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ORIGINAL ARTICLE

Preoperative heart disease and risk for postoperative complications after pancreatoduodenectomy

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Abstract

Background: Comorbidities increase the risk for postoperative complications after pancreatoduodenectomy. The importance of different categories of heart disease on postoperative outcomes has not been thoroughly studied.

Methods: Patients aged ≥18 years undergoing pancreatoduodenectomy between 2008 and 2019 at Karolinska University Hospital, Sweden were included. Heart disease was defined as a preoperatively established diagnosis, and subcategorized into ischaemic, valvular, heart failure and atrial fibrillation. Postoperative outcome was analysed by multivariable regression.

Results: Out of 971 patients, 225 (23.3%) had heart disease. Heart disease was associated with an increased risk for complications; Clavien–Dindo score ≥ IIIa (Odds Ratio [OR] 1.53, 95% confidence interval [CI] 1.07–2.18; p = 0.019), intensive care unit admissions (OR 3.20, 95% CI 1.81–5.66; p < 0.001) and longer hospitalizations (median 14 vs. 11 days; p < 0.001). Although heart disease was not associated with 90-day mortality, it conferred a shorter median overall survival (22 vs. 32 months; p < 0.001). Atrial fibrillation and heart failure were each associated with increased risk for postoperative complications, whereas ischaemic and valvular heart disease were not.

Conclusion: Atrial fibrillation and heart failure were independently associated with increased risk for postoperative complications. Despite no association with early postoperative mortality, heart disease negatively affected long-term survival.

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Introduction

Pancreatoduodenectomy is a complex procedure used to treat malignancies in the pancreatic head.[1,2] It is associated with significant post-operative risks and 90-day mortality is reported to be 1–8 per cent.[3,4] In spite of surgical resection, the prognosis remains dismal with a five-year survival rate ranging from 25 to 40 per cent.[5] Although the risk for postoperative complications has decreased in the last decades due to advances in perioperative management,[6] the risks associated with pancreatoduodenectomy remain high. Therefore, it is challenging to determine if the possible benefits of surgery outweigh the risks.[7]

Preoperative assessment of comorbidities offers an avenue of treatment optimization which may decrease risks associated with surgery.[8] Some comorbidities, including heart disease, increase the risk of postoperative complications after pancreatic surgery.[9–11] There are several formulae designed to estimate the effect of comorbidities on complications, one being Charlson Comorbidity Index.[12] Many of these preoperative risk estimation models are, however, mainly dichotomous and do not account for different types of heart disease.[13–16]

The aim of this study was to investigate the impact of different categories of heart disease on morbidity and mortality after pancreatoduodenectomy.

Methods

Study population

All adult patients (age ≥ 18 years) treated with pancreatoduodenectomy, regardless of indication, between January 2008 and June 2019 at Karolinska University Hospital, Stockholm, Sweden, a tertiary referral centre for pancreatic surgery, were included. Patients with prior pancreatic surgery were excluded. Data were systematically and prospectively collected via electronic health records, and thereafter retrospectively controlled and classified.

The study was reported in accordance to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines[17] and approved by the National Ethical Review Agency (registration number: 2020/05238).

Data variables and definitions

Baseline characteristics

Data were collected on age, Body Mass Index (BMI), sex, estimated glomerular filtration rate (eGFR), American Society of Anaesthesiologists – Physical Status (ASA-PS) classification,[18] Eastern Cooperative Oncology Group (ECOG) Performance Status,[19] preoperative smoking status, history of hypertension and diabetes, pathological report on operative specimen and ejection fraction (EF) on preoperative echocardiography, if present.

Heart disease

The data on cardiac diagnosis/heart disease were based on systematic review of the patients' electronic health records. Heart disease was defined as a preoperatively established cardiac diagnosis, and was coded according to the International Statistical Classification of Diseases and Related Health Problems (ICD) 10th version,[20] or classified according to pathological findings on preoperative echocardiography, not older than 6 months at the time of surgery. Heart disease was *a priori* categorized into four groups; ischaemic heart disease, atrial fibrillation, heart failure and valvular heart disease.

