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ORIGINAL ARTICLE

Long-term survival following radical surgery for pancreatic adenocarcinoma in a high-complexity Latin American center

Supervivencia a largo plazo tras cirugía radical por adenocarcinoma pancreático en un centro de alta complejidad en América Latina

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Abstract

Introduction. Pancreatic cancer remains one of the deadliest malignancies worldwide, with limited long-term survival. Surgical resection continues to be the primary curative option for pancreatic adenocarcinoma. This study aimed to assess intraoperative and postoperative associated with long-term survival following radical pancreatic cancer surgery.

Methods. A single-center cohort survival analysis was conducted including patients who underwent radical surgery for pancreatic adenocarcinoma between 2006 and 2019 at a high-complexity institution. Factors such as factors type of surgery, operative time, intraoperative blood loss, macroscopic pancreatic features, histopathological findings, and postoperative complications were included.

Results. A total of 118 pancreatic adenocarcinoma resections were analyzed. Thirty-day mortality was 4.2%, occurring exclusively in the Whipple group. Actuarial survival reached 10.6%, while at 1-year and 5-year survival rates were 67.8% and 12.1%, respectively. Survival was negatively affected by lymphovascular invasion (HR 1.52; 95% CI 1.009–2.314), positive resection margins (HR 1.73; 95% CI 1.091–2.773), lymph-node resection ratio ≥0.3 (HR 1.52; 95% CI 1.656–4.823), preoperative CA 19–9 ≥ 400 U/ml (HR 1.52; 95% CI 1.007–2.372), and transfusion requirements (HR 1.52; 95% CI 1.097–2.825).

Conclusion. The long-term survival after radical surgery for pancreatic adenocarcinoma is influenced by several modifiable factors.

Keywords: pancreatic neoplasms; pancreatectomy; pancreaticoduodenectomy; survival; mortality; risk factors.

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Resumen

Introducción. El cáncer de páncreas continúa siendo una de las neoplasias más letales a nivel mundial, con una supervivencia a largo plazo muy limitada. La resección quirúrgica sigue siendo la principal opción curativa para el adenocarcinoma pancreático. Este estudio tuvo como objetivo evaluar factores intraoperatorios y postoperatorios asociados con la supervivencia a largo plazo después de la cirugía radical por cáncer de páncreas.

Métodos. Se realizó un análisis de supervivencia de una cohorte de pacientes sometidos a cirugía radical por adenocarcinoma pancreático, en una institución de alta complejidad entre 2006 y 2019. Se incluyeron factores como tipo de cirugía, tiempo quirúrgico, sangrado intraoperatorio, características macroscópicas pancreáticas, hallazgos histopatológicos y complicaciones postoperatorias.

Resultados. Se analizaron 118 resecciones por adenocarcinoma pancreático. La mortalidad a 30 días fue 4,2 %, presentándose exclusivamente en el grupo sometido a procedimiento tipo Whipple. La supervivencia actuarial fue 10,6 %, mientras que la supervivencia a 1 y 5 años fue 67,8 % y 12,1 %, respectivamente. La supervivencia se vio afectada negativamente por la invasión linfovascular (HR 1,52; $IC_{95\%}$ 1,009–2,314), los márgenes quirúrgicos positivos (HR 1,73; $IC_{95\%}$ 1,091–2,773), un índice de ganglios resecados ≥0,3 (HR 1,52; $IC_{95\%}$ 1,656–4,823), niveles preoperatorios de CA 19–9 ≥400 U/ml (HR 1,52; $IC_{95\%}$ 1,007–2,372) y el requerimiento de transfusión (HR 1,52; $IC_{95\%}$ 1,097–2,825).

Conclusión. La supervivencia a largo plazo después de la cirugía radical por adenocarcinoma pancreático está influenciada por varios factores modificables.

Palabras clave: neoplasias pancreáticas; pancreatectomía; pancreaticoduodenectomía; sobrevida; mortalidad; factores de riesgo.

