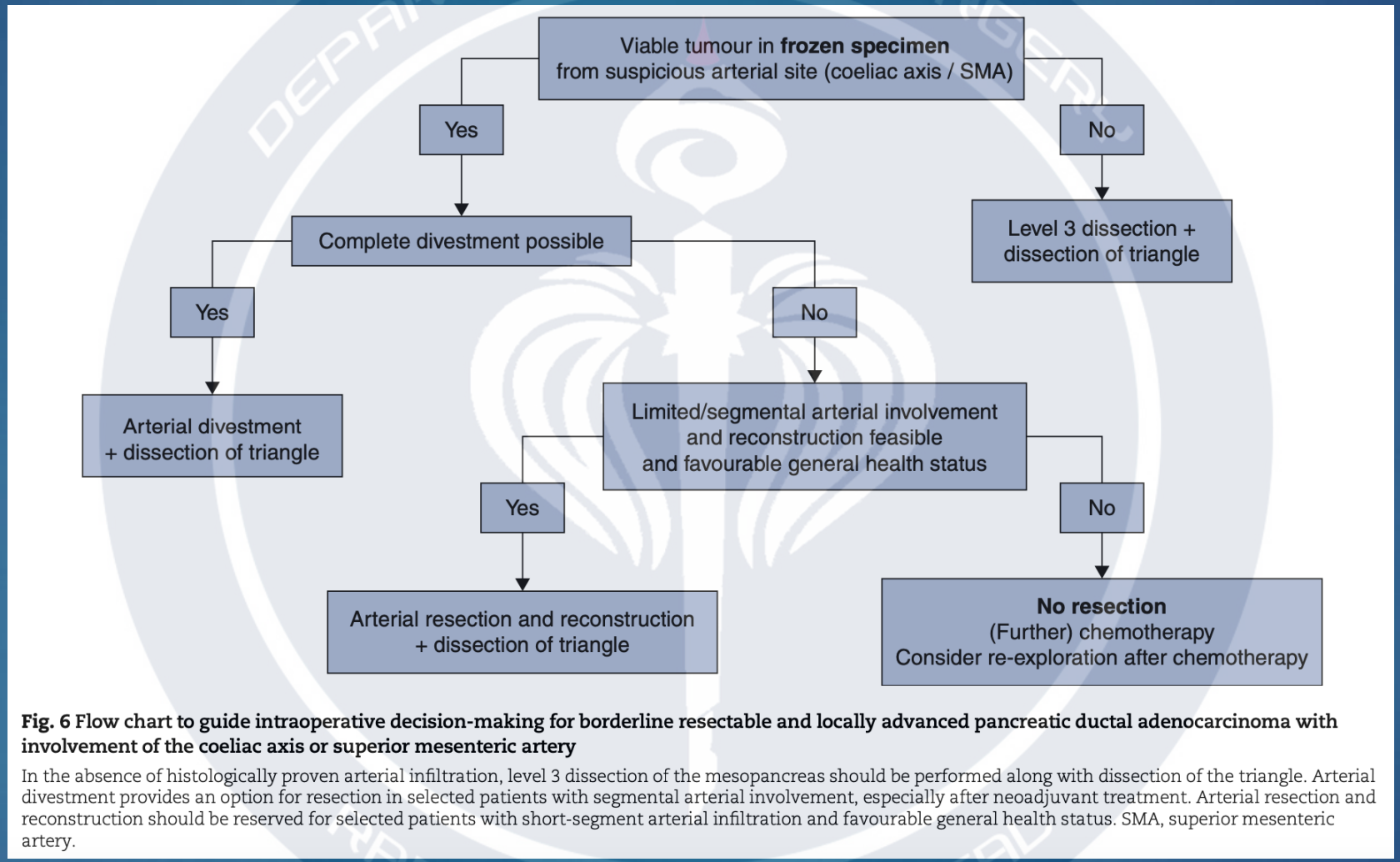


Fig. 6 Flow chart to guide intraoperative decision-making for borderline resectable and locally advanced pancreatic ductal adenocarcinoma with involvement of the coeliac axis or superior mesenteric artery

In the absence of histologically proven arterial infiltration, level 3 dissection of the mesopancreas should be performed along with dissection of the triangle. Arterial divestment provides an option for resection in selected patients with segmental arterial involvement, especially after neoadjuvant treatment. Arterial resection and reconstruction should be reserved for selected patients with short-segment arterial infiltration and favourable general health status. SMA, superior mesenteric artery.

Table 2 Perioperative and postoperative outcomes

	Extended resection ($n = 611$)	Standard resection ($n = 1217$)	P‡
Type of resection			<0·001
Pancreatoduodenectomy	286 (46·8)	830 (68·2)	
Distal pancreatectomy	122 (20·0)	220 (18·1)	
Total pancreatectomy	203 (33·2)	167 (13·7)	
Duration of surgery (min)*	355 (284–435)	306 (248–375)	<0·001¶
Blood loss (ml)*	800 (500–1500)	500 (400–1000)	<0·001¶
Need for transfusion	140 (22·9)	161 (13·2)	<0·001
No. of units transfused*	2 (2–4·5)	2 (2–3)	0·089¶
Morbidity			
Non-surgical	228 (37·3)	344 (28·3)	<0·001
Surgical	261 (42·7)	416 (34·2)	<0·001
Pancreatic fistula†	33 (5·4)	58 (4·8)	0·556
Bleeding	46 (7·5)	64 (5·3)	0·061§
Delayed gastric emptying	146 (23·9)	232 (19·1)	0·016
Relaparotomy	96 (15·7)	92 (7·6)	<0·001
Mortality			
In-hospital	46 (7·5)	44 (3·6)	<0·001
30-day	26 (4·3)	22 (1·8)	0·002
90-day	66 (10·8)	64 (5·3)	<0·001
ICU stay (days)*	1 (0–3)	1 (0–1)	<0·001¶
Hospital stay (days)*	14 (11–22)	12 (10–16)	<0·001¶

Values in parentheses are percentages unless indicated otherwise; *values are median (i.q.r.). †Grades B and C according to the International Study Group on Pancreatic Fistula definition[17]. ‡χ^2 test, except §Fisher's exact test and ¶Mann–Whitney U test.

Table 3 Characteristics of extended resections

	Pancreatoduodenectomy ($n = 286$)	Distal pancreatectomy ($n = 122$)	Total pancreatectomy ($n = 203$)	P‡
No. of additional organs resected*				<0·001
1	241 (84·3)	79 (64·8)	111 (54·7)	
2	38 (13·3)	27 (22·1)	62 (30·5)	
≥3	7 (2·4)	16 (13·1)	30 (14·8)	
Portal vein resection				<0·001
No	23 (8·0)	72 (59·0)	12 (5·9)	
Type 1	65 (22·7)	22 (18·0)	19 (9·4)	
Type 2	9 (3·1)	1 (0·8)	0 (0)	
Type 3	171 (59·8)	23 (18·9)	164 (80·8)	
Type 4	18 (6·3)	4 (3·3)	8 (3·9)	
Colonic resection	49 (17·1)	34 (27·9)	34 (16·7)	0·024
Arterial resection	12 (4·2)	8 (6·6)	45 (22·2)	<0·001
Gastric resection	9 (3·1)	33 (27·0)	46 (22·7)	<0·001
Adrenalectomy	1 (0·3)	42 (34·4)	4 (2·0)	<0·001
Small bowel resection	3 (1·0)	10 (8·2)	7 (3·4)	0·001§
Nephrectomy	1 (0·3)	10 (8·2)	3 (1·5)	<0·001§
Resection status				0·002
R0	74 (26·0)	46 (38·7)	40 (19·9)	
R1	207 (72·6)	69 (58·0)	157 (78·1)	
R2	4 (1·4)	4 (3·4)	4 (2·0)	
Rx	1	3	2	
Morbidity				
Pancreatic fistula†	10 (3·5)	23 (18·9)	0 (0)	<0·001§
Bleeding	16 (5·6)	12 (9·8)	18 (8·9)	0·224
Delayed gastric emptying	72 (25·2)	27 (22·1)	47 (23·2)	0·768
Relaparotomy	39 (13·6)	14 (11·5)	43 (21·2)	0·028
Mortality				
In-hospital	17 (5·9)	4 (3·3)	25 (12·3)	0·006§
30-day	13 (4·5)	2 (1·6)	11 (5·4)	0·235§
90-day	26 (9·1)	7 (5·7)	33 (16·3)	0·007§

Values in parentheses are percentages. *Additional resection of colon, stomach, small bowel, adrenal gland, kidney, portomesenteric vein, arteries (as defined by the International Study Group of Pancreatic Surgery[7]). †Grades B and C according to the International Study Group on Pancreatic Fistula definition[17]. ‡χ^2 test, except §Fisher's exact test.