Ischaemic heart disease was defined as preoperative myocardial infarction, previous percutaneous coronary intervention, a diagnosis of angina pectoris or chronic coronary disease. Heart failure was defined as presence of a preoperatively established heart failure diagnosis, or a left ventricular ejection fraction less than 40 per cent on a preoperative echocardiography, if available. For patients without an available echocardiography, either symptoms of heart failure requiring medical treatment or elevated biochemical markers (such as natriuretic peptides) had to be present. Valvular disease was defined as a preoperative established diagnosis of aortic stenosis or an aortic valve continuous doppler flow velocity of >2.5 m/s, or a diagnosis of mitral regurgitation, or at least moderate mitral regurgitation on a pre-operative echocardiography. Atrial fibrillation was defined as any preoperative history of diagnosed atrial fibrillation, whether paroxysmal, persistent or permanent. For a detailed list of ICD-codes and echocardiographic criteria, see the supplementary material (Table S1). Any case of *de novo* peri- or postoperative heart disease diagnosis without recorded preoperative clinical findings supporting that diagnosis *preoperatively* was not classified as a preoperative condition.

Outcomes

The primary outcome measure was postoperative complication defined as Clavien–Dindo (CD) score ≥ IIIa.[21] Secondary outcomes were 30-day, 90-day and overall mortality, 1-, 3- and 5-year survival, intensive care unit (ICU) admission, length of stay in the ICU and length of stay in hospital. Delayed gastric emptying, postoperative pancreatic fistula, postoperative pancreatic haemorrhage and bile leakage were also considered secondary outcomes and classified according to the International Study Group of Pancreatic Surgery (ISGPS) and International Study Group of Liver Surgery (ISGLS) guidelines; only grade B and C complications were considered to be of clinical relevance.[22–25]

Statistical analysis

Categorical variables were analysed using Chi-square test or Fisher's exact test and presented as counts with percentages. Continuous data were analysed with independent samples *t*-test or Mann–Whitney U test and presented as medians with interquartile range (i.q.r). Normality was tested using the Shapiro–Wilk test.

Survival was analysed using the Kaplan–Meier method and analysed with the log rank test. Multivariable logistic regressions were performed to analyse the association between heart disease and postoperative complications. Results of the logistic regression analyses were presented in odds ratio (OR) and 95 per cent confidence intervals (CI). Variables in the multivariable logistic regression model were decided *a priori* and included: age (continuous), sex (male, female), smoking (never, active, previous), hypertension (no, yes), BMI (continuous), diabetes mellitus (no, yes), pulmonary disease (any degree of chronic obstructive pulmonary disease or pulmonary fibrosis) and eGFR (continuous). Statistical significance was considered as two-tailed p-value <0.050. All analyses were performed with StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP.

Results

In total, 971 patients met the inclusion criteria, of which 225 (23.2 per cent) had at least one preoperative cardiac diagnosis (Fig. 1). The median follow-up time was 6.2 years (i.q.r 3.5 years–8.9 years). Among all patients, 122 (12.6 per cent) had atrial fibrillation, 107 (11.0 per cent) had ischaemic heart disease, 52 (5.4 per cent) had heart failure and 25 (2.6 per cent) had valvular heart disease. Patients with heart disease were older, predominantly male and had higher ASA-PS and ECOG-levels.

