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Impact of portal/superior mesenteric vein abutment angle on prognosis in pancreatic cancer: a single-center retrospective cohort study

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Purpose: Pancreatic cancer has a poor prognosis; however, the implementation of neoadjuvant treatment enables borderline resectable cases to undergo curative resection and improves the overall survival rate. Attempts have been made to expand the eligibility criteria for neoadjuvant treatment, even in resectable cases. Some studies have suggested a correlation between vein abutment and poor prognosis or that the abutment angle may affect prognosis. This study investigated the anatomical factors affecting the vessel abutment angle and its prognostic value in pancreatic cancer.
Methods: Patients with pancreatic ductal adenocarcinoma who underwent surgery between 2012 and 2017 were included in this study. Patients who underwent neoadjuvant treatment were excluded. Data from only the intent-to-treat pancreaticoduodenectomy group were included in the analysis. Clinicopathological characteristics; preoperative factors such as CA 19-9, preoperative biliary drainage, American Society of Anesthesiologists physical status classification, portal vein/superior mesenteric vein contact angle measured via CT scan; and intraoperative factors were collected for analysis.
Results: A total of 365 patients were included in this study, and the abutment group included 92 patients (25.2%). The abutment and no-contact groups did not show any significant differences in terms of the overall survival or disease-free survival rate. Among the abutment groups, patients with less than 90° and 90°–180° did not show any significant differences. In the multivariate analysis, the only preoperative factor that had a prognostic effect was CA 19-9, a biological factor.
Conclusion: When there is no vessel invasion in the abutment group, upfront surgery should be considered because the angle does not affect the overall prognosis.
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Key Words: Pancreatic cancer, Vessel abutment angle, Prognosis

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INTRODUCTION

Pancreatic cancer is one of the most devastating cancers worldwide, with a dismal 5-year survival rate of approximately 11% [1]. The majority of patients with pancreatic cancer are asymptomatic, making early diagnosis challenging [2]. Approximately, 20%–25% of cases are amenable to resection at the point of diagnosis where surgical resection offers the best chance for a cure [3].

Since 2016, based on the National Comprehensive Cancer Network (NCCN), the establishment of neoadjuvant therapy (NAT) marked a pivotal advancement in the management of borderline resectable pancreatic cancer (BRPC) [4]. A randomized controlled trial in Korea supports the effectiveness of NAT for BRPC, showing promising results in oncological benefits such as downstaging tumors and increasing the chances of achieving complete resection [5]. However, despite showing a favorable prognosis than BRPC, resectable pancreatic cancer (RPC) still has a poor prognosis compared to other gastrointestinal cancers, often with rapid recurrence [6,7]. This has led to efforts to extend the use of NAT to RPCs as well.

In accordance with the NCCN guidelines, NAT can be considered a biological factor for patients diagnosed with RPC, particularly for those presenting with elevated CA 19-9 levels as a biological factor [4]. Nonetheless, a consensus remains elusive concerning the application of NAT for patients with RPC in relation to anatomical factors. In addition, the existing literature has recognized the importance of portal vein (PV) or superior mesenteric vein (SMV) vessel abutment and abutment angle and their impact on prognosis in patients with RPC [8,9]. However, the clinical significance of the PV/SMV abutment angle and its relationship to the prognosis of patients with RPC has not been fully established. Therefore, in this study, we investigated the impact of the PV/SMV vessel abutment angle on the prognosis of patients with RPC.

METHODS

Ethics statement

The study was approved by the Institutional Review Board (IRB) of the Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea (No. 2022-12-100). This study was conducted in accordance with the ethical principles of the Declaration of Helsinki (1989). Patient consent was waived by IRB due to the retrospective study design.

Study design

This was a large single-center cohort study that included patients with RPC who underwent pancreaticoduodenectomy (PD) at the Samsung Medical Center between 2012 and 2017. The assessment of resectability followed the definitions outlined in the NCCN guidelines of 2024 [4].

Patients

Patients who underwent RPC and PD at the Samsung Medical Center between 2012 and 2017 were included in the study. A total of 555 patients diagnosed with pancreatic ductal adenocarcinoma (PDAC) between 2012 and 2017 at the Samsung Medical Center were identified. A total of 107 patients who met the following criteria were excluded: those who had undergone neoadjuvant chemotherapy or received palliative treatment, and BRPC-A or BRPC patients with a PV contact angle greater than 180°. In addition, 69 patients who underwent surgical resection of PDAC other than PD were excluded. Ultimately, data from 379 participants were analyzed (Fig. 1).

