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ORIGINAL ARTICLE

Volume–outcome relationships in pancreatoduodenectomy for cancer

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Abstract

Background: Volume–outcome relationships in pancreatic surgery are well established, but an optimal volume remains to be determined. Studies analyzing outcomes in volume categories exceeding 20 procedures annually are lacking.

Study design: A consecutive 3420 patients underwent PD for primary pancreatic or periampullary carcinoma (2005–2013) and were registered in the Netherlands Cancer Registry. Relationships between hospital volume (<5, 5–19, 20–39 and ≥40 PDs/year) and mortality and survival were explored.

Results: There was a non-significant decrease in 90-day mortality from 8.1 to 6.7% during the study period (p = 0.23). Ninety-day mortality was 9.7% in centers performing <5 PDs/year (n = 185 patients), 8.9% for 5–19 PDs/year (n = 1432), 7.3% for 20–39 PDs/year (n = 240) and 4.3% for ≥40 PDs/year (n = 562, p = 0.004). Within volume categories, 90-day mortality did not change over time. After adjustment for confounding factors, significantly lower mortality was found in the ≥40 category compared to 20–39 PDs/year (OR = 1.72 (1.08–2.74)). Overall survival adjusted for confounding factors was better in the ≥40 category compared to categories under 20 PDs/year: HR (≥40 vs 5–19/year) = 1.24 (1.09–1.42). In the ≥40 category significantly more patients received adjuvant chemotherapy and had >10 lymph nodes retrieved compared to lower volume categories.

Conclusions: Volume–outcome relationships in pancreatic surgery persist in centers performing ≥40 PDs annually, regarding both mortality and survival. The volume plateau for pancreatic surgery has yet to be determined.

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Introduction

Pancreatic carcinoma affects 10 per 100,000 persons annually.[1] Resection offers the only chance for cure in patients with pancreatic or periampullary (duodenum, ampulla, distal bile duct) carcinoma. Pancreatic surgery is traditionally regarded as low-volume, high-complex surgery. Many studies have clearly demonstrated improved postoperative outcomes following pancreatoduodenectomy (PD) in centers with higher procedural volumes compared to low volume hospitals. However, most studies examine volume–outcome relationships up to more than

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20 procedures per year, and an optimal volume cut-off level is currently unknown.[2–5]

Over the past decade, centralization of pancreatic surgery has occurred in The Netherlands which was accompanied by improved postoperative and long-term survival.[6–9] Nationwide minimum volumes have been set for various procedures and are reviewed periodically. For PD, in 2011 the Dutch Society for Surgery has set a minimum volume level of 20 procedures per center annually.[10] The question was raised whether further increasing the volume cut-off for PD from 20 to 40 could further improve outcomes. The aim of this study was to examine postoperative mortality and long-term survival in patients who underwent PD for primary pancreatic or periampullary malignancy in The Netherlands with hospital volume categories higher than previously examined.

Methods

Patient selection

This study was approved by the review board of the Netherlands Comprehensive Cancer Organization (IKNL), which was established to protect the privacy rights of patients and hospitals in the Netherlands Cancer Registry (NCR). Newly diagnosed malignancies in The Netherlands are registered in the population-based NCR, covering 17 million inhabitants. Completeness is estimated to be at least 95%. Topography and morphology are coded according to the international Classification of Diseases for Oncology (ICD-O).[11] The tumor – lymph node – metastasis (TNM) classification was used to record tumor stage at diagnosis.[12] Survival data was obtained from the Municipal Personal Records Database.

All patients who underwent a PD (either pylorus-preserving or Whipple-Kausch) for primary pancreatic (C25), ampulla of Vater (C24.1), extrahepatic bile duct (C24.0) or duodenal (C17.0) adenocarcinoma between 2005 and 2013 were selected from the NCR. Patients residing or resected abroad, other (pancreatic) resections and age under 18 years old were excluded. Tumor location was categorized as pancreas or periampullary (ampulla, distal bile duct and duodenum). Tumor stage (TNM 6th (2005–2009) and 7th (2010–2013) edition) was based on pathological TNM. Socioeconomic status (SES) was based on The Netherlands Institute for Social Research and deciles were collapsed into three categories (high: 1st–3rd, intermediate: 4th–7th, low: 8th–10th deciles).

Hospital volume and outcome measures

Hospital volume was categorized as <5, 5–19, 20–39 and ≥40 PDs per year. The highest volume category was based on doubling of the current volume cut-off of 20 PDs per year.[6,9] Hospital volume classification was based on the number of PDs for primary malignancies. The volume category per hospital was calculated for each years separately. For each hospital, the volume category could vary per year. To account for late fatal outcomes of postoperative complications, postoperative mortality was defined as death from any cause within 90 days postoperatively. Patients with metastatic disease undergoing PD (n = 61) were excluded from the analysis of survival. Overall survival (OS) was defined as the time between PD and death. Patients alive after December 31st, 2014 were censored. To minimize the influence of postoperative mortality on results of long-term survival, patients alive at 90 days postoperatively were included in the analysis of conditional survival (CS).

Statistical analysis

Baseline patient characteristics (gender, age, prior cancer, SES), tumor characteristics (location, stage, grade) and treatment characteristics (margin status, lymph nodes, chemotherapy) were compared between hospital volume categories using Pearson's chi-square tests. A p-value <0.05 was considered statistically significant. The chi-square test was used to investigate the association between hospital volume and postoperative outcomes. Univariable and multivariable logistic regression analyses were performed to investigate hospital volume and the influence of patient and tumor characteristics on 90-day postoperative mortality. Supplementary multilevel analysis did not reveal relevant clustering within hospitals (likelihood ratio test, $p = 0.14$) and was discarded. Cox proportional hazard regression analysis was used to evaluate the relation between hospital volume and (conditional) survival. Characteristics with a $p < 0.10$ in univariable analysis were entered into multivariable models, as well as period of surgery to adjust for possible time effects of (high) hospital volumes. Hospital volume was entered in all models. Analyses were performed using STATA/SE (version 13.0; STATA Corp., College Station, Texas, USA).

Results

Patient and hospital characteristics

In total 3420 patients were included. The nationwide total volume of PDs for primary pancreatic or periampullary carcinoma doubled from 270 patients in 2005 to 538 patients in 2013. Between 2005 and 2013, an increase was found in the proportion of patients receiving PD aged 65 years or older (from 54 to 64%, $p = 0.003$) and the proportion of stage II pancreatic carcinoma (T3 or N1, 66–73%, $p < 0.001$). Patient and hospital characteristics are shown in Table 1. Patients in high volume centers more often had high SES (37 vs 24–30%, $p = 0.002$). In the lowest volume category the tumor was more often located in the periampullary region (50 vs 40–44%, $p = 0.012$).

Between 2005 and 2013, the number of hospitals performing PD for pancreatic or periampullary carcinoma halved from 42 to 21. The median annual number of PDs per hospital increased from 4 (interquartile range [IQR] 2–7) to 23 (IQR 20–32). The highest volume category of ≥40 procedures per year contained 4% of all hospital-years (5 different hospitals), while the lowest volume category consisted of 30% of all hospital-years. The