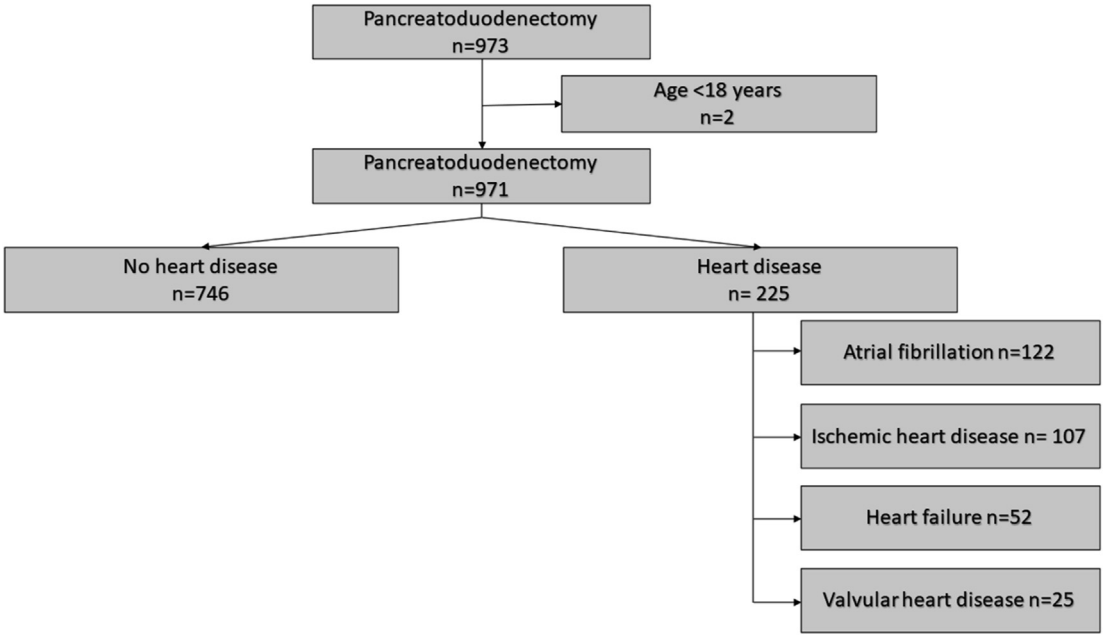

Figure 1 Flowchart of patient distribution

Additionally, hypertension and diabetes were more prevalent among patients with heart disease (Table 1). Also, patients with heart disease were more often evaluated with a preoperative echocardiography than those without heart disease. There was no difference in the proportion of malignant histopathology in the postoperative specimens when comparing patients with and without heart disease. All patients with valvular heart disease had an available standard transthoracic echocardiography.

Postoperative outcomes are presented in Table 2. The proportion of patients with severe complications, defined as CD score $\geq$ IIIa (32.9 per cent vs. 24.7 per cent, p = 0.014) and delayed gastric emptying grade B–C (38.7 per cent vs. 28.2 per cent, p = 0.003), was higher among patients with heart disease compared to patients without heart disease. The median hospital length of stay was longer (14 days vs. 11 days, p < 0.001) and the proportion of ICU admission higher (14.2 per cent vs. 4.7 per cent, p < 0.001) compared to patients with no heart disease.

In a multivariable logistic regression analysis, heart disease was associated with increased risk for severe complications with CD score $\geq$ IIIa (OR 1.53, 95% CI 1.07–2.18, p = 0.019), ICU admission, hospital stay $\geq$14 days and delayed gastric emptying grade B–C compared to patients with no heart disease (Table 3).

Multivariable logistic regression analyses showed that atrial fibrillation and heart failure were independent risk factors for severe complications with CD score $\geq$ IIIa, and hospital length of stay $\geq$14 days. Also, ischaemic heart disease, atrial fibrillation and heart failure were associated with increased risk of ICU admission. Heart failure was associated with increased risk for DGE grade B–C (Table 3).

There was no difference in 30-day mortality rate when comparing patients with and without heart disease (Table 2). The 90-day mortality rate was higher for patients with heart disease compared to patients without heart disease (5.8 per cent vs. 3.0 per cent, p = 0.046). However, there was no association between heart disease and risk of 90-day mortality in a multivariable adjusted logistic regression analysis (Table 3). Overall, patients with heart disease had a shorter median survival (21.8 months vs. 31.6 months; p < 0.001) and lower rates of 1-, 3- and 5-year survival than patients with no heart disease (Fig. 2). The proportion of malignant diagnosis among patients surviving 5 years or more did not differ significantly between patients with and without heart disease (24 patients, 63.2 per cent vs. 100 patients, 57.1 per cent respectively, p = 0.496).