Table 5 Multivariable analysis of in-hospital mortality in patients undergoing extended pancreatectomy

	Odds ratio	P
Total pancreatectomy *versus* distal pancreatectomy and pancreatoduodenectomy	2·37 (1·22, 4·70)	0·012
ASA grade III–IV *versus* grade I–II	2·65 (1·34, 5·52)	0·007
Duration of surgery (min)		
300–419 *versus* <300	4·99 (1·33, 32·45)	0·038
≥420 *versus* <300	11·14 (3·20, 70·44)	0·001

Values in parentheses are 95 per cent confidence intervals. A total of 534 patients with complete data were included in multivariable analysis; 77 with missing values were excluded.

Table 7 Multivariable analysis of survival in patients undergoing extended pancreatectomy

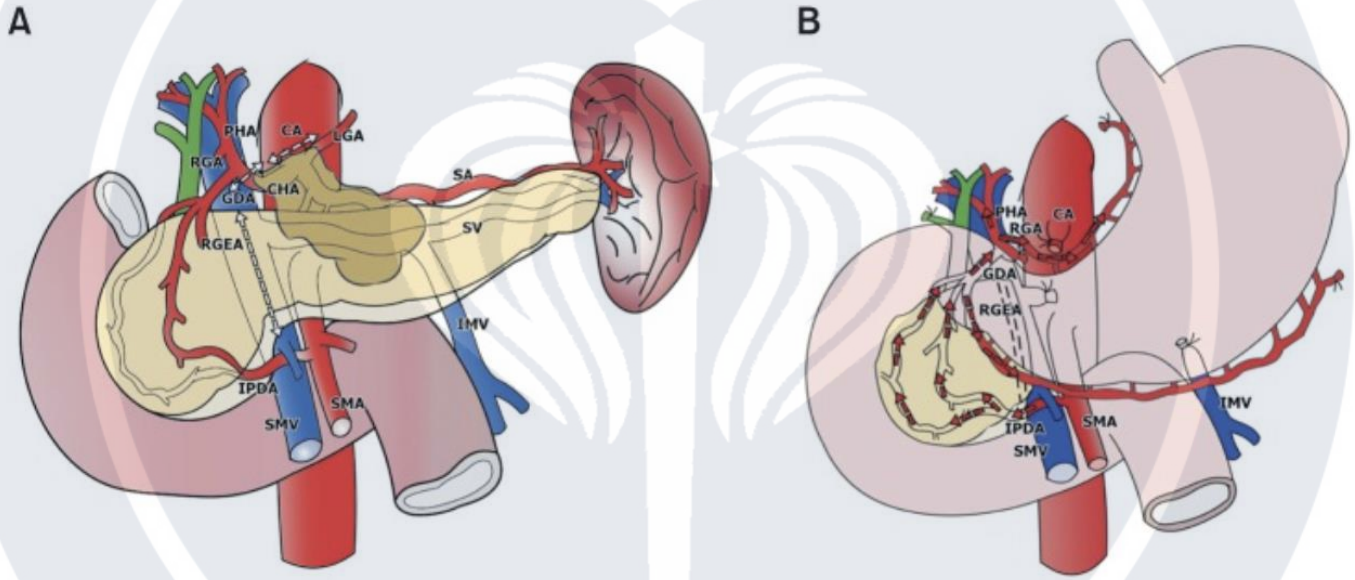
	Hazard ratio	P
Age (≥70 *versus* <70 years)	1·41 (1·12, 1·78)	0·003
Tumour grade (G3/4 *versus* G1/2)	1·70 (1·37, 2·12)	<0·001
Positive lymph nodes		
2–7 *versus* 0–1	1·37 (1·06, 1·76)	0·016
≥8 *versus* 0–1	1·43 (1·06, 1·93)	0·018
Resection status (R2 *versus* R0/1)	2·06 (1·05, 4·03)	0·035
Duration of surgery (≥420 *versus* <420 min)	1·35 (1·06, 1·72)	0·016
Blood loss (≥1000 *versus* <1000 ml)	1·26 (1·01, 1·58)	0·040

Values in parentheses are 95 per cent confidence intervals. A total of 437 patients with complete data were included in multivariable analysis; 88 with missing values were excluded.

DP-CAR

DP-CAR

Fig. 2



Schematic showing distal pancreatectomy with *en bloc* celiac axis resection. (A) White dotted line indicates dissection plane, (B) shematic drawing collateral arterial circulation via pancreaticoduodenal arcades from superior mesenteric artery (SMA) after DP-CAR. DP-CAR, distal pancreatectomy with *en bloc* celiac axis resection; CA, celiac axis; CHA, common hepatic artery; SA, splenic artery; LGA, left gastric artery; PHA, proper hepatic artery; RGA, right gastric artery; GDA, gastroduodenal artery; RGEA, right gastroepiploic artery; IPDA, inferior pancreaticoduodenal artery; PV, portal vein; SV, splenic vein; SMV, superior mesenteric vein; IMV, inferior mesenteric vein.

Review Article

Distal pancreatectomy with *En bloc* celiac axis resection for locally advanced pancreatic body/tail cancer: A systematic review and meta-analysis

Lu Liu [a, b, 1], Tian-Xiang Liu [b, 1], Wan-Xia Huang [c, 1], Zhong Yang [b], Shang Wang [a], Ming-Xu Da [b, *], Yang Dong [d, **]

[a] *College of Clinical Medicine, Gansu University of Traditional Chinese Medicine, Lanzhou, China*
[b] *Department of Surgical Oncology, Gansu Provincial Hospital, Lanzhou, China*
[c] *College of Clinical Medicine, Ningxia Medical University, Yinchuan, China*
[d] *The First Affiliated Hospital, Zhejiang University School of Medicine, Hangzhou, China*

Table 1
The characteristics of studies.

Study	Recruited time	Country	Study design	Group size		Gender (M/F)		Age		BMI (kg/m^2)		NOS Score	Outcomes
				DP-CAR	DP	DP-CAR	DP	DP-CAR	DP	DP-CAR	DP		
Yamamoto, T 2018[9]	2001–2012	Japan	NRCS	72	323	40/32	194/129	66	69	22.06	21.90	7	a, b, d, e, f, g, h, i, m, n, o
Sugiura, T 2017[8]	2002–2014	Japan	NRCS	16	76	10/6	44/32	70	71	NR	NR	8	a, b, c, d, f, g, h, m, n, o
Okada, K 2013[11]	2005–2010	Japan	NRCS	16	36	11/5	23/13	63	68	NR	NR	8	a, b, d, e, f, h, j, k, l, m, n
Takahashi, Y 2011[12]	1993–2010	Japan	NRCS	16	27	8/8	17/10	65	70	NR	NR	8	a, b, c, d, g, i, j, l, m, o
Yamamoto, Y 2012[17]	1991–2009	Japan	NRCS	13	58	10/3	39/19	64	66	NR	NR	8	a, b, c, d, e, f, g, i, j, k, n
Peters, NA 2016[18]	2004–2016	USA	NRCS	17	51	9/8	29/22	64.5	67	24.9	25.2	8	a, b, c, d, e, f, g, h, i, j, k, m
Beane, JD 2015[19]	2011–2012	USA	NRCS	20	172	6/14	57/115	64	66	25.3	26.6	8	a, c, f, g, h, j, k, l
Ham, H 2015[20]	2004–2014	Korea	NRCS	7	31	3/4	16/15	58	67.5	NR	NR	7	a, b, c, e, f, h, i, j, k, m, n
Sperti, C 2010[21]	1989–2007	Italy	NRCS	5	49	3/2	23/26	62.8	63.8	NR	NR	7	a, c, e, f, g, h, k, l
Mayumi, T 1997[22]	1975–1994	Japan	NRCS	6	19	4/2	NR	61.2	59.5	NR	NR	7	a, b, c, f, g, m, o
Wu, X 2010[23]	2003–2008	China	NRCS	9	34	4/5	18/16	55.6	62.1	21.6	22.2	7	a, b, c, f, h