Introduction

Pancreatic cancer remains among the most lethal malignancies, consistently showing high global mortality [1]. Current estimates indicate a 5-year survival close to 10%, placing it as a major contributor to cancer-related deaths worldwide [2]. Its incidence has steadily increased, partly due to population aging and lifestyle-associated risks.

In the United States, the annual incidence is approximately 12.5 cases per 100,000 inhabitants [3–5]. In Colombia, pancreatic cancer ranked as the sixth leading cause of cancer mortality in 2020. Because symptoms usually develop late and the disease often progresses silently [6], fewer than 20% of patients are eligible for resection at the time of diagnosis [7–9], and nearly 28% already exhibit distant metastases even when tumors measure under 1 cm [10].

Despite advances in systemic therapy, surgical resection—either pancreatoduodenectomy or distal pancreatectomy—remains the cornerstone of curative treatment for pancreatic adenocarcinoma [2,11–14]. These procedures carry substantial morbidity, commonly related to pancreatic anastomotic failure, postoperative bleeding, delayed gastric emptying, and infection [2,15,16]. Nevertheless, outcomes have improved in high-volume centers, where accumulated expertise and multidisciplinary care have reduced in-hospital mortality to below 5%, compared to figures approaching 20% in the 1990s [6,17].

In Colombia, limited research has examined long-term survival and outcomes following radical pancreatic cancer surgery. Prior studies have identified intra- and postoperative prognostic factors, with some reporting 80-month survival around 30% [16]. Surgical volume and technical standardization appear to have a major impact on outcomes [6]. Additional evaluation is therefore essential to better identify early-stage patients and improve long-term survival.

Methods

Population and type of study

We conducted a single-center cohort study evaluating survival among patients who underwent open radical surgery for pancreatic cancer between 2006 and 2019 at a high-complexity institution in Medellín, Colombia.

Variables

Clinical information was obtained from secondary data extracted from medical records. Type of leak (pancreatic leak type A, B or C according to the 2016 update of the international study group definition and grading of postoperative pancreatic fistula) [18], as well bile leak and intestinal anastomotic leak was included. Survival was calculated from the date of surgery to the most recent follow-up visit with the institution's hepatobiliary surgery team. When this information could not be retrieved, patients or families were contacted by phone. Individuals for whom no follow-up data could be obtained were excluded.

Data analysis

Data were prospectively entered into a database maintained by the hepatobiliary surgery service. Statistical analyses were performed using SPSS Statistics 20. Categorical variables were reported as absolute and relative frequencies, and continuous variables as measures of central tendency and dispersion. The Kolmogorov–Smirnov test was applied to assess normality. Survival analysis was conducted using the Kaplan–Meier method, and comparisons between groups were performed using the log-rank test and Cox regression modeling. Adjusted hazard ratios (HR) were used to estimate associations.

Results

Cohort summary

A total of 420 pancreatic resections were performed, and 118 patients underwent open radical surgery for pancreatic adenocarcinoma. The median age was 64 years (interquartile range [IQR] 55 to 69 years), and half of the patients were men. Whipple surgery was performed on 77% (n=91) of the patients, 17% (n=21) underwent distal pancreatectomy, and 6% (n=6) underwent total pancreatoduodenectomy. The overall mortality at 30 days postoperatively was 4.2%, and all the mortalities occurred in the Whipple group (the mortality was 5.6% for this subgroup), as shown in table 1. The median hospital stay was 8 days (IQR 6–16 days) for all patients. The median hospital stay in the Intensive Care Unit (ICU) and Special Care Unit (SCU) was 1 day (IQR 1–2 days).

The most common symptoms were abdominal pain (73.5%), weight loss (72%), and jaundice (65%). Only 18.6% of the patients had a presurgical biopsy (mostly done by endoscopic retrograde cholangiopancreatography, ERCP), and of these, 59% of the cases were consistent with the definitive pathology. As a diagnostic imaging tool, 75.4% had magnetic resonance imaging (MRI) of the abdomen, 52.5% had contrast-enhanced computed tomography (CT), 28.8% had ERCP, and 11% had echoendoscopy. Pre-surgical tumor markers were routinely measured, and the median CA 19–9 level was 138 U/ml (IQR 20–926 U/ml), while the median carcinoembryonic antigen (ACE) level was 4.0 µg/L (IQR 2–22 µg/L).