Discussion

This high-volume, single centre cohort study, including 971 consecutive patients with a study period of more than ten years, affirms that heart disease is associated with postoperative complications after pancreatoduodenectomy.

While it has been shown that preoperative heart disease is a risk factor for complications after pancreatic surgery, the reported risks associated with different types of heart disease have varied between studies.[9,13,14,26] Ischaemic heart disease has consequently been a risk factor in these studies, whereas heart failure has not. This may be due to different study designs, definitions of disease, sample sizes and selection bias. In the present study heart failure and atrial fibrillation were

Table 1 Baseline characteristics of patients with and without heart disease undergoing pancreatoduodenectomy

	No heart disease (n = 746)	Heart disease (n = 225)	Overall (n = 971)	p value†
Age (years)[a]	67.3 (60.6–74.0)	72.1 (67.1–77.1)	68.4 (62.0–74.8)	<0.001‡
BMI (kg/m^2)[a]	24.3 (21.6–27.0)	24.8 (22.2–27.4)	24.4 (21.8–27.0)	0.110‡
Sex				<0.001
Men	366 (49.1)	152 (67.6)	518 (53.4)	
Women	380 (50.9)	73 (32.4)	453 (46.7)	
eGFR (ml/min/1.73 m^2)[a]	90 (78–102)	90 (78–102)	90 (78–102)	0.913‡
ASA grade				<0.001
1	102 (13.7)	6 (2.7)	108 (11.1)	
2	459 (61.5)	91 (40.4)	550 (56.6)	
3	180 (24.1)	118 (52.4)	298 (30.7)	
4	5 (0.7)	10 (4.4)	15 (1.5)	
ECOG performance status				0.001
0	482 (64.6)	112 (49.8)	594 (61.2)	
1	107 (14.3)	45 (20.0)	152 (15.7)	
2	25 (3.4)	16 (7.1)	41 (4.2)	
3	3 (0.4)	3 (1.3)	6 (0.6)	
Missing	129 (17.3)	49 (21.8)	178 (18.3)	
Smoking				0.511
Never	546 (73.2)	158 (70.2)	704 (72.5)	
Currently	141 (18.9)	44 (19.6)	185 (19.1)	
Former	59 (7.9)	23 (10.2)	82 (8.4)	
Hypertension	193 (25.9)	125 (55.6)	318 (32.8)	<0.001
Diabetes	107 (14.3)	73 (32.4)	180 (18.5)	<0.001
Malignant histology	570 (76.4)	182 (80.9)	752 (77.5)	0.159
Preoperative echocardiography	57 (7.6)	90 (40.0)	147 (15.1)	<0.001
Ejection fraction				<0.001
≥40%	55 (96.5)	73 (81.1)	128 (87.1)	
<40%	0 (0.0)	17 (18.9)	17 (11.6)	
Missing	2 (3.5)	0 (0.00)	2 (1.4)	

Values in parenthesis are percentages unless indicated otherwise. p-value indicates difference between patients with and without heart disease. †χ^2 test, except ‡Mann–Whitney U-test.
[a] Indicates median (interquartile range).

each, independently associated with major postoperative complications, whereas ischaemic heart disease and left sided valvular heart disease (mild or moderate degree) were not. Interestingly, the increased risk for major complications was not explained by a higher incidence of specific complications after pancreatic surgery, such as grade B–C postoperative pancreatic fistulas, bile leakage or postoperative pancreatic haemorrhage. Instead, the need of ICU admissions for supportive intensive care, rather than re-operations, constituted one of the most important major complications for patients with heart disease. The association of heart disease with ICU admissions and longer hospital stays, however, did not translate into early postoperative mortality. Despite the increased risk of complications among patients with heart disease, the results imply that these were successfully treated, rendering prolonged hospital stays but no negative effects on early post-operative survival. The association of preoperative atrial fibrillation with an increased risk for major post-operative complications after pancreatoduodenectomy is a novel finding for this patient category, although similar effects have been reported in other surgical settings.[27,28] Mechanisms, such as an increased need of anticoagulation, heart rate control, and elevated risk of both thromboembolism and bleeding may explain this association.