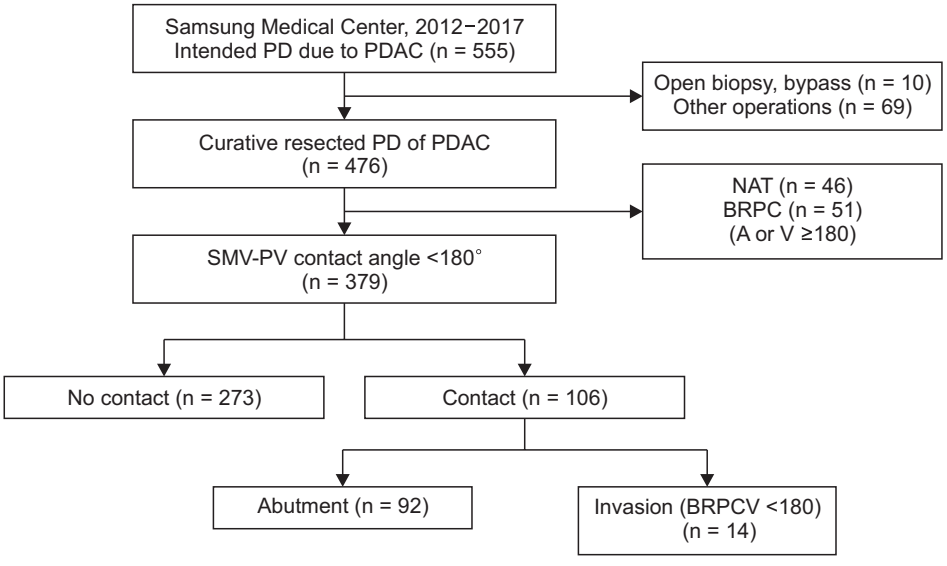


Fig. 1. Flow chart of patient selection. PD, pancreaticoduodenectomy; PDAC, pancreatic ductal adenocarcinoma; NAT, neoadjuvant therapy; BRPC, borderline resectable pancreatic cancer; SMV, superior mesenteric vein; PV, portal vein.

Data collection

Demographic and clinicopathological data of the patients were retrospectively reviewed. In this study, the data included sex, age, body mass index, preoperative biliary drainage, preoperative CA 19-9 level, preoperative total bilirubin level, American Society of Anesthesiologists physical status classification, PV/SMV contact angle, PV/SMV contact depth, type of operation, vascular resection, expected blood loss, and operation time. The distinction between borderline resectable and resectable cases was established based on radiologic evaluation conducted by experienced radiologists. Contour irregularity was identified as radiologic evidence of invasion and classified as borderline resectable. Similarly, changes in lumen caliber and compression of the PV/SMV were also categorized as borderline resectable by the radiologists. Total bilirubin and CA 19-9 levels were measured immediately before surgery. For postoperative data, Clavien-Dindo (CD) classification, duration of postoperative hospital stay, T stage, N stage, residual margin status (R status), lymphovascular invasion, perineural invasion, pathologic PV/SMV invasion, type of adjuvant treatment, and recurrence were analyzed. The 8th edition of the AJCC (American Joint Committee on Cancer) Cancer Staging System was used.

Statistical analysis

Means and standard deviations were used for continuous variables, and categorical variables were expressed as numbers and proportions. Nominal and continuous variables were compared using the chi-square and t-tests, respectively. Tumor markers are expressed as median values and interquartile ranges. The Kaplan-Meier method and log-rank test were used to analyze overall survival (OS) and disease-free survival (DFS), and the log-rank test was used to analyze the differences. Multivariate analysis of independent prognostic factors for OS and DFS was performed using the Cox proportional hazards model. A P-value of <0.05 was considered as significant. Statistical analyses were performed using the SPSS software (version 27.0, IBM Corp.).

RESULTS

Patient characteristics

The demographic and clinicopathological data of 379 patients are shown in Table 1. The mean age of the patients was 64.31 years with 235 males (62.0%) and 144 females (38.0%). The median tumor marker value was 905.17 U/mL for CA 19-9. Among the patients, 273 patients (72.0%) had no abutment with the PV/SMV and 106 (28.0%) had abutment with the PV/SMV. Among those with abutments, 92 patients (24.3%) had abutments without radiologic invasion and 14 (3.7%) had abutments with invasion. Additionally, among those with abutments to the PV/SMV, 71 patients (19.8%) had a contact angle of less than 90°, and 35 (9.2%) had a contact angle between 90° and 180°. Pathological PV/SMV invasion was observed in 46 patients (12.1%). PD was performed in 178 patients (47.0%) and pylorus-preserving pancreaticoduodenectomy was performed in 201 (53.0%). The pathological depth of the tumors was T1 in 75 patients (19.8%), T2 in 264 (69.7%), T3 in 39 (10.3%), and only

