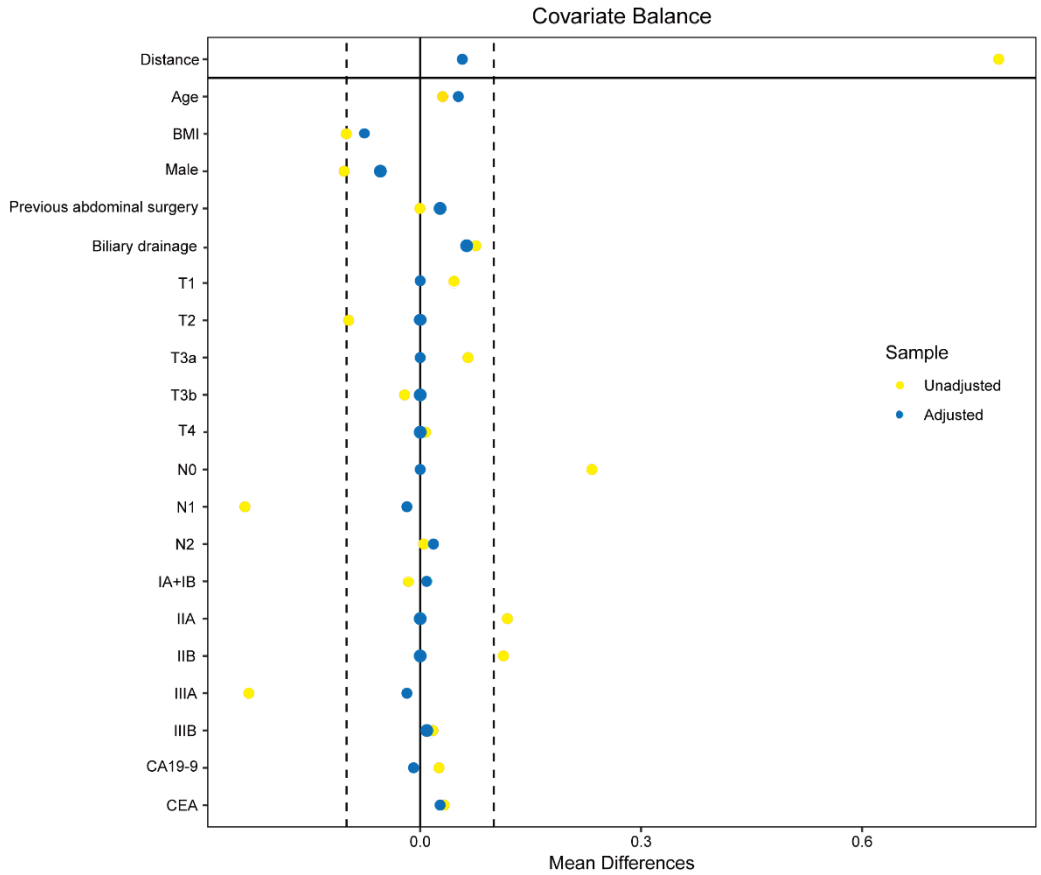


Supplementary Figure 1. Covariate balance before and after propensity score matching.

The plot shows covariate differences between the laparoscopic and open pancreaticoduodenectomy groups before and after propensity score matching. Yellow dots indicate covariate differences before matching, and blue dots indicate covariate differences after matching. Dashed vertical lines represent the reference threshold for covariate balance. BMI, body mass index; T stage, tumor stage; N stage, nodal stage; TNM stage, tumor–node–metastasis stage; CA19-9, carbohydrate antigen 19-9; CEA, carcinoembryonic antigen.

Supplementary Table 1. Sensitivity analysis using Tumor–node–metastasis stage in the multivariable Cox regression model.