Table 2 Postoperative morbidity and mortality according to the presence of heart disease at baseline

	No heart disease (n = 746)	Heart disease (n = 225)	Overall (n = 971)	p value†
CD grade IIIa-V	184 (24.7)	74 (32.9)	258 (26.6)	0.014
30-day mortality	13 (1.7)	5 (2.2)	18 (1.9)	0.640
90-day mortality	22 (3.0)	13 (5.8)	35 (3.6)	0.046
Median survival (months)[a]	31.6 (10.5–52.7)	21.8 (5.7–37.9)	28.7 (8.2–49.2)	<0.001‡
1-year survival	615 of 746 (82.4)	172 of 225 (76.4)	787 of 971 (81.1)	0.044
3-year survival	325 of 601 (54.1)	69 of 186 (37.1)	394 of 787 (50.1)	<0.001
5-year survival	175 of 431 (40.6)	38 of 148 (25.7)	213 of 579 (36.8)	<0.01
Days of hospital stay[a]	11 (7–15)	14 (8–20)	12 (8–16)	<0.001‡
Days in hospital				<0.001
1–13 days	470 (63.0)	111 (49.3)	581 (59.8)	
≥14 days	276 (37.0)	114 (50.7)	390 (40.2)	
ICU admission	35 (4.7)	32 (14.2)	67 (6.9)	<0.001
Days of ICU stay[a]	5 (0–10)	5.5 (1–10)	5 (0–10)	0.875‡
Days in ICU				<0.001
0 days	711 (95.3)	193 (85.8)	904 (93.1)	
1–6 days	21 (2.8)	19 (8.4)	40 (4.1)	
7–13 days	6 (0.8)	6 (2.7)	12 (1.2)	
≥14 days	8 (1.1)	7 (3.1)	15 (1.5)	
DGE grade B–C	210 (28.2)	87 (38.7)	297 (30.6)	0.003
POPF grade B–C	126 (16.9)	48 (21.3)	174 (17.9)	0.128
PPH grade B–C	81 (10.9)	35 (15.6)	116 (12.0)	0.057
Bile leakage grade B–C	24 (3.2)	11 (4.9)	35 (3.6)	0.238

CD, Clavien–Dindo; ICU, intensive care unit; DGE, delayed gastric emptying, POPF, postoperative pancreatic fistula; PPH, post pancreatectomy haemorrhage. Values in parenthesis are percentages unless indicated otherwise. †χ^2 test, except ‡Student's *t* test.
[a] Values are median (interquartile range).

Table 3 Multivariable logistic regressions for postoperative complications according to categories of heart disease at baseline

	Heart disease	Atrial fibrillation	Ischaemic heart disease	Heart failure	Valvular heart disease
	Odds ratio	Odds ratio	Odds ratio	Odds ratio	Odds ratio
CD grade IIIa-V	1.53 (1.07–2.18)	1.53 (1.00–2.32)	1.55 (0.97–2.46)	2.25 (1.25–4.02)	0.84 (0.33–2.15)
30-day mortality	0.87 (0.28–2.68)	1.33 (0.40–4.42)	0.79 (0.17–3.72)	1.44 (0.30–6.79)	1
90-day mortality	1.62 (0.75–3.49)	1.36 (0.55–3.33)	1.37 (0.52–3.62)	1.23 (0.35–4.29)	2.00 (0.44–8.98)
ICU admission	3.19 (1.81–5.63)	2.44 (1.32–4.53)	2.55 (1.31–5.00)	3.02 (1.39–6.55)	1.09 (0.25–4.77)
Hospital stay ≥ 14 days	1.65 (1.19–2.28)	1.70 (1.15–2.53)	1.08 (0.70–1.67)	1.92 (1.08–3.42)	1.09 (0.49–2.44)
DGE grade B–C	1.45 (1.03–2.04)	1.33 (0.88–2.00)	1.42 (0.91–2.22)	1.79 (1.00–3.18)	0.98 (0.41–2.32)
POPF grade B–C	1.27 (0.84–1.94)	1.44 (0.89–2.34)	0.67 (0.35–1.25)	0.81 (0.37–1.77)	0.37 (0.08–1.62)
PPH grade B–C	1.56 (0.97–2.52)	1.59 (0.91–2.76)	1.71 (0.95–3.08)	1.29 (0.58–2.89)	1.39 (0.46–4.18)
Bile leakage grade B–C	1.70 (0.75–3.86)	1.81 (0.72–4.51)	0.24 (0.03–1.82)	1.71 (0.48–6.07)	1.16 (0.15–8.98)