Table 1. Demographic and clinicopathological characteristics

Characteristic	Data
No. of patients	379
Sex, male/female	235/144
Age (yr)	64.31 ± 9.91
Body mass index (kg/m^2)	22.87 ± 3.18
Preoperative biliary drainage	238 (62.8)
CA 19-9 (U/mL)	905.17 (26.58–393.7)
Preoperative total bilirubin (mg/dL)	2.91 ± 3.59
ASA PS classification	
I	54 (14.2)
II	289 (76.3)
III	36 (9.5)
PV/SMV contact angle (°)	
No contact	273 (72.0)
>0 to <90	71 (18.7)
≥90 to <180	35 (9.2)
PV/SMV contact depth	
Abutment	92 (24.3)
Radiologic invasion (BRPC)	14 (3.7)
PD/PPPD	178 (47.0)/201 (53.0)
Vascular resection	76 (20.1)
Estimated blood loss (mL)	436.49 ± 330.05
Operation time (min)	365.42 ± 71.77
CD classification ≥IIIa	95 (25.1)
Postoperative hospital (day)	13.97 ± 9.7
T stage 1/2/3/4	75 (19.8)/264 (69.7)/39 (10.3)/1 (0.3)
N stage 0/1/2	115 (30.3)/163(43.0)/101 (26.6)
R0/R1/R2	251 (66.2)/123 (32.5)/ 5 (1.3)
Lymphovascular invasion	255 (67.3)
Perineural invasion	364 (96.0)
Pathologic PV/SMV invasion	46 (12.1)
Adjuvant treatment	
Chemotherapy only	47 (12.4)
Radiation therapy only	4 (1.1)
Chemotherapy and radiation therapy	181 (47.8)
Recurrence	249 (65.7)

Values are presented as number only, mean ± standard deviation, median (interquartile range), or number (%).
ASA, American Society of Anesthesiologists; PS, physical status; PV, portal vein; SMV, superior mesenteric vein; BRPC, borderline resectable pancreatic cancer; PD, pancreaticoduodenectomy; PPPD, pylorus-preserving pancreaticoduodenectomy; CD, Clavien-Dindo; T, tumor; N, nodal; R0, resection margin negative; R1, microscopically positive resection margin; R2, grossly positive resection margin.

1 patient in T4. In terms of lymph nodes, 264 patients (69.6%) had lymph node metastasis. R0 resection was achieved in 251 patients (66.2%). The complications were classified according to the CD classification, and the proportion of grade III or higher was 25.1%. A total of 232 patients (61.3 %) received adjuvant treatment after surgery. Recurrence occurred in 249 patients (65.7%) during follow-up.

Survival outcomes in the group with portal vein/superior mesenteric vein contact angle within 180°

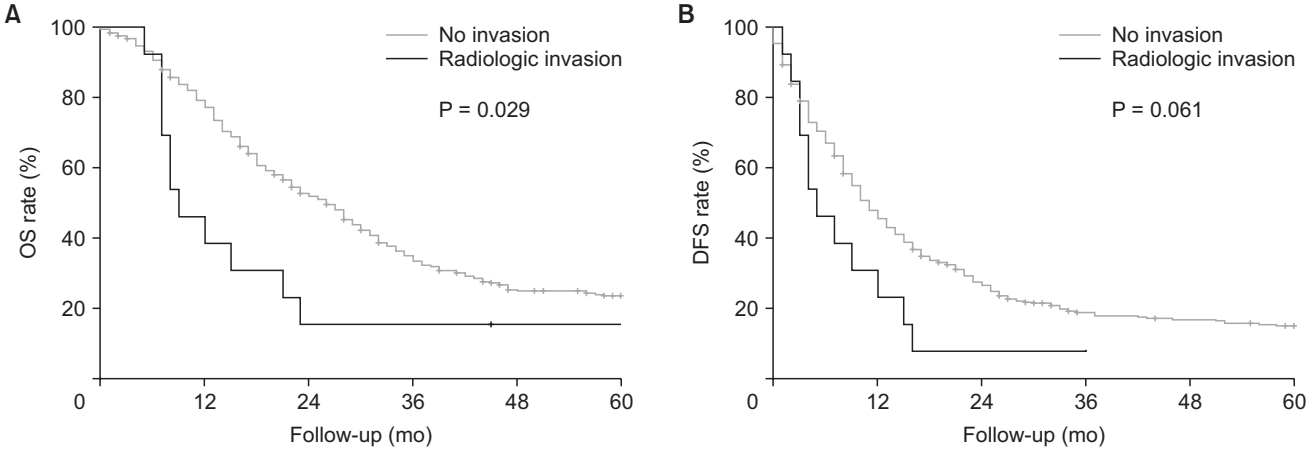
The survival and recurrence rates analyzed using the Kaplan-Meier survival curves are shown in Fig. 2. First, survival analysis was performed to identify the survival outcomes of patients with PDAC with PV/SMV contact angle within 180° regarding the anatomical relation to the vessels, such as tumor depth to the vessel and contact angle to the vessel. In terms of radiologic invasion, the OS rate in the invasion group was significantly inferior to that in the no invasion group (no contact and abutment groups, respectively) (5-year OS: 21.8 months *vs.* 15.4 months, respectively; P = 0.029) (Fig. 2A). The DFS rate in the invasion group was also inferior to that in the no invasion group (Fig. 2B). In terms of the contact angle, the OS rate in the group with a contact angle of more than 90° did not show any s significant difference between the no contact angle and contact angle less than 90° groups (Supplementary Fig. 1A). The DFS rate in the group with a contact angle less than 90° showed a significant difference between the no contact angle and contact angle less than 90° groups (Supplementary Fig. 1B).