M/F, Male/Female; BMI, Body mass index; NOS, Newcastle–Ottawa Scale; DP-CAR, Distal pancreatectomy with En-bloc celiac axis resection; DP, Distal pancreatectomy; NRCS, Non-randomized controlled study; NR, Not reported. Outcomes: a, operation time (min); b, estimated blood loss (ml); c, length of hospital stay (day); d, portal vein resection rate; e, R0 resection rate; f, postoperative mortality; g, postoperative morbidity; h, postoperative pancreatic fistula (POPF); i, clinically relevant POPF; j, delayed gastric emptying (DGE); k, abdominal bleeding; l, reoperation rate; m, 1-year survival rate; n, 2-year survival rate; o, 3-year survival rate.

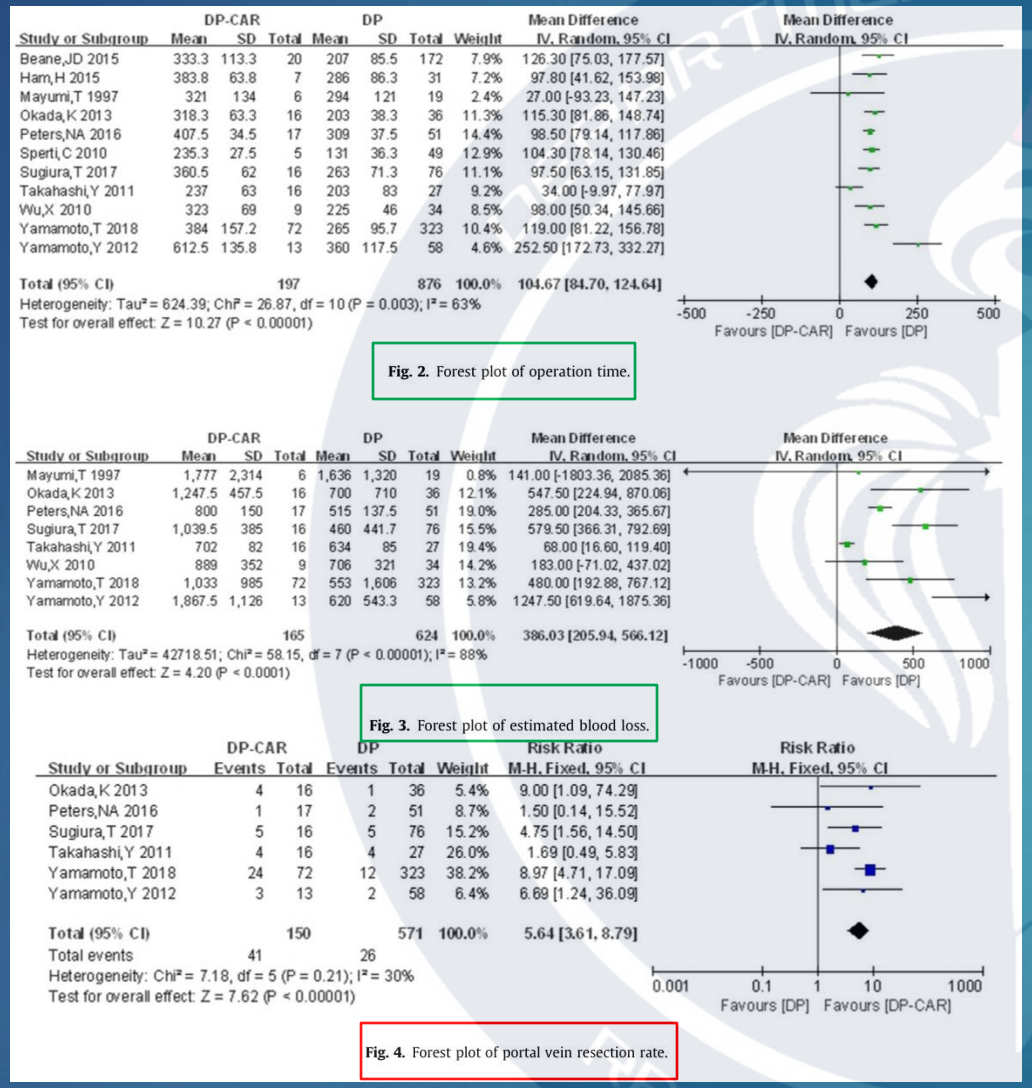


Fig. 2. Forest plot of operation time.

Fig. 3. Forest plot of estimated blood loss.

Fig. 4. Forest plot of portal vein resection rate.

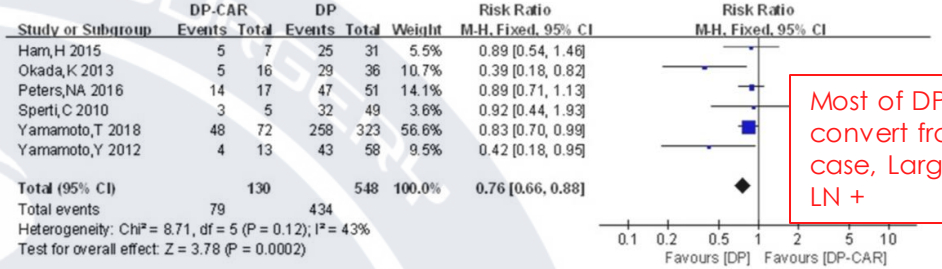


Fig. 5. Forest plot of R0 resection rate.

Most of DP-CAR patient convert from unresectable case, Larger tumor, higher LN +

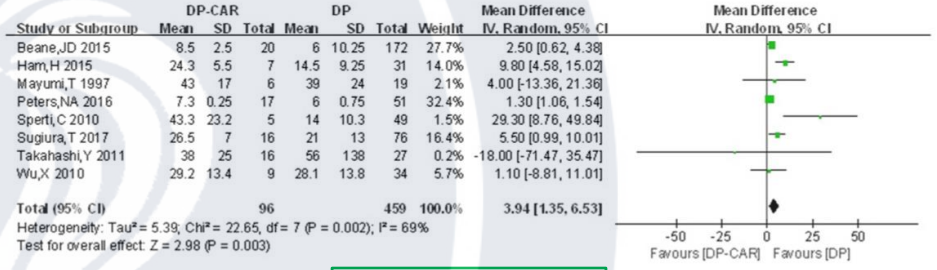


Fig. 6. Forest plot of length of hospital stay.

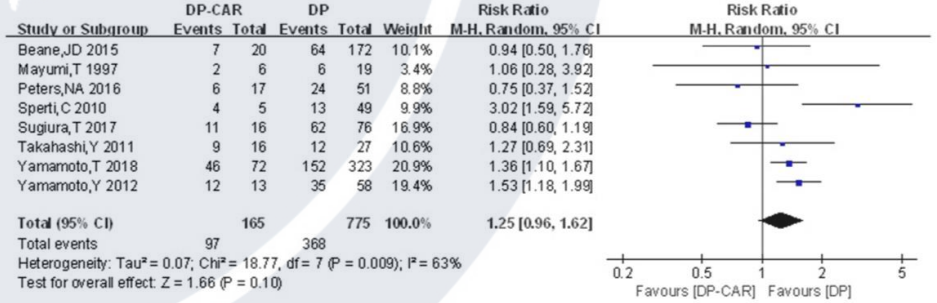


Fig. 7. Forest plot of the incidence of postoperative morbidity.