CD, Clavien–Dindo; ICU, intensive care unit; DGE, delayed gastric emptying, POPF, postoperative pancreatic fistula; PPH, post pancreatectomy haemorrhage. Values in parenthesis are 95 per cent confidence interval. The following covariates were included in the multivariable logistic regression models: age, sex, BMI, eGFR, diabetes mellitus, hypertension, smoking status, pulmonary disease.

To the best of our knowledge there are no reports describing the association between preoperative heart disease and the risk for delayed gastric emptying after pancreatic surgery. Postoperative atrial fibrillation, however, has been found to be a risk factor for delayed gastric emptying after pancreatoduodenectomy.[29] Moreover, age has been identified as a risk factor for

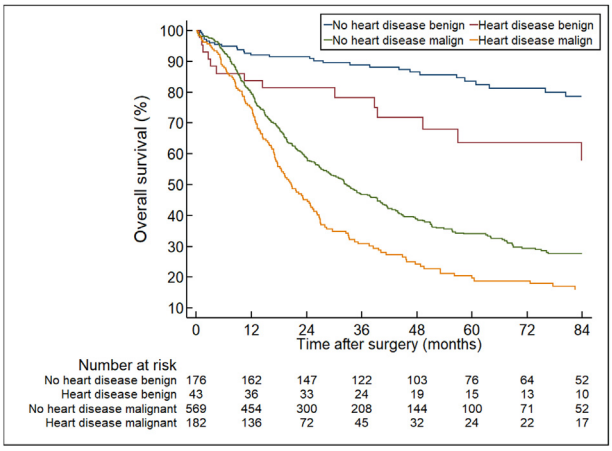

Figure 2 Kaplan–Meier overall survival curves in patients undergoing pancreatoduodenectomy, stratified by presence of heart disease. $p < 0.001$ (log rank test) when comparing groups with malignant histology; $p = 0.001$ (log rank test) when comparing groups with benign histology

delayed gastric emptying after pancreatic surgery.[2,10] However, the mechanism between age and delayed gastric emptying is not fully understood: whether age itself or diseases associated with ageing are responsible for this association remains unclear. Here, we report an association between heart disease – a major disease group of ageing – and postoperative delayed gastric emptying.

We found that heart disease was associated with an increased risk for long-term all-cause postoperative mortality after pancreatoduodenectomy, whereas no such association with short-term mortality was detected. The long-term survival among patients with malignant histology should, however, be interpreted with caution as there was no data on the tumour stage nor administration of adjuvant chemotherapy. However, there was no difference in the prevalence of malignant diagnosis between patients with or without heart disease, and the proportion of patients surviving with a malignant diagnosis decreased at equal rates in these two groups during follow-up. These findings imply that with modern perioperative treatment and postoperative surveillance, patients with and without heart disease have similar risks for short-term complications. However, over time, patients with heart disease have an increased risk for overall mortality. This indicates that heart disease and its management might indeed constitute an important competing long-term mortality risk among patients who undergo pancreatoduodenectomy. These results suggest that optimized post-operative management of heart disease may offer an additional avenue towards clinical benefit, possibly even survival.