Prognostic factors in the group with portal vein/superior mesenteric vein contact angle within 180°

The results of the univariate and multivariate analyses are shown in Table 2. Multivariate analysis revealed that radiological invasion (hazard ratio [HR], 2.096; 95% confidence interval [CI], 1.052–4.177; P = 0.035) was a significant prognostic factor for survival. In addition, old age (HR, 1.277; 95% CI, 1.002–1.626; P = 0.048), elevated CA 19-9 level (HR, 1.468; 95% CI, 1.152–1.869; P = 0.002), elevated total bilirubin level (HR, 1.362; 95% CI, 1.078–1.722; P = 0.010), vascular resection (HR, 1.413; 95% CI, 1.053–1.897; P = 0.021), margin status (HR, 1.447; 95% CI, 1.129–1.854; P = 0.003), T stage, and N stage were also significant prognostic factors in this multivariate analysis. Importantly, the univariate analysis showed that the contact angle had no relationship with patient prognosis.

Survival outcomes in the resectable pancreatic cancer subgroup

In this subgroup analysis, we only included patients with RPC, excluding the radiologic invasion groups from the previous analysis, and analyzed the survival outcomes according to anatomical factors. We performed a Kaplan-Meier survival analysis for the presence of contact with the PV/SMV and contact angle. No significant differences were found between the groups (Fig. 3). Further analysis with no contact, 0°–90° contact, and 90°–180° contact groups also showed no significant difference in terms of OS and DFS rates (Fig. 4).



Patients (n = 379)	5-yr OS (%)	Median (mo)
No invasion (n = 365)	21.8	26
Invasion (n = 14)	15.4	9

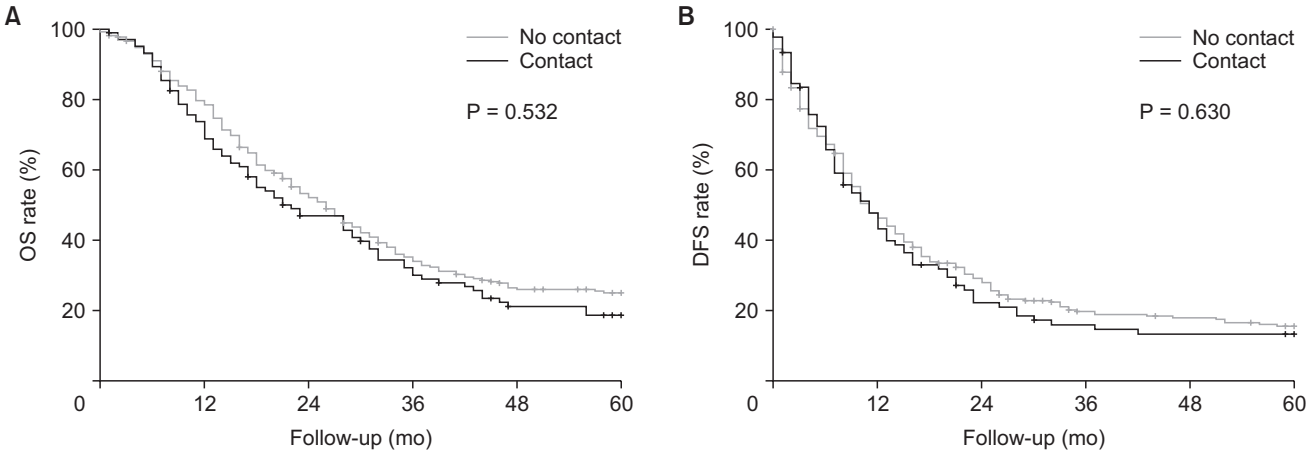
Patients (n = 379)	5-yr DFS (%)	Median (mo)
No invasion (n = 365)	15.0	11
Invasion (n = 14)	7.7	5