Table 1. Patient characteristics (n=118)

Variable	Freq.	%
Median age (years) IQR	64 55–69	
Men Women	58 60	49.2 50.8
Whipple Distal resection Total pancreatectomy	91 21 6	77.2 17.7 5.1
Median intraoperative bleeding (ml) IQR	200 100–400	
Total cohort postoperative mortality Whipple postoperative mortality	5 5	4.2 5.6

* IQR: Interquartile range.

Source: The authors.

Intraoperative data

The median surgical time was 240 minutes (IQR 210–360 minutes). The median intraoperative bleeding was 200 ml (IQR 100–400 ml); 20% of the cases required transfusion, while only 4.6% needed four or more units of red blood cells. Furthermore, 17.8% of all patients required vascular resection (mostly in cases of Whipple surgery). The pancreas consistency was soft in 37.6% of the cases (53.3% in the Whipple group), and the median Wirsung diameter was 3.0 mm (IQR 2.0–4.0 mm) in the Whipple group.

Surgical pathology

Regarding histological differentiation of the tumors, almost half of the patients had a moderately differentiated pancreatic carcinoma (48.3%), 28% well differentiated, and 23.7% poorly differentiated. A median of 15 lymph nodes (IQR 10–22) were resected, and a positive result was found in 72% of cases. Lymphovascular involvement occurred in 56% of the tumors, and 88% had neuronal involvement. The average size of the tumor was 29.7 mm, 78% of the patients obtained negative margins in the resection, and 22% had R1 resections with positive microscopic margins.

Postoperative complications

Reoperation was performed on 22% of the patients in the first 30 days postoperatively, which was mostly due to pancreato-jejunal anastomosis leak. Some types of leakage occurred in 33% of all patients, of which 23% were due to pancreatic leak (5.9% type A, 10.2% type B, and 6.8% type C), 8.4% involved bile leak, and 2.5% involved intestinal anastomotic leak. Major postoperative type B and C bleeding occurred in 11.9%, 22.9% presented superficial and deep surgical site infection, and 18.6% had organ-space surgical site infection. Delayed gastric emptying occurred in 9.2%, 11% had distant associated infections, 15.2% had sepsis, 11.9% had postoperative ileus, and 5.9% had vascular thrombosis. Postoperative measurement of drain amylase levels was routinely performed for all patients who underwent Whipple surgery. The average was 1164 mg/dl on the first day, 832 mg/dl on the second day, 626 mg/dl on the third day, 285 mg/dl on the fourth day, and 712 mg/dl on the fifth day.

Survival

The actuarial survival of the cohort was 10.6%. Survival at 1 and 5 years was 67.8% and 12.1%, respectively, and there was no statistically significant difference between different types of resections (Figure 1).

The mean survival time was 32 ± 3.8 months. Among patients with poorly and moderately differentiated adenocarcinomas, 85.9% died, whereas 63.6% of patients with well-differentiated tumors died. However, the median difference in survival time was not statistically significant (16 months (IQR 14–18 months) vs. 23 months (IQR 12–33 months), respectively (p=0.09).

Patients with negative margins had a mean survival time of 30.6 ± 3 months, while it was 22 ± 7 months for those with microscopic compromise (R1 margins) (p=0.01). No patient had macroscopic involvement (R2 margins). Regarding lymph node resection, an index greater than 0.3 was associated with a mean survival time of 12 ± 1.5 months compared to 36 ± 4.4 months for those with a lower index (p=0.000). The mean survival time was of 33 ± 5 months for patients without lymphovascular involvement and 26 ± 5 months (p=0.04) for those who did have involvement. No statistically significant association was found between perineural involvement, tumor size, reoperation, age, and survival. On the other hand, patients who received a transfusion had a lower mean survival time of 16 ± 3 months compared to those without a transfusion (35 ± 4.5 months; p=0.17), as shown in table 2.