This study has several limitations. As with all retrospective cohort analyses, residual confounding may exist. A further limitation was the lack of information on subjects who were excluded from surgery, and the unknown prevalence of heart disease among these patients. Also, *de novo* cases of heart disease, such as atrial fibrillation occurring post-operatively were not studied. Categorization of heart disease was based on previous diagnostic work up and coding. However, a thorough validation of diagnostic coding was conducted through systematic, case by case review of the patients' electronic health records, including evaluation of discharge notes, office visits, diagnostic or multidisciplinary meetings, echocardiography and radiology reports, notes from procedures, and laboratory/biochemical data. The data collection and review of heart disease variables were conducted by two of the investigators in order to minimize the risk of systematic sampling error in the collection.

The frequent use of pre-operative echocardiography, and the relatively low prevalence of reduced left ventricular ejection fraction among operated patients with heart disease, point towards a negative selection of more severe forms of left ventricular dysfunction. It is thus likely, that among patients with heart disease only those with higher physiological performance status underwent surgery. In the light of our main findings that atrial fibrillation and heart failure significantly contribute to post-operative complications, this further underlines the importance of a thorough preoperative cardiac assessment, and optimized post-operative care, regardless of surgical indication.

Conclusions

In the present study we report that atrial fibrillation and heart failure are each independently associated with an increased risk for early postoperative complications after pancreatoduodenectomy, whereas ischaemic heart disease and valve disease are not. Furthermore, heart disease was associated with significantly worse long-term survival, independent of the underlying histopathology, and thus may constitute an important competing mortality risk among patients who undergo pancreatoduodenectomy.

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Declaration of interests

He authors declare no conflict of interest.

References

1. McGuigan A, Kelly P, Turkington RC, Jones C, Coleman HG, McCain RS. (2018) Pancreatic cancer: a review of clinical diagnosis, epidemiology, treatment and outcomes. *World J Gastroenterol* 24: 4846–4861.
2. Hartwig W, Hackert T, Hinz U, Gluth A, Bergmann F, Strobel O *et al*. (2011) Pancreatic cancer surgery in the new millennium: better prediction of outcome. *Ann Surg* 254:311–319.
3. Swanson RS, Pezzi CM, Mallin K, Loomis AM, Winchester DP. (2014) The 90-day mortality after pancreatectomy for cancer is double the 30-day mortality: more than 20,000 resections from the national cancer data base. *Ann Surg Oncol* 21:4059–4067.
4. Shia BC, Qin L, Lin KC, Fang CY, Tsai LL, Kao YW *et al*. (2020) Age comorbidity scores as risk factors for 90-day mortality in patients with a