Fig. 2. Kaplan-Meier survival curves of the overall survival (OS) and disease-free survival (DFS) rates between the no-invasion and invasion groups. (A) The median OS was 26 months *vs.* 9 months, and the 5-year OS rate was 21.8% *vs.* 15.4%, respectively (P = 0.029). (B) The median DFS was 11 months *vs.* 5 months, and the 5-year DFS rate was 15.0% *vs.* 7.7%, respectively (P = 0.061).

Table 2. Univariate and multivariate analyses of prognostic factors for overall survival with PV/SMV contact angle within 180°

Variable	No. of patients	5-yr OS (%)	Univariate analysis		Multivariate analysis	
			HR (95% CI)	P-value	HR (95% CI)	P-value
Sex, male/female	235/144	24.1/17.2	1.160 (0.916–1.468)	0.217		
Age (yr), ≤65/>65	207/172	24.8/17.7	1.355 (1.077–1.705)	0.010*	1.277 (1.002–1.626)	0.048*
ASA PS classification						
I	54	23.6		0.166		
II	289	21.8	0.982 (0.705–1.366)	0.913		
III/IV	379	16.7	1.427 (0.888–2.293)	0.142		
Preoperative CA 19-9 (U/mL), ≤150/>150	215/164	27.1/14.1	1.599 (1.269–2.015)	<0.001*	1.468 (1.152–1.869)	0.002*
Contact angle (°), <90/≥90	344/35	22.7/11.1	1.363 (0.933–1.990)	0.108		
Radiologic invasion (BRPC), no/yes	365/14	21.8/15.4	1.924 (1.051–3.521)	0.034*	2.096 (1.052–4.177)	0.035*
Total bilirubin (mg/dL), ≤2.0/>2.0	225/154	26.1/15.1	1.295 (1.027–1.632)	0.029*	1.362 (1.078–1.722)	0.010*
Vascular resection, no/yes	303/76	24.7/9.6	0.799 (0.697–0.916)	0.001*	1.413 (1.053–1.897)	0.021*
EBL (mL), ≤500/>500	298/81	24.2/12.3	1.337 (1.022–1.748)	0.034*	1.187 (0.888–1.585)	0.247
T stage						
T1	75	40.5		<0.001*		0.010*
T2	264	17.9	1.774 (1.292–2.437)	<0.001*	1.612 (1.156–2.247)	0.005*
T3, 4	40	11.1	2.338 (1.500–3.644)	<0.001*	1.855 (1.156–2.975)	0.010*
N stage						
N0	115	37.2		<0.001*		<0.001*
N1	163	21.2	1.537 (1.148–2.057)	0.004*	1.540 (1.129–2.101)	0.006*
N2	101	5.8	2.752 (2.008–3.771)	<0.001*	2.466 (1.766–3.443)	<0.001*
Resection margin, R0 *vs.* R1	251/123	26.0/14.0	1.377 (1.083–1.751)	0.009*	1.447 (1.129–1.854)	0.003*
PV/SMV pathologic invasion	333/46	23.7/7.0	1.884 (1.360–2.608)	<0.001*	1.008 (0.636–1.596)	0.973
Lymphovascular invasion, no/yes	113/255	41.0/13.7	2.051 (1.549–2.715)	<0.001*	1.291 (0.851–1.956)	0.229
Perineural invasion, no/yes	14/364	63.5/19.7	3.006 (1.332–6.785)	0.008*	1.958 (0.818–4.688)	0.132
Chemotherapy, no/yes	151/228	9.9/28.6	0.523 (0.414–0.661)	<0.001*	0.435 (0.337–0.560)	<0.001*
Radiation therapy, no/yes	194/185	15.8/27.4	0.649 (0.516–0.818)	<0.001*	0.905 (0.621–1.319)	0.603