Characteristic	Univariable analysis				Multivariable analysis			
	OS		DFS		OS		DFS	
	HR	*P*-value	HR	*P*-value	HR	*P*-value	HR	*P*-value
TO achievement								
No	Ref.		Ref.					
Yes	0.50 (0.36, 0.68)	<0.001[a]	0.61 (0.46, 0.81)	<0.001[a]	0.63 (0.46, 0.87)	0.005[a]	0.70 (0.50,0.99)	0.042[a]
Sex								
Female	Ref.		Ref.					
Male	0.91 (0.67, 1.24)	0.606	0.87 (0.65, 1.17)	0.355				
Age(years)	1.02 (1.00, 1.03)	0.064	1.01 (1.00, 1.03)	0.157				
Tumor differentiation								
Well	Ref.		Ref.					
Poor	2.89 (2.12, 3.94)	<0.001[a]	2.19 (1.65, 2.89)	<0.001[a]	1.68 (1.20, 2.35)	0.003[a]	1.29 (0.94, 1.76)	0.103
TNM-stage								
IA+IB	Ref.		Ref.		Ref.		Ref.	
IIA	2.13 (1.24, 3.65)	0.003[a]	1.58 (1.00, 2.47)	0.048[a]	1.87 (1.08, 3.23)	0.025[a]	1.46 (0.93, 2.31)	0.102
IIB	4.09 (2.16, 7.77)	<0.001[a]	2.63 (1.47, 4.70)	<0.001[a]	3.23 (1.68, 6.22)	<0.001[a]	2.25 (1.25, 4.04)	0.007[a]
IIIA	5.06 (3.24, 7.91)	<0.001[a]	3.66 (2.53, 5.29)	<0.001[a]	4.21 (2.66, 6.67)	<0.001[a]	3.36 (2.29, 4.91)	<0.001[a]
IIIB	12.3 (7.26, 20.9)	<0.001[a]	9.59 (6.01, 15.3)	<0.001[a]	7.36 (4.13, 13.1)	<0.001[a]	6.29 (3,76, 10.53)	<0.001[a]
Perineural invasion	2.34 (1.46, 3.73)	<0.001[a]	2.11 (1.35, 3.32)	<0.001[a]	1.62 (1.02, 2.65)	0.038[a]	1.59 (1.02, 2.54)	0.039[a]
Preoperative raised serum CA19-9(＞37U/mL)	1.79 (1.28, 2.51)	<0.001[a]	1.84 (1.36, 2.48)	<0.001[a]	1.51 (1.07, 2.14)	0.019[a]	1.64 (1.21, 2.24)	0.001[a]
Preoperative raised serum CEA(＞5 ng/mL)	0.95 (0.63, 1.41)	0.753	0.82 (0.57, 1.20)	0.279				
Operation method								
OPD	Ref.		Ref.					
LPD	1.05 (0.77, 1.43)	0.848	1.09 (0.82, 1.43)	0.538				

Characteristic	Univariable analysis				Multivariable analysis			
	OS		DFS		OS		DFS	
	HR	*P*-value	HR	*P*-value	HR	*P*-value	HR	*P*-value
Tumor size (cm)	1.10 (0.99, 1.22)	0.078	1.05 (0.95, 1.16)	0.429				
Positive resection margin	3.74 (2.21, 6.32)	<0.001[a]	3.17 (1.89, 5.32)	<0.001[a]	2.43 (1.40, 4.20)	0.002[a]	1.88 (1.09, 3.25)	0.022[a]
Additional organ resection	1.10 (0.45, 2.68)	0.831	0.89 (0.37, 2.17)	0.802				

[a]*P* <0.05.OS: Overall survival, DFS: Disease-free survival, TO: Textbook outcome, TNM-stage: Tumor–node–metastasis stage, CA19-9: Carbohydrate antigen 19-9, CEA: Carcinoembryonic antigen, OPD: Open pancreaticoduodenectomy, LPD: Laparoscopic pancreaticoduodenectomy.

Supplementary Table 2 Temporal sensitivity analysis.

Characteristic	Univariable analysis				Multivariable analysis			
	OS		DFS		OS		DFS	
	HR	*P* value	HR	*P* value	HR	*P* value	HR	*P* value
TO achievement								
No	Ref.		Ref.					
Yes	0.50 (0.36, 0.68)	<0.001[a]	0.61 (0.46, 0.81)	<0.001[a]	0.61 (0.44, 0.84)	0.003*	0.74 (0.56,0.99)	0.047[a]
Sex								
Female	Ref.		Ref.					
Male	0.91 (0.67, 1.24)	0.606	0.87 (0.65, 1.17)	0.355				
Age(years)	1.02 (1.00, 1.03)	0.064	1.01 (1.00, 1.03)	0.157				
Tumor differentiation								
Well	Ref.		Ref.					
Poor	2.89 (2.12, 3.94)	<0.001[a]	2.19 (1.65, 2.89)	<0.001[a]	1.56 (1.11, 2.19)	0.011[a]	1.25 (0.92, 1.70)	0.163
T-stage								
T1	Ref.		Ref.					
T2	1.97 (0.88, 4.42)	0.102	1.81 (0.99, 3.30)	0.054	1.73 (0.77, 3.92)	0.187	1.68 (0.92, 3.10)	0.093
T3a	4.00 (1.79, 8.94)	<0.001[a]	2.78 (1.50, 5.14)	<0.001[a]	3.10 (1.37, 7.02)	0.007[a]	2.40 (1.28, 4.47)	0.006[a]
T3b	11.0 (4.97, 24.1)	<0.001[a]	6.81 (3.72, 12.5)	<0.001[a]	5.75 (2.51, 13.2)	<0.001[a]	4.00 (2.11, 7.56)	<0.001[a]
T4	18.7 (6.83, 51.3)	<0.001[a]	11.3 (4.85, 26.2)	<0.001[a]	6.38 (2.20, 18.5)	<0.001[a]	4.33 (1.76, 10.7)	0.001[a]
N-stage								
N0	Ref.		Ref.					
N1	2.71 (1.92, 3.81)	<0.001[a]	2.37 (1.75, 3.22)	<0.001[a]	1.94 (1.34, 2.82)	<0.001[a]	1.89 (1.36, 2.63)	<0.001[a]
N2	6.73 (4.22, 10.7)	<0.001[a]	6.81 (4.35, 10.7)	<0.001[a]	2.86 (1.67, 4.91)	<0.001[a]	3.38 (1.96, 5.71)	<0.001[a]
Perineural invasion	2.34 (1.46, 3.73)	<0.001[a]	2.11 (1.35, 3.32)	<0.001[a]	1.67 (1.01, 2.76)	0.024[a]	1.74 (1.08, 2.80)	0.022[a]
Preoperative raised serum CA19-9(＞37U/mL)	1.79 (1.28, 2.51)	<0.001[a]	1.84 (1.36, 2.48)	<0.001[a]	1.48 (1.05, 2.09)	0.027[a]	1.64 (1.20, 2.23)	0.002[a]