Post operative complication of DP-CAR ~ 40-70%

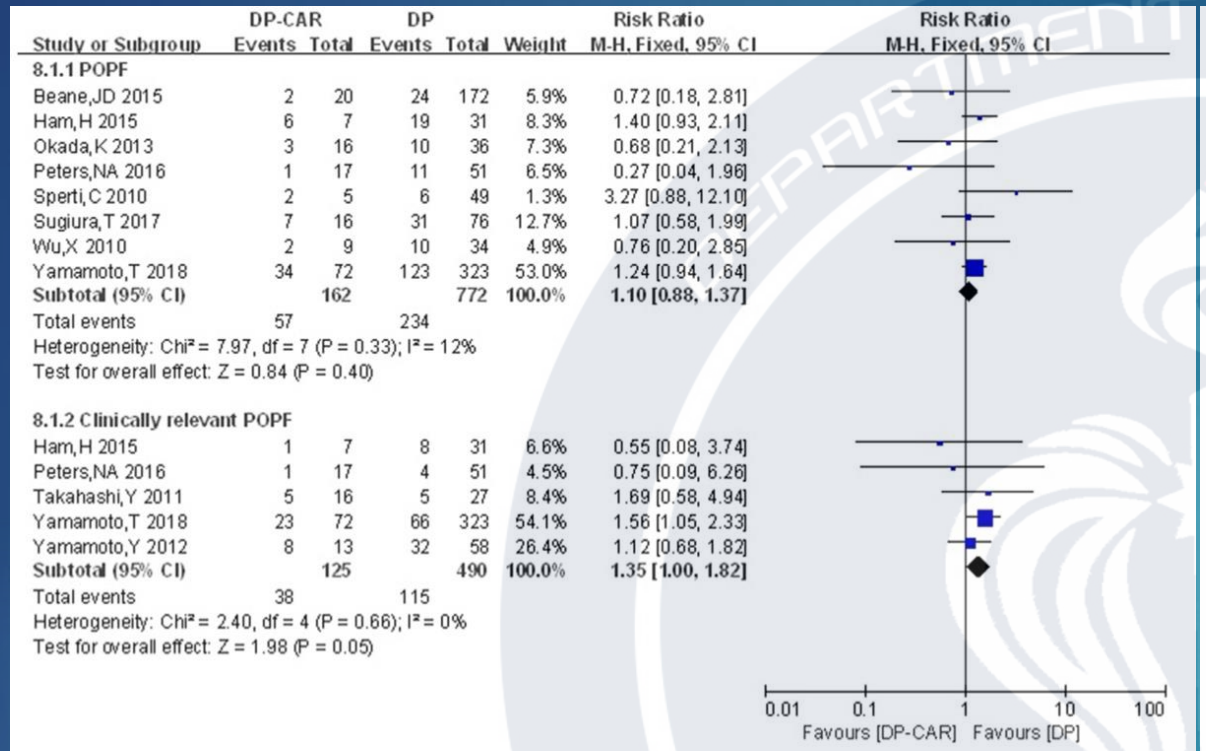


Fig. 8. Forest plot of the incidence of POPF and clinically relevant POPF.

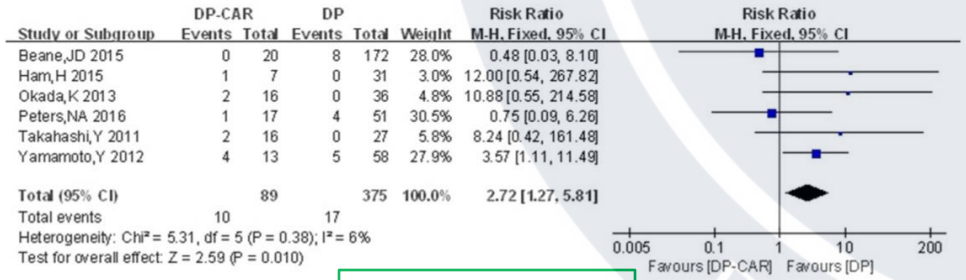


Fig. 9. Forest plot of the incidence of DGE.

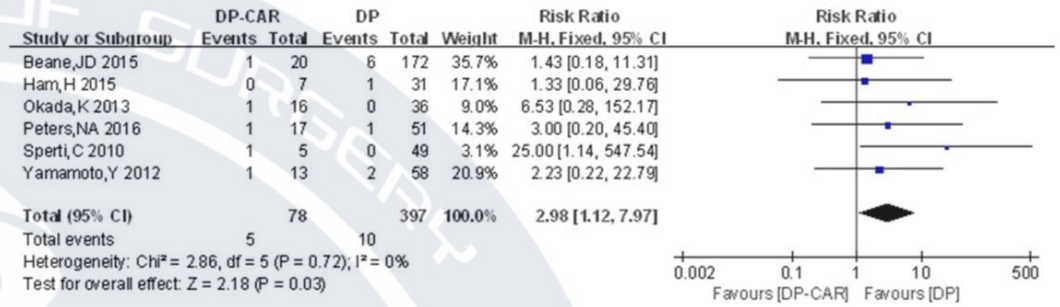


Fig. 10. Forest plot of the incidence of abdominal bleeding.

Fig. 11. Forest plot of reoperation rate.

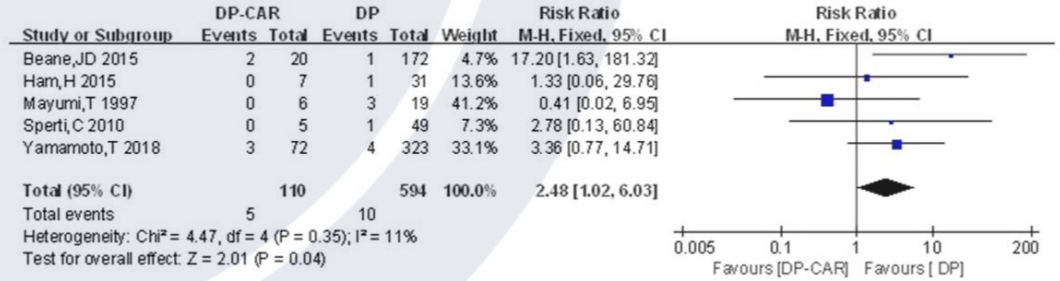


Fig. 12. Forest plot of postoperative mortality.