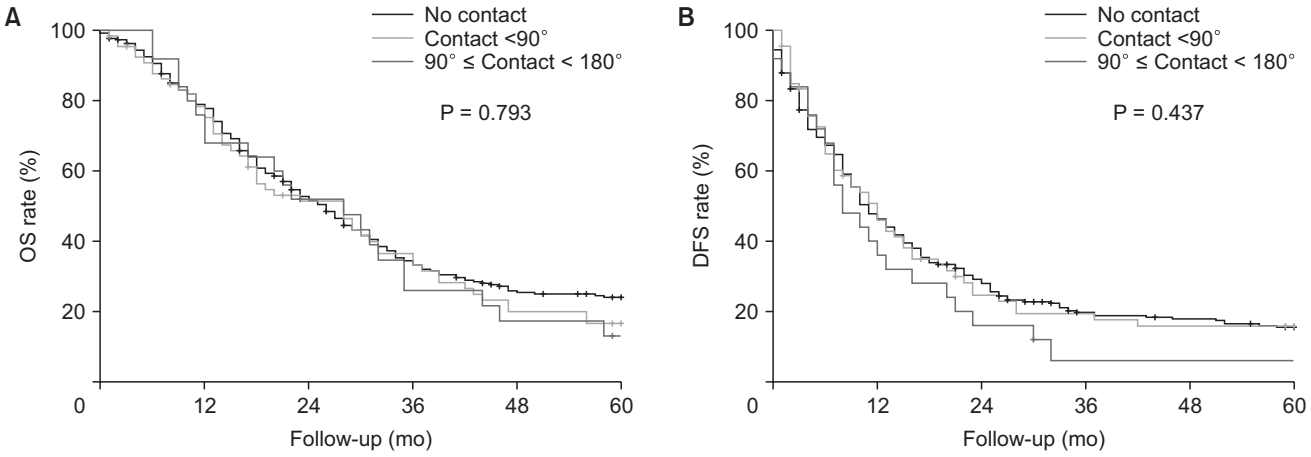
PV, portal vein; SMV, superior mesenteric vein; OS, overall survival; HR, hazard ratio; CI, confidence interval; ASA, American Society of Anesthesiologists; PS, physical status; BRPC, borderline resectable pancreatic cancer; EBL, estimated blood loss; T, tumor; N, nodal; R0, resection margin negative; R1, microscopically positive resection margin.
*P < 0.05.



Patients (n = 365)	5-yr OS (%)	Median (mo)
No contact (n = 273)	24.1	26
Contact (n = 92)	15.6	28

Patients (n = 365)	5-yr DFS (%)	Median (mo)
No contact (n = 273)	15.5	11
Contact (n = 92)	13.3	11

Fig. 3. Kaplan-Meier survival curves of overall survival (OS) and disease-free survival (DFS) rates between the no-contact and contact groups. (A) The median OS was 26 months *vs*. 28 months, and the 5-year OS rate was 24.1% *vs*. 15.6%, respectively (P = 0.532). (B) The median DFS was 11 months *vs*. 11 months, and the 5-year DFS rate was 15.5% *vs*. 13.3%, respectively (P = 0.630).



Patients (n = 365)	5-yr OS (%)	Median (mo)
No contact (n = 273)	24.1	26
0–90 (n = 67)	16.6	28
90–180 (n = 25)	13.0	28

Patients (n = 365)	5-yr DFS (%)	Median (mo)
No contact (n = 273)	15.5	11
0–90 (n = 67)	15.8	12
90–180 (n = 25)	6.0	8

Fig. 4. Kaplan-Meier survival curves of the overall survival (OS) and disease-free survival (DFS) rates among the no contact, 0°–90°contact, and 90°–180° contact groups. (A) The median OS was 26, 28, and 28 months, and the 5-year OS rate was 24.1%, 16.6%, and 13.0%, respectively (P = 0.793). (B) The median DFS was 11, 12, and 8 months, and the 5-year OS rates were 15.5%, 15.8%, and 6.0%, respectively (P = 0.437).

Prognostic factors in the resectable pancreatic cancer subgroup

The results of the univariate and multivariate analyses of the RPC subgroups are shown in Table 3. Multivariate analysis revealed that elevated CA 19-9 level (HR, 1.450; 95% CI, 1.136–1.851; P = 0.003) was the only preoperative factor with a prognostic effect. In addition, vascular resection (HR, 1.426; 95% CI, 1.062–1.941; P = 0.018), margin status (HR, 1.442; 95% CI, 1.120–1.856; P < 0.0001), T stage, and N stage were significant prognostic factors for survival.

DISCUSSION

RPC has a better prognosis than BRPC; however, it still has a poor prognosis compared to other gastrointestinal cancers. To date, the biological factor, CA 19-9, is one of the best preoperative factors for determining the prognosis of RPC [10-12]. However, the preoperative prognosis of RPC is limited to biological factors, and other factors are not well established. Therefore, in this study, we investigated preoperative factors other than biological factors such as anatomical factors. We aimed to determine how these anatomical factors affect RPC prognosis.