To evaluate the experience of the surgical group, a survival analysis was performed in two time periods: before and after 2013. The results showed no statistically significant differences. Patients with preoperative CA 19–9 values less than or equal to 400 U/ml had a greater mean survival time of 35.9 ± 5 months compared to those

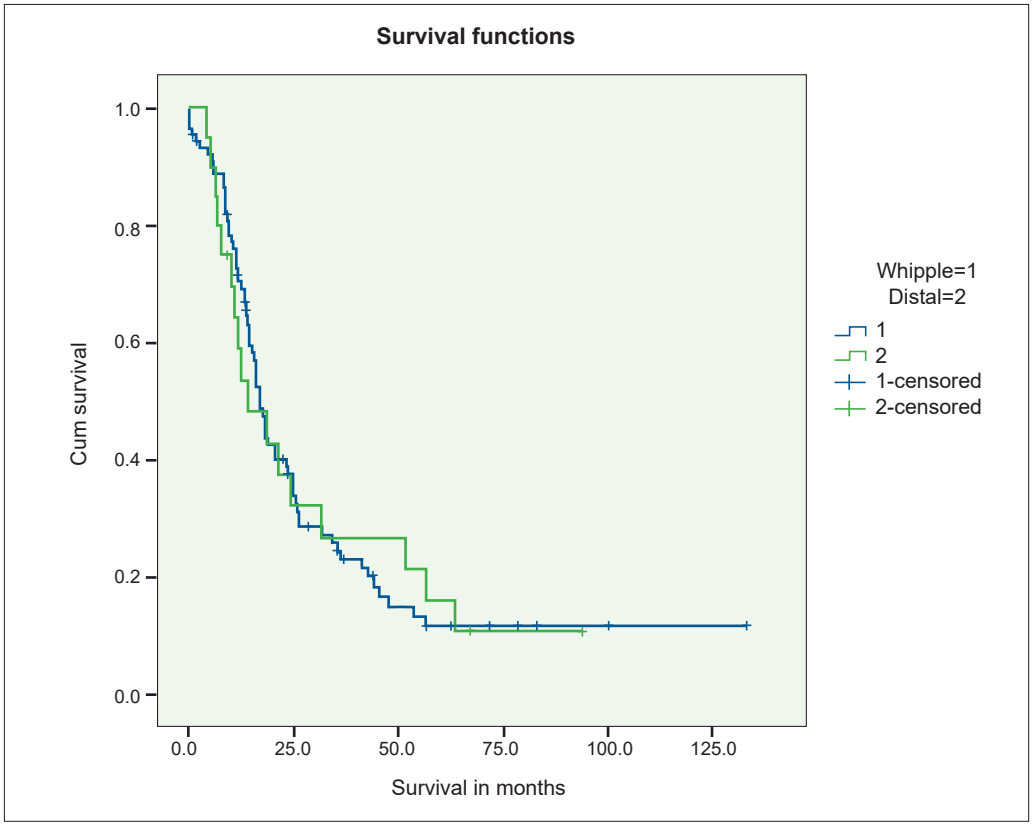

Figure 1. Kaplan–Meier curves for survival of Whipple vs. distal pancreatectomy groups.
Source: The authors.

Table 2. Statistically significant variables in bivariate analysis.

Variable	Mean survival in months	p-value
Lymphovascular involvement		
Positive	26	0.04
Negative	33	
Microscopic tumor margins		
Positive R1	22	0.018
Negative R0	30	
Lymph-node resection index*		
> 0.3	12	< 0.001
≤ 0.3	35	
CA 19-9		
≥ 400 U/ml	21	0.04
< 400 U/ml	35	
Transfusion		
Yes	16	0.01
No	35	

*Positive lymph nodes/resected lymph nodes.
** CA: Carbohydrate antigen.
Source: The authors.

with higher levels (21 ± 4 months; p=0.04). ACE levels with cutoff points of 10 and 20 µg/L did not significantly influence survival, although there was a tendency toward a greater mean survival for those with lower ACE levels. Patients who did not present any type of leak had a higher mean survival of 39 ± 6 months compared to those who did develop this complication (23 ± 3 months; p=0.00). No statistically significant difference was found in survival with respect to the degree of pancreatic leakage (p>0.05).