DP-CAR cause gastric ischemia and gastric congestion

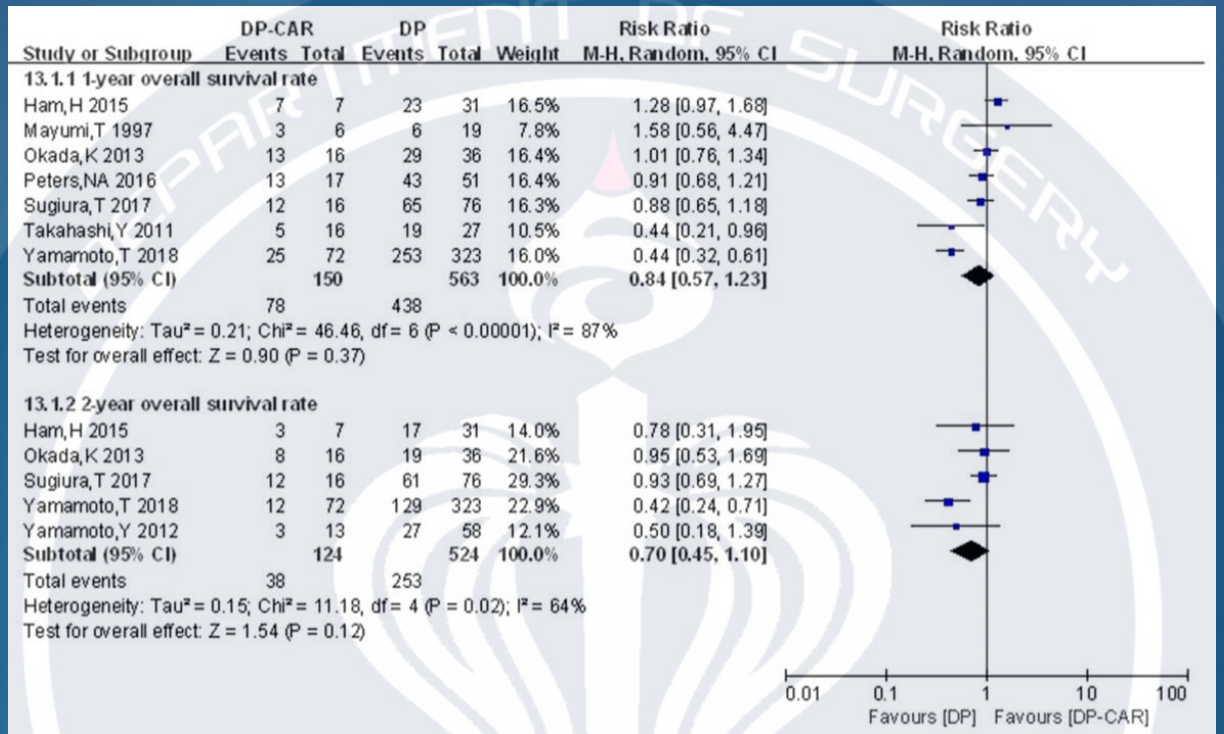


Fig. 13. Forest plot of 1-year overall survival rate and 2-year overall survival rate.

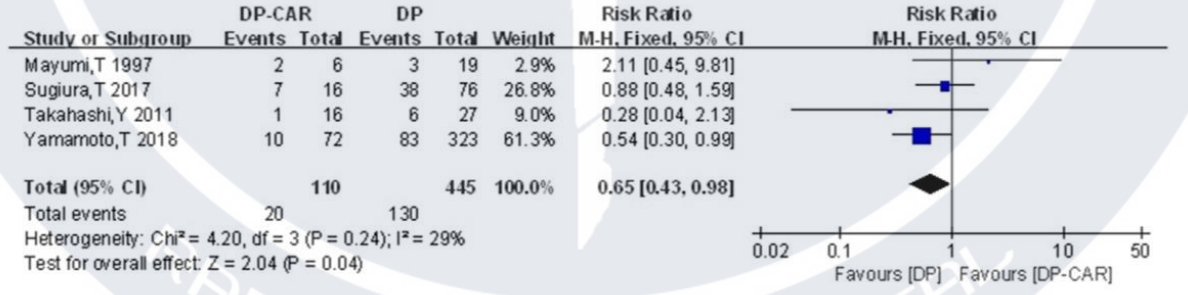
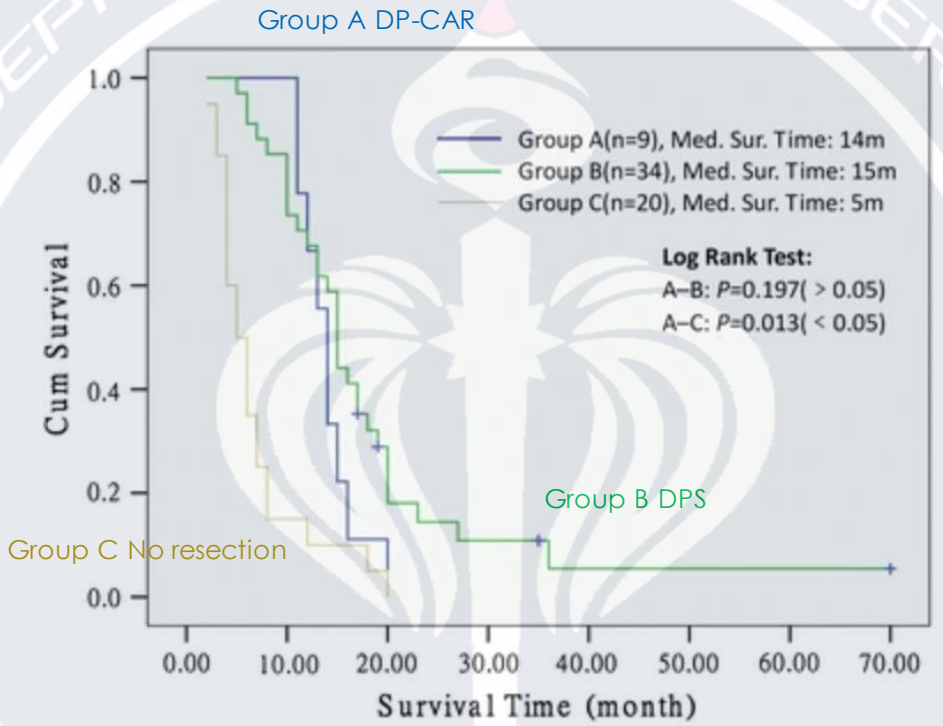


Fig. 14. Forest plot of 3-year overall survival rate.

1& 2-year OS are not difference

Fig. 3



Kaplan–Meier survival curve of different treatment modalities to patients with carcinoma of the body/tail of pancreas

Distal Pancreatectomy With En Bloc Celiac Axis Resection (DP-CAR) for Locally Advanced Pancreatic Cancer

A Safe and Effective Procedure

Martin Loos, MD, Elias Khajeh, MD, MPH,* Arianeb Mehrabi, MD,* Benedict Kinny-Köster, MD,* Mohammed Al-Saeedi, MD,* Christoph Berchtold, MD,* Katrin Hoffmann, MD,* Martin Schneider, MD,* Pegah Eslami, MD,* Manuel Feisst, MSc,† Ulf Hinz, MSc,* Thilo Hackert, MD,* and Markus W. Büchler, MD*✉*

TABLE 2. Intraoperative and Pathologic Data of Patients Undergoing Distal Pancreatectomy With En bloc celiac Axis Resection

Parameter	N (%)/median (IQR)
Subtotal distal pancreatectomy	33 (46.5)
Mesenterico-portal vein resection	31 (43.7)
Arterial reconstruction	7 (9.9)
Multivisceral resection	42 (59.2)
Gastrectomy	
Stomach preservation	50 (70.4)
Partial gastrectomy	17 (23.9)
Total gastrectomy	4 (5.6)
Adrenalectomy	31 (43.7)
Colon resection	6 (8.5)
Small bowel resection	5 (7)
Liver resection	3 (4.2)
Ovariectomy	2 (2.8)
Operation time (min)	278 (229–319)
Estimated blood loss (mL)	1300 (800–2000)
Negative resection margin (R0)	41 (57.7)
CRM	
CRM−	11 (15.5)
CRM+	14 (19.7)

IQR indicates interquartile range.

59% combine with multivisceral resection

TABLE 1. Basic and Pathological Characteristics of the Patients Undergoing Distal Pancreatectomy With En bloc Celiac Axis Resection

Parameter	N (%)/mean ± SD
Age (y)	61.1 ± 10.4
Sex	
Female	32 (45.1)
Male	39 (54.9)
BMI (kg/m^2)	25.0 ± 4.4
ASA	
ASA I	7 (9.9)
ASA II	37 (52.1)
ASA III	26 (36.6)
ASA IV	1 (1.4)
Tumor location	
Pancreas body	44 (62.0)
Pancreas tail	14 (19.7)
Pancreas body and tail	13 (18.3)
Tumor type	
Ductal adenocarcinoma	66 (93.0)
Adenosquamous carcinoma	1 (1.4)
Anaplastic carcinoma	1 (1.4)
Neuroendocrine carcinoma	1 (1.4)
Gastric adenocarcinoma	1 (1.4)
Metastasis	1 (1.4)
T (category)	
pT1	0
ypT 1	2 (2.8)
pT2	5 (7.0)
ypT2	15 (21.1)
pT3	17 (23.9)
ypT3	16 (22.5)
pT4	6 (8.5)
ypT4	10 (14.1)
N (category)	
pN0	2 (2.8)
ypN0	13 (18.3)
pN1	19 (26.8)
ypN1	22 (31.0)
pN2	7 (9.9)
ypN2	8 (11.3)
Distant metastasis	9 (12.7)
G (category)	
G_x	32 (45.1)
G1	0
G2	28 (39.4)
G3	11 (15.5)
Neoadjuvant chemotherapy	43 (60.6)

ASA indicates American Society of Anesthesiology; BMI, body mass index.