This study aimed to investigate the prognostic significance of PV/SMV abutment angle in patients with RPC. Our findings revealed that the PV/SMV abutment angle did not significantly affect the prognosis of RPC.

NAT has gained a pivotal role in the management of BRPC, and several studies have highlighted the benefits of NAT in improving the outcomes of these patients, including better resection rates and survival outcomes [5,13,14]. With this notable improvement in BRPC management, several attempts have been made to apply NAT to RPC [15-18].

BRPC can be defined in several ways: anatomical, biological, and conditional. Using these definitions, we analyzed subgroups within RPC that may have a poorer prognosis or at least a difference in prognosis. Thus, this study examined the relevance of anatomical factors, such as the PV/SMV contact angle and contact depth, in the prognosis of RPC patients.

Several studies have focused on the prognostic significance of PV/SMV abutment angle and contact depth in pancreatic cancer. Wang et al. [19] reported that the depth of portal system tumor invasion is an independent risk factor for the prognosis of patients with pancreatic cancer. However, this study only included patients with BRPC; thus, we cannot suggest anything on the impacts of the depth of portal system tumor invasion on patients with RPC. Song et al. [20] showed that tumor invasion of the SMV/PV is associated with aggressive biological behavior and indicates poor prognosis after PDAC resection. However, the study was a meta-analysis, thus, it has heterogeneity problems and lacks standardized radiologist evaluations. The authors did not divide the patients into RPC or BRPC groups; however, all patients with PDAC who underwent resection were placed in the RPC group; thus, the study results provide incomplete information. Shirai et al. [8] reported that RPC with SMV/PV contact had a worse prognosis and that SMV/PV contact itself is a prognostic factor (HR, 2.17; 95% CI, 1.27–3.70; P < 0.01). However, the study provides information on only

Table 3. Univariate and multivariate analyses of prognostic factors for overall survival in patients with resectable pancreatic cancer

Variable	No. of patients	5-yr OS (%)	Univariate analysis		Multivariate analysis	
			HR (95% CI)	P-value	HR (95% CI)	P-value
Sex, male/female	225/140	24.2/17.7	0.868 (0.683–1.103)	0.247		
Age (yr), ≤65/>65	197/168	25.0/18.2	1.361 (1.077–1.720)	0.010*	1.275 (0.999–1.628)	0.051
ASA PS classification						
I	53	24.0		0.033*		
II	280	22.4	0.858 (0.672–1.095)	0.219		
III/IV	32	12.1	0.832 (0.691–1.002)	0.052		
Preoperative CA 19-9 (U/mL), ≤150/>150	204/161	26.4/15.4	1.634 (1.291–2.068)	<0.001*	1.450 (1.136–1.851)	0.003*
Contact angle (°), <90/≥90	340/25	22.5/13.0	1.126 (0.722–1.758)	0.595		
Total bilirubin (mg/dL), ≤2.0/>2.0	214/151	26.4/15.4	1.300 (1.027–1.646)	0.029*	1.232 (0.951–1.597)	0.114
Vascular resection, no/yes	301/64	24.8/8.5	0.814 (0.704–0.942)	0.006*	1.426 (1.062–1.914)	0.018*
EBL (mL), ≤500/>500	291/74	24.7/11.0	1.387 (1.052–1.829)	0.021*	1.234 (0.919–1.658)	0.163
T stage						
T1	73	41.6				0.010*
T2	257	17.5	1.842 (1.332–2.547)	<0.001*	1.667 (1.192–2.333)	0.003*
T3/4	35	12.8	2.190 (1.370–3.499)	0.001*	1.687 (1.028–2.769)	0.038*
N stage						
N0	112	37.1		<0.001*		<0.001*
N1	159	21.1	1.531 (1.141–2.055)	0.005*	1.518 (1.110–2.075)	0.009*
N2	94	6.3	2.617 (1.898–3.610)	<0.001*	2.387 (1.701–3.349)	<0.001*
Resection margin, R0 *vs.* R1	243/118	26.1/14.4	1.434 (1.135–1.812)	0.003*	1.442 (1.120–1.856)	<0.001*
PV/SMV pathologic invasion	329/36	23.7/6.0	1.719 (1.200–2.464)	0.003*	1.069 (0.666–1.698)	0.797
Lymphovascular invasion, no/yes	110/244	41.0/13.8	2.007 (1.511–2.667)	<0.001*	1.382 (0.919–2.077)	0.120
Perineural invasion, no/yes	14/350	63.5/19.7	2.979 (1.319–6.725)	0.009*	1.979 (0.825–4.748)	0.126
Chemotherapy, no/yes	146/219	10.2/28.9	0.523 (0.412–0.665)	<0.001*	0.429 (0.331–0.555)	<0.001*
Radiation therapy, no/yes	187/178	15.7/28.0	0.636 (0.503–0.805)	<0.001*	0.827 (0.564–1.211)	0.329