Characteristic	Univariable analysis				Multivariable analysis			
	OS		DFS		OS		DFS	
	HR	*P* value	HR	*P* value	HR	*P* value	HR	*P* value
Preoperative raised serum CEA(> 5 ng/mL)	0.95 (0.63, 1.41)	0.753	0.82 (0.57, 1.20)	0.279				
Operation method								
OPD	Ref.		Ref.					
LPD	1.05 (0.77, 1.43)	0.848	1.09 (0.82, 1.43)	0.538				
Tumor size (cm)	1.10 (0.99, 1.22)	0.078	1.05 (0.95, 1.16)	0.429				
Positive resection margin	3.74 (2.21, 6.32)	<0.001[a]	3.17 (1.89, 5.32)	<0.001[a]	2.28 (1.29, 4.04)	0.005[a]	1.76 (1.01, 3.11)	0.046[a]
Additional organ resection	1.10 (0.45, 2.68)	0.831	0.89 (0.37, 2.17)	0.802				
Year of surgery								
2012-2017	Ref.		Ref.		Ref.		Ref.	
2018-2022	1.04 (0.76, 1.42)	0.815	1.13 (0.85, 1.50)	0.398	1.10 (0.80, 1.52)	0.569	1.25 (0.94, 1.67)	0.125

[a]*P* <0.05.OS: Overall survival, DFS: Disease-free survival, TO: Textbook outcome, T-stage: Tumor stage, N-stage: Nodal stage, TNM-stage: Tumor–node–metastasis stage, CA19-9: Carbohydrate antigen 19-9, CEA: Carcinoembryonic antigen, OPD: Open pancreaticoduodenectomy, LPD: Laparoscopic pancreaticoduodenectomy.

Supplementary Table 3 Schoenfeld residual test for the proportional hazards assumption in the multivariable Cox model for overall survival

Characteristic	chisq	df	*P* value	interpretation
TO achievement	0.656	1	0.418	No evidence of PH violation
Tumor differentiation	0.229	1	0.632	No evidence of PH violation
T-stage	3.097	4	0.542	No evidence of PH violation
N-stage	2.060	2	0.357	No evidence of PH violation
Perineural invasion	1.537	1	0.215	No evidence of PH violation
Preoperative raised serum CA19-9(> 37U/mL)	1.006	1	0.316	No evidence of PH violation
Positive resection margin	0.203	1	0.652	No evidence of PH violation
GLOBAL	10.732	11	0.466	No evidence of PH violation

TO: Textbook outcome, T-stage: Tumor stage, N-stage: Nodal stage, CA19-9: Carbohydrate antigen 19-9.

Supplementary Table 4 Schoenfeld residual test for the proportional hazards assumption in the multivariable Cox model for disease-free survival.

Characteristic	chisq	df	*P* value	interpretation
TO achievement	1.374	1	0.241	No evidence of PH violation
Tumor differentiation	0.410	1	0.522	No evidence of PH violation
T-stage	8.511	4	0.075	No evidence of PH violation
N-stage	1.754	2	0.416	No evidence of PH violation
Perineural invasion	0.903	1	0.342	No evidence of PH violation
Preoperative raised serum CA19-9(> 37U/mL)	1.096	1	0.295	No evidence of PH violation
Positive resection margin	0.034	1	0.854	No evidence of PH violation
GLOBAL	15.084	11	0.179	No evidence of PH violation

TO: Textbook outcome, T-stage: Tumor stage, N-stage: Nodal stage, CA19-9: Carbohydrate antigen 19-9.