TABLE 4. Comparison of Postoperative Outcomes Between Groups With or Without Multivisceral and/or Mesenterico-portal Vein Resection

Parameter	Standard DP-CAR (n = 16) N (%)/median (IQR)	DP-CAR + MVR and/or VR (n = 55) N (%)/median (IQR)	*P*
ICU stay (d)	0 (0–1)	1 (0–1)	0.07
Hospital stay (d)	13 (10–17)	21 (13–30)	0.003
Delayed gastric emptying	3 (18.8)	8 (14.5)	0.70
Gastric ischemia	0	10 (18.2)	0.10
Liver ischemia	0	4 (7.3)	0.57
Impaired wound healing	1 (6.2)	10 (18.2)	0.44
Bowel perforation	0	4 (7.3)	0.57
PPH	1 (6.3)	8 (14.5)	0.67
Intra-abdominal abscess	4 (25)	11 (20.0)	0.73
POPF	2 (12.5)	13 (23.6)	0.49
Reoperation	2 (12.5)	19 (34.5)	0.12
Major complication	3 (18.8)	20 (36.4)	0.24
30-day mortality	0	2 (3.6)	0.99
90-day mortality	0	6 (10.9)	0.33

IQR indicates interquartile range.

TABLE 5. Trends in Outcomes of Distal Pancreatectomy With En bloc Celiac Axis Resection (2003–2022)

Parameter	2003–2013 (n = 16) N (%)/median (IQR)	2014–2022 (n = 55) N (%)/median (IQR)	*P*
Subtotal distal pancreatectomy	8 (50)	25 (45.5)	0.74
Arterial reconstruction	5 (31.2)	2 (3.6)	0.005
Mesenterico-portal vein resection	6 (37.5)	25 (45.4)	0.57
Multivisceral resection	10 (62.5)	32 (58.2)	0.75
Gastrectomy	—	—	0.38
Stomach preservation	10 (62.5)	40 (72.7)	—
Partial gastrectomy	4 (25)	13 (23.6)	—
Total gastrectomy	2 (12.5)	2 (3.6)	—
Adrenalectomy	7 (43.7)	24 (42.5)	0.99
Colon resection	1 (6.3)	5 (9.0)	0.99
Small bowel resection	1 (6.3)	4 (7.2)	0.99
Liver resection	0	3 (5.4)	0.99
Operation time (min)	244 (205–328)	280 (234–316)	0.61
Estimated blood loss (mL)	1150 (775–1800)	1350 (850–2000)	0.27
Negative resection margin (R0)	7 (43.7)	34 (61.8)	0.20
Major complication	6 (37.5)	17 (30.9)	0.62
30-day mortality	2 (12.5)	0	0.048
90-day mortality	4 (25)	2 (3.6)	0.021

IQR indicates interquartile range.

Improvement of outcome after 2014

DP-CAR has longer hospital stay ($p<0.003$)
DP-CAR with MVR and/or VR has higher major morbidity and 90 day mortality

Outcomes and Risk Score for Distal Pancreatectomy with Celiac Axis Resection (DP-CAR): An International Multicenter Analysis

Sjors Klompmaker, MD[1], Niek A. Peters, MD[2,3], Jony van Hilst, MD[1], Claudio Bassi, MD[4], Ugo Boggi, MD, PhD[5], Olivier R. Busch, MD, PhD[1], Willem Niesen, MD[6], Thomas M. Van Gulik, MD, PhD[1], Ammar A. Javed, MD[2], Jorg Kleeff, MD, FACS[7], Manabu Kawai, MD, PhD[8], Mickael Lesurtel, MD, PhD[9], Carlo Lombardo, MD[5], A. James Moser, MD, FACS[10], Ken-ichi Okada, MD, PhD[8], Irinel Popescu, MD[11], Raj Prasad, MD[12], Roberto Salvia, MD[4], Alain Sauvanet, MD[13], Christian Sturesson, MD[14], Matthew J. Weiss, MD, FACS[2], Herbert J. Zeh, MD, FACS[15], Amer H. Zureikat, MD, FACS[16], Hiroki Yamaue, MD, PhD[8], Christopher L. Wolfgang, MD, MS, PhD[2], Melissa E. Hogg, MD, FACS[17], Marc G. Besselink, MD, PhD[1], and the E-AHPBA DP-CAR study group

20 centers in EU

JHH, UPMC – USA
WMUH - Japan

TABLE 1 Patient characteristics per cohort

Baseline	Design cohort		Validation cohort		*P* Value
	n = 71	%	*n* = 120	%	
Female sex	34	48	53	44	0.654
Median age: years (IQR)	60 (52–67)		64 (58–71)		0.009
Mean age (years)	59 ± 10.6		63 ± 10.0		
Median BMI: kg/m^2 (IQR)	24.0 (24–26.3)		24.4 (21.8–27.2)		0.353
Mean BMI (kg/m^2)	24.3 ± 3.6		24.7 ± 4.2		
ASA					< 0.001
ASA 1	12	17	2	2	
ASA 2	53	75	50	42	
ASA 3 or 4	6	8	68	57	
Abdominal surgery history ≥ 1	22	31	53	44	0.061
Neoadjuvant therapy					< 0.001
None	35	49	28	23	
Chemotherapy	16	23	33	28	
Radiotherapy	1	1	2	2	
Both or chemoradiation	19	27	57	48	
Hepatic artery embolization	16	23	46	38	0.037
Left gastric artery embolization	6	8	19	16	0.185
Tumor characteristics (pathology)					
Ductal adenocarcinoma	62	87	113	94	0.194
Median tumor size: mm (IQR)	40 (34–50)		33 (22–45)		< 0.001
Mean tumor size (mm)	47 ± 29		34 ± 18		
AJCC[a]					
T stage ≥ 3	64	90	101	84	0.046
N stage > 0	46	66	64	53	0.168
M stage > 0	1	2	4	3	0.655

IQR, interquartile range; BMI, body mass index; ASA, American Society of Anesthesiologists; AJCC, American Joint Committee on Cancer

[a]Based on the 7th AJCC criteria[23]

TABLE 2 Outcomes per cohort

Perioperative	Design cohort		Validation cohort		*P* Value
	n = 71	%	*n* = 120	%	
Treated at high-volume DP-CAR center[a]	8	11	120	100	< 0.001
Minimally invasive approach	2	3	18	15	0.012
Median operative time: min (IQR)	343 (248–425)		350 (291–447)		0.103
Mean operative time (min)	346 ± 122		380 ± 131		
Additional organs resected[b]					
None	41	58	78	65	0.361
Stomach	9	13	8	7	0.190
Liver	3	4	3	3	0.672
Kidney	3	4	3	3	0.672
Adrenal gland	17	24	31	26	0.864
DP-CAR type					< 0.001
Standard DP-CAR	52	73	79	66	
SMV/portal vein resection[c]	10	14	14	12	
Hepatic artery reconstruction	9	13	5	4	
Left gastric artery preservation/reconstruction	0	–	23	19	
Median EBL: mL (IQR)	560 (350–1450)		560 (300–1100)		0.374
Mean EBL (mL)	1015 ± 1145		996 ± 1502		
Blood transfusion for bleeding (< 72 h)	22	33	17	14	0.005
Residual status overall					0.206
R0 (> 1-mm margin)	38	55	75	63	
R1 (< 1-mm margin)	29	42	38	32	
R2 (macroscopically positive)	2	3	1	1	
90-Day outcomes					
Mortality	11	16	7	6	0.077
Clavien-Dindo 3a–4b complication	18	25	33	28	0.866
Post-pancreatectomy hemorrhage[d]	6	8	9	8	0.787
Liver ischemia/infarction	12	19	28	23	0.575
Gastric ischemia	5	7	13	11	0.452
Abdominal cavity infection	4	6	23	19	0.016
Pancreatic fistula grade B/C[d]	15	21	27	23	0.858
Delayed gastric emptying grade B/C[d]	11	15	12	10	0.495
Reoperation	10	14	6	5	0.018
Median hospital stay: days (IQR)	17 (11–26)		11 (7–21)		0.005
Mean hospital stay (days)	20 ± 14		18 ± 21		
Unplanned readmission	9	13	38	32	0.005
Long-term outcomes					
Adjuvant treatment					0.261
None	23	32	26	22	
Chemotherapy	41	58	72	60	
Radiotherapy	2	3	3	3	
Both or chemoradiation	2	3	10	8	
Unknown	3	4	10	8	
Median follow-up: days (IQR)	309 (128–617)		447 (207–939)		0.019
Median overall survival: months (95% CI)	20 (10–36)		21 (16–26)		