The risk of death increased by 52% and 73% when there was lymphovascular involvement and positive margins (R1) compared to those without these conditions (p= 0.04, 95% CI 1.009–2.314; p=0.02, CI 1.091–2.773, respectively). Additionally, the risk of death increased by 182%, 54%, and 76% in cases with lymph-node resection indices greater than 0.3, CA 19–9 levels ≥ 400 U/ml, and transfusion requirements, respectively (p=0.00,

95% CI 1.656 -4.823; p=0.04, 95% CI 1.007–2.372; p=0.01, 95% CI 1.097–2.825). When adjusting these values for confounding variables, only the result for lymph node resection indices greater than or equal to 0.3 persisted and raised the risk of death by 100% (p=0.02, 95% CI 1.092–3.663). The other variables lost their statistical significance.

Discussion

Management of pancreatic cancer and its demanding surgical procedures continues to pose significant challenges, given the high morbidity and mortality historically associated with this disease. Previous studies have documented 5-year survival rates ranging from 6% to 10% [4,6,14,19], comparable to the 10.6% actuarial and 12.1% 5-year survival observed in our cohort. These results may partly reflect the consistency of care provided by an experienced surgical team within a high-complexity center.

Institutional expertise may also explain the reduced stays in high-dependency units, the strong adherence to preoperative imaging and laboratory protocols, and the notable proportion of R0 resections. Survival did not significantly differ by type of resection, suggesting that tumor biology—rather than surgical technique alone—may play a predominant role. Postoperative mortality of 4.2% aligns with reports from other specialized centers [6,19].

Given the aggressive nature of pancreatic adenocarcinoma, identifying prognostic factors that influence survival is essential. Severe postoperative complications may lead to prolonged immunosuppression, favoring tumor progression according to prior evidence [14,20]. In our study, 22% of patients required reoperation, mainly for pancreatic leaks, hemorrhage, or abscesses—rates comparable with other high-volume institutions [4,14].

Several variables were associated with decreased survival: lymphovascular invasion, positive margins, lymph node resection ratio ≥0.3, transfusion requirement, and preoperative CA 19–9 ≥400 U/ml, in accordance with earlier findings [6,13,15]. After adjustment for confounders, only the lymph node resection ratio remained statistically significant, likely due to sample-size constraints. Although histological differentiation did not reach significance, patients with well-differentiated tumors demonstrated a trend toward longer survival, consistent with prior literature [6,21].

This study has limitations, including its single-center design, relatively small cohort, and retrospective nature, factors that may limit generalizability and produce potential biases. Nevertheless, the findings contribute valuable insight into determinants of long-term survival following radical pancreatic surgery.

Conclusion

Long-term survival after radical resection for pancreatic adenocarcinoma is negatively influenced by lymphovascular invasion, positive margins, lymph node ratio, elevated tumor markers, and transfusion requirements. Given the persistent postoperative morbidity and mortality associated with this disease, continued refinement of surgical strategies and systemic therapies is essential to improve oncologic outcomes.

Compliance with ethical standards

Informed consent: This study was classified as risk-free since it was a retrospective analysis. All procedures adhered to the ethical standards of the national and institutional committees responsible for human experimentation (Resolution 008430 of 1993 issued by the Colombian Ministry of Health).

Conflicts of Interest: The authors declare that they have no conflicts of interest.

Use of Artificial Intelligence: The authors declare that no artificial intelligence–assisted technologies were used during the development of the project.

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Author's contributions:

- Study design and conception: Sergio Hoyos.
- Data acquisition: Sergio Hoyos, Natalia Guzmán-Arango, Romario Chanci-Drago, Santiago Salazar-Ochoa, Álvaro Andrés Duarte, Jaime Chávez.

- Data analysis and interpretation: Sergio Hoyos, Natalia Guzmán-Arango, Romario Chanci-Drago.
- Manuscript drafting: Sergio Hoyos, Natalia Guzmán-Arango, Romario Chanci-Drago.
- Critical review and final approval: Sergio Hoyos, Natalia Guzmán-Arango, Romario Chanci-Drago.

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