pancreatic head adenocarcinoma receiving a pancreaticoduodenectomy: a National Population-Based Study. *Cancer Med* 9:562–574.
5. Strobel O, Neoptolemos J, Jäger D, Büchler MW. (2019) Optimizing the outcomes of pancreatic cancer surgery. *Nat Rev Clin Oncol* 16:11–26.
6. Luberice K, Downs D, Sadowitz B, Ross S, Rosemurgy A. (2017) Has survival improved following resection for pancreatic adenocarcinoma? *Am J Surg* 214:341–346.
7. Mohammed S, Van Buren G, Fisher WE. (2014) Pancreatic cancer: advances in treatment. *World J Gastroenterol* 20:9354–9360.
8. Tateosian VS, Richman DC. (2018) Preoperative cardiac evaluation for noncardiac surgery. *Anesthesiol Clin* 36:509–521.
9. Ronnekleiv-Kelly SM, Greenblatt DY, Lin CP, Kelly KJ, Cho CS, Winslow ER *et al*. (2014) Impact of cardiac comorbidity on early outcomes after pancreatic resection. *J Gastrointest Surg* 18:512–522.
10. Casadei R, Ricci C, Lazzarini E, Taffurelli G, D'Ambra M, Mastroroberto M *et al*. (2014) Pancreatic resection in patients 80 years or older: a meta-analysis and systematic review. *Pancreas* 43: 1208–1218.
11. Greenblatt DY, Kelly KJ, Rajamanickam V, Wan Y, Hanson T, Rettammel R *et al*. (2011) Preoperative factors predict perioperative morbidity and mortality after pancreaticoduodenectomy. *Ann Surg Oncol* 18:2126–2135.
12. Charlson ME, Pompei P, Ales KL, MacKenzie CR. (1987) A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 40:373–383.
13. Asano T, Yamada S, Fujii T, Yabusaki N, Nakayama G, Sugimoto H *et al*. (2017) The Charlson age comorbidity index predicts prognosis in patients with resected pancreatic cancer. *Int J Surg* 39:169–175.
14. Hill JS, Zhou Z, Simons JP, Ng SC, McDade TP, Whalen GF *et al*. (2010) A simple risk score to predict in-hospital mortality after pancreatic resection for cancer. *Ann Surg Oncol* 17:1802–1807.
15. Shah R, Velanovich V, Syed Z, Swartz A, Rubinfeld I. (2012) Limitations of patient-associated co-morbidity model in predicting postoperative morbidity and mortality in pancreatic operations. *J Gastrointest Surg* 16: 986–992.
16. Joliat GR, Petermann D, Demartines N, Schäfer M. (2015) External assessment of the early mortality risk score in patients with adenocarcinoma undergoing pancreaticoduodenectomy. *HPB* 17:605–610.
17. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP *et al*. (2007) The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Lancet* 370:1453–1457.
18. Hurwitz EE, Simon M, Vinta SR, Zehm CF, Shabot SM, Minhajuddin A *et al*. (2017) Adding examples to the ASA-physical status classification improves correct assignment to patients. *Anesthesiology* 126:614–622.
19. Kelly CM, Shahrokni A. (2016) Moving beyond Karnofsky and ECOG performance status assessments with new technologies. *J Oncol* 2016: 6186543.
20. Brämer GR. (1988) International statistical classification of diseases and related health problems. Tenth revision *World Health Stat Q* 41:32–36.
21. Dindo D, Demartines N, Clavien PA. (2004) Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 240:205–213.
22. Bassi C, Marchegiani G, Dervenis C, Sarr M, Abu Hilal M, Adham M *et al*. (2017) The 2016 update of the International Study Group (ISGPS) definition and grading of postoperative pancreatic fistula: 11 years after. *Surgery* 161:584–591.
23. Wente MN, Veit JA, Bassi C, Dervenis C, Fingerhut A, Gouma DJ *et al*. (2007) Postpancreatectomy hemorrhage (PPH): an international study group of pancreatic surgery (ISGPS) definition. *Surgery* 142:20–25.
24. Wente MN, Bassi C, Dervenis C, Fingerhut A, Gouma DJ, Izbicki JR *et al*. (2007) Delayed gastric emptying (DGE) after pancreatic surgery: a suggested definition by the International Study Group of Pancreatic Surgery (ISGPS). *Surgery* 142:761–768.
25. Shukla PJ, Barreto SG, Fingerhut A, Bassi C, Büchler MW, Dervenis C *et al*. (2010) Toward improving uniformity and standardization in the reporting of pancreatic anastomoses: a new classification system by the International Study Group of Pancreatic Surgery (ISGPS). *Surgery* 147:144–153.
26. Dias-Santos D, Ferrone CR, Zheng H, Lillemoe KD, Fernández-Del Castillo C. (2015) The Charlson age comorbidity index predicts early mortality after surgery for pancreatic cancer. *Surgery* 157:881–887.
27. Wang M, Yang YF, Guo BD, Hou HM, Meng LF, Wang X *et al*. (2020) The impact of atrial fibrillation on outcomes in patients undergoing radical prostatectomy. *World J Urol* 39:1509–1519.
28. Vannucci A, Rathor R, Vachharajani N, Chapman W, Kangrga I. (2014) Atrial fibrillation in patients undergoing liver transplantation-a single-center experience. *Transplant Proc* 46:1432–1437.
29. Botwinick IC, Shonkwiler RJ, Steele J, Yu G, Chabot JA. (2011) Atrial fibrillation and delayed gastric emptying. *PLoS One* 6e25499.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.hpb.2022.07.002.