IQR, interquartile range; SMV, superior mesenteric vein; EBL, estimated blood loss; AJCC, American Joint Committee on Cancer; ASA, American Society of Anesthesiologists; CI, confidence interval

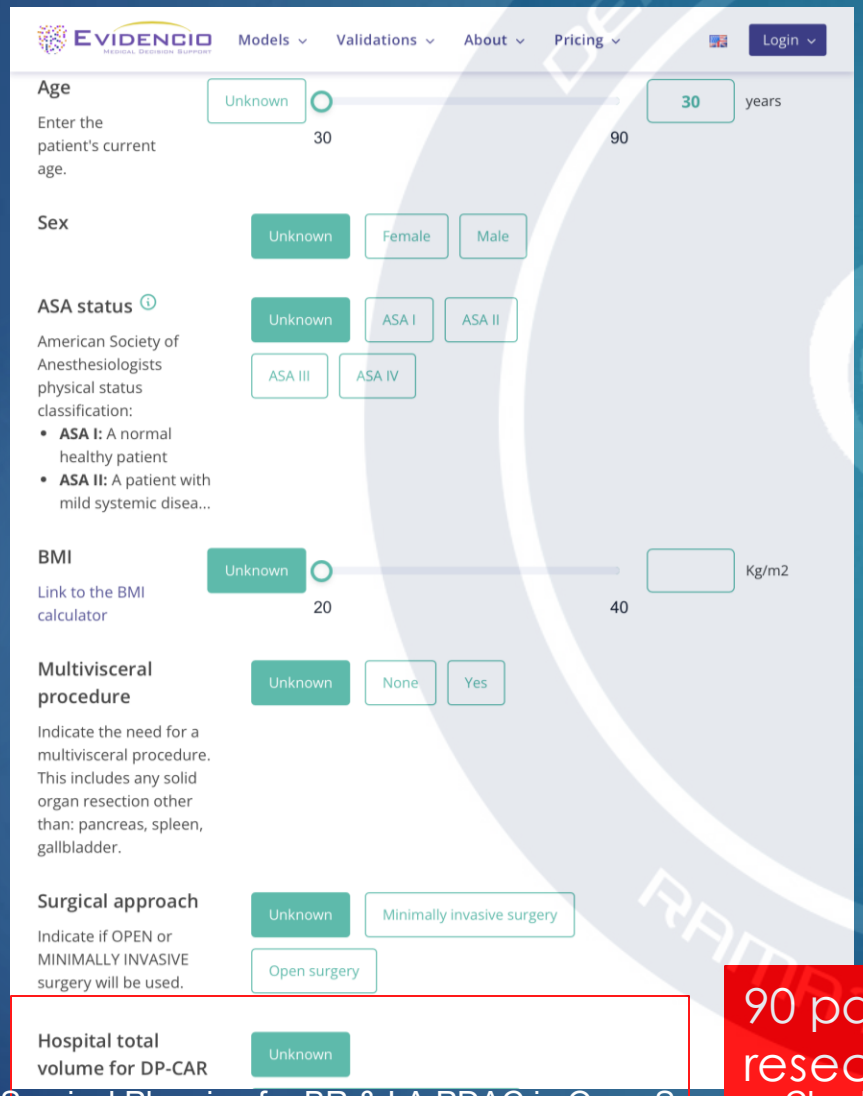
[a]Mean volume of 1 per year between 1 January 2014 and 31 December 2016

[b]Other than celiac axis, gallbladder, pancreas, or spleen

[c]Excluding side bite

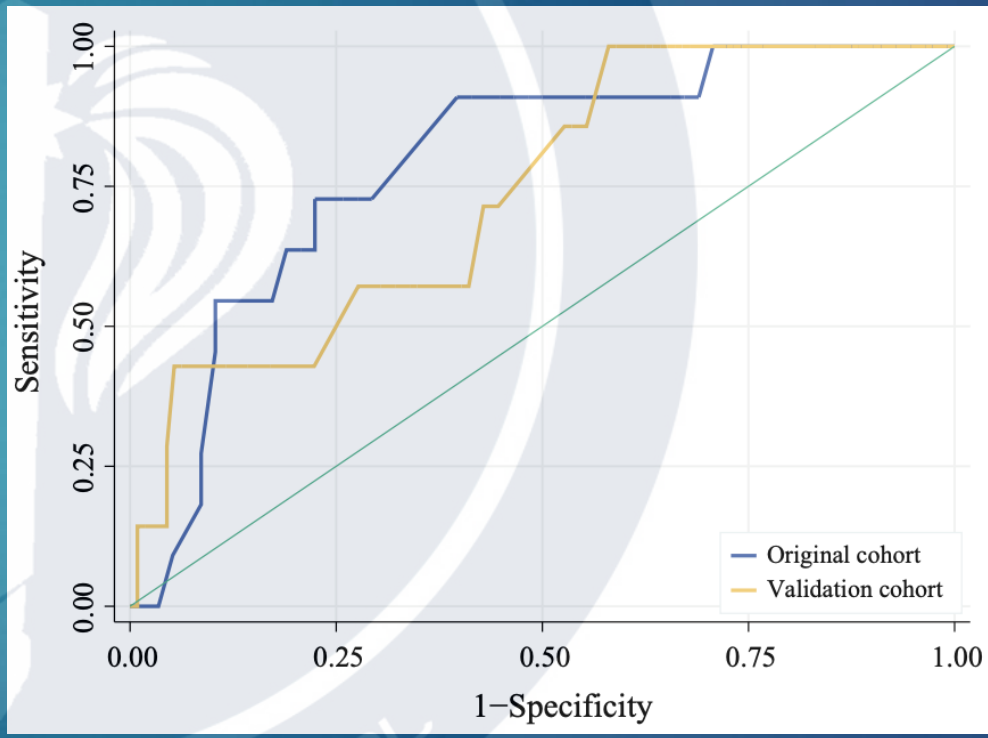
[d]International Study Group on Pancreatic Surgery (ISGPS) definition[16–18]