HR, hazard ratio; CI, confidence interval; ASA, American Society of Anesthesiologists; PS, physical status; EBL, estimated blood loss; T, tumor; N, nodal; R0, resection margin negative; R1, microscopically positive resection margin; PV, portal vein; SMV, superior mesenteric vein.
*P < 0.05.

contact degrees >180° and <180° and no contact. The one with contact over 180° corresponded to BRPC, and this information was not useful for our study. Thus, there was no detailed information on these degrees. However, in our study, we had groups with less than 90°and between 90°and 180°. In addition, in that study, there were 186 patients, with 38 contact RPC cases and 25 BRPC cases, which is a relatively smaller sample size than that analyzed in our study. Likewise, Molnár et al. [9] revealed that the portomesenteric venous contact ≤180° is associated with poorer survival in patients with RPC with upfront surgery than in those in the no contact group (15.3 *vs.* 23.0 months, respectively; P = 0.059). However, it contains information about only contact ≤180° or no contact. There is no detailed information regarding these degrees. They also had a total of 183 patients, with 39 contact patients, which is a relatively small sample size compared to that of our study. In our study, we attempted to overcome these limitations by standardizing the angle measurement technique used by the same radiologists and focusing on a specific patient group with large single-center data.

Despite our efforts, the only significant prognostic factor was the elevated CA 19-9 levels (>150 U/mL). Specifically, the result was as follows: HR, 1.468; 95% CI, 1.152–1.869; P = 0.002 in all patients and HR, 1.450; 95% CI, 1.136–1.851; P = 0.003 in only patients with RPC, indicating significant independent prognostic factor for both groups. In contrast, contrary to expectations, no significant differences in prognosis were observed between groups stratified by a contact angle of 90° or less. This finding suggests that the contact angle does not independently influence outcomes in RPC cases.

Additional notable results from this study include discrepancies between univariate and multivariate analyses of vascular resection outcomes in Tables 2 and 3. Vascular resection was performed to achieve an R0 margin, but its underlying causes—such as adhesion, fibrosis, or true invasion—can vary. In radiologically resectable cases without preoperative evidence of vascular invasion, imaging may have underestimated the extent of disease, potentially categorizing some advanced cases into the vascular resection group. The multivariate analysis, which accounted for T and N stages as

well as adjuvant treatments, underscores the need for further investigation. Future studies with larger sample sizes could facilitate subgroup analyses within the vascular resection group to identify factors influencing survival outcomes.

Interestingly, even among radiologically resectable cases, pathologic vascular invasion was infrequently observed. Pathologic invasion is likely associated with a more advanced stage of disease, explaining its significance as a poor prognostic factor in univariate analysis. However, the multivariate analysis yielded differing results, potentially due to the confounding effects of adjuvant treatment administered to patients with more advanced disease stages. These treatments may have masked the prognostic impact of vascular invasion. To clarify this relationship, further investigations involving larger cohorts of cases with pathologic invasion are warranted.

This study also raises critical questions about the management of vascular abutment lesions in radiologically RPC. While preoperative CT scans identified these cases as resectable, some demonstrated pathological vein invasion postoperatively. Although this study alone cannot conclusively determine whether such lesions should be surgically resected or preserved, the findings suggest that upfront surgery may be appropriate for patients with vascular abutment, as the abutment itself was not associated with adverse prognostic impact. Larger patient cohorts are needed to refine surgical strategies based on preoperative evaluations.

This study has a few limitations worthy of discussion. First, this was a retrospective study, which might have introduced a selection bias. Second, there is the potential for changes in chemotherapy regimens over time. Third, during the experimental period, the definition of BRPC changed, which may have affected our findings. However, this study is significant because it is a large single-center cohort with a specific patient group and standardized PV/SMV angle measurements by radiology specialists.

In conclusion, while our findings underscore the prognostic significance of elevated CA 19-9 levels, they suggest that contact angles and vascular abutment may not independently influence outcomes in RPC. These insights, combined with the study's methodological rigor, provide a foundation for future research aimed at optimizing patient selection and surgical strategies in this challenging disease.

SUPPLEMENTARY MATERIALS

Supplementary Fig. 1 can be found via https://doi.org/10.4174/astr.2025.108.4.231.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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