Risk of 90-day mortality after DP-CAR

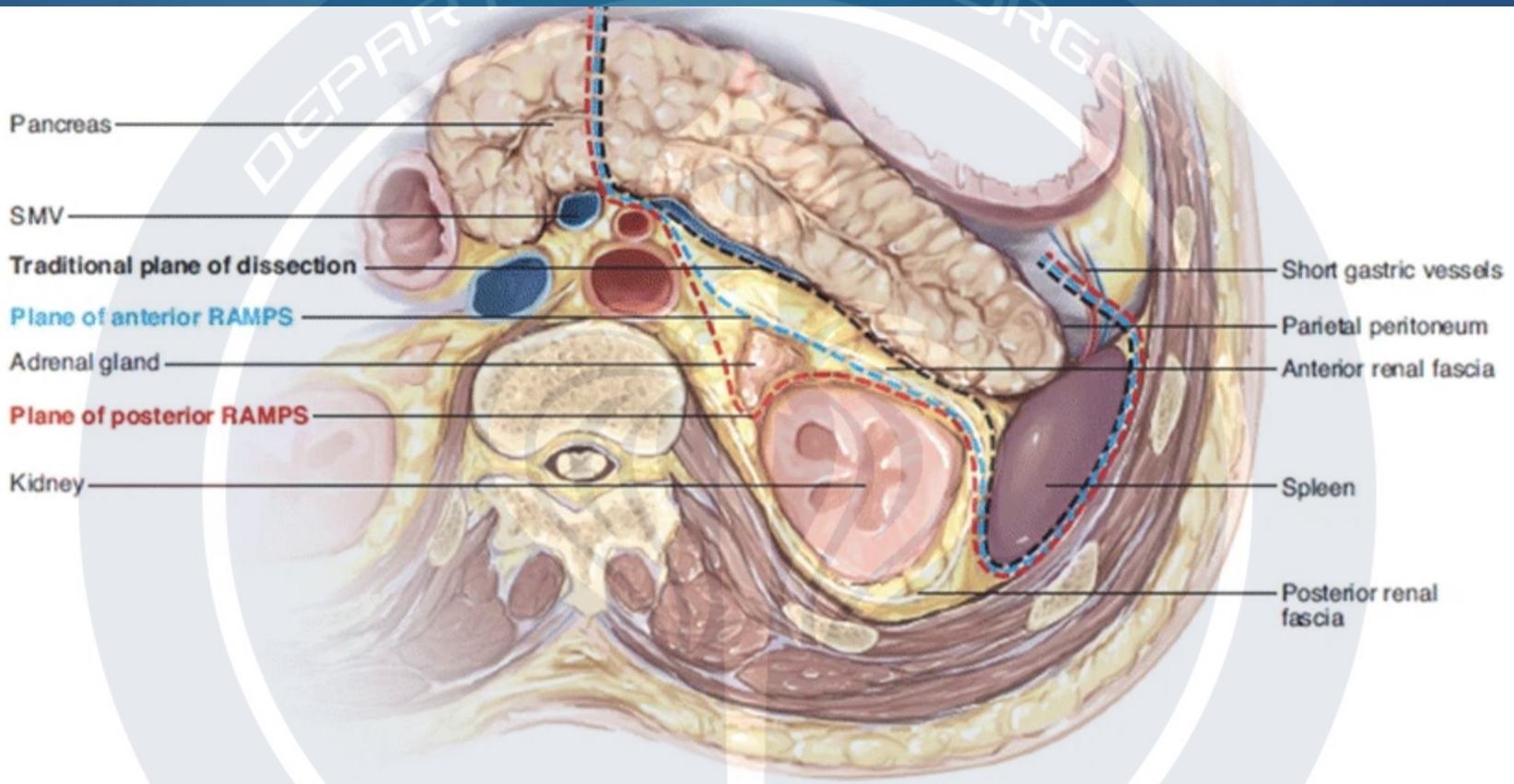


90 pancreatic resections/year

AUC 0.79; 95% CI, 0.68–0.90



RAMPS VS DPS



Planes of retroperitoneal dissection for resection of adenocarcinoma of the pancreatic body and/or tail. *SMV* superior mesenteric vein, *RAMPS* radical antegrade modular pancreatosplenectomy. Reprinted from Nelson et al. with permission5

RAMPS vs DPS

- Right to left
- Margin-negative: deep to the anterior renal fascia
- Transection the neck of the pancreas
- Regional lymph nodes, additionally, nodes around the hepatic artery, celiac trunk and superior mesenteric artery

- Left to right
- Margin-negative: deep to the gross tumor or pancreas
- Transection margin: proximal to the gross disease
- Regional lymph nodes

The efficacy of radical antegrade modular pancreatosplenectomy: A systematic review and meta-analysis

Jun Watanabe[1,2] | Kazuma Rifu[1] | Hideki Sasanuma[1] | Kazuhiko Kotani[2] | Naohiro Sata[1]

TABLE 1 The characteristics of the include studies

Authors [ref no.]	Year	Country	Study type	Propensity score matching	RAMPS no.	Control no.	Center	Age, year	Male, %	Stage	NOS
You[26]	2010	Korea	P	No	11	50	Single	61	64	NR	4
Latorre[27]	2013	Italy	R	No	8	17	Single	61	64	NR	6
Park[28]	2014	Korea	R	No	38	54	Single	63	63	I-IV	4
Trottman[29]	2014	USA	P	No	6	20	Single	NR	NR	NR	3
Abe[30]	2016	Japan	R	No	53	40	Single	69	65	I-III	7
Kim EY[31]	2016	Korea	R	No	30	19	Single	64	40	I-II	6
Xu[25]	2016	China	R	No	21	78	Single	62	52	I-IV	4
Huo[32]	2019	China	R	No	11	16	Single	64	48	I-IV	4
Kim NH[33]	2019	Korea	R	Yes	139	71	Multi	NR	NR	NR	7
Sham[11]	2020	USA	R	No	253	193	Multi	65	60	NR	5
Yin[34]	2020	China	R	Yes	101	203	Single	64	NR	NR	6
Dai[35]	2021	China	R	No	46	57	Single	62	50	I-III	8
Kim HS[12]	2021	Korea	R	Yes	53	53	Multi	66	45	I-III	8

Abbreviations: NOS, the Newcastle-Ottawa Quality Rating Scale; NR, not reported; P, prospective cohort study; R, retrospective cohort study.

On going RCT > DPS shift to MIS

TABLE 2 Summary of findings

The efficacy of radical antegrade modular pancreatosplenectomy (RAMPS)				
Patient or population: adults, setting: pancreatosplenectomy, intervention: RAMPS, Comparison: Control				
Outcomes	**Relative effect (95% CI)***	**Patient number (Studies)**	**Certainty of the Evidence (GRADE)**	**Comments**
OS	HR 0.92 (0.79 to 1.09)	1119 (9 cohort studies)	Low[a,b]	RAMPS resulted in little difference in OS
RFS	HR 0.72 (0.37 to 1.38)	711 (4 cohort studies)	Low [a,b]	RAMPS resulted in little difference in RFS
DFS	HR 0.59 (0.41 to 0.86)	792 (6 cohort studies)	Low [a,b]	RAMPS increased DFS
R0 resection	RR 1.06 (0.98 to 1.15)	1198 (10 cohort studies)	Low [a,c]	RAMPS did not increase R0 resection
Retrieved lymph nodes	MD 4.06 (2.37 to 5.76)	1468 (10 cohort studies)	Low [a,c]	RAMPS increased number of retrieved lymph nodes
Postoperative complications	RR 0.85 (0.51 to 1.41)	911 (7 cohort studies)	Low[b,c]	RAMPS did not decrease postoperative complications

CI, confidence interval; HR, hazard ratio; MD, mean difference; MD, mean difference; RR, risk ratio.

*The risk in the intervention group (and its 95% CI) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI). GRADE Working Group grades of evidence; High certainty: We are very confident that the true effect lies close to that of the estimated effect. Moderate certainty: We are moderately confident in the estimated effect. The true effect is likely to be close to the estimated effect, but there is a possibility that it is substantially different. Low certainty: Our confidence in the estimated effect is limited: The true effect may be substantially different from the estimated effect. Very low certainty: We have very little confidence in the estimated effect. The true effect is likely to be substantially different from the estimated effect.

[a]Downgraded because of inconsistency due to statistical analysis and reporting.

[b]Downgraded because of imprecision due to the small sample size.

[c]Downgraded because of inconsistency due to substantial heterogeneity.

RAMPS is safe but not associated with an improvement in RFS or OS

Conclusion

- PD: artery-first approach benefit from intraoperative decision making (Point of no return)
- Arterial divestment is an option to avoid arterial resection and reconstruction
- DP-CAR should be done in highly selective cases and high volume-center
  - Ischemic complication is concerned
  - But better OS than palliative
- DPS = RAMPS, waiting for RCT of MIS DPS