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ORIGINAL ARTICLE

Patient selection and the volume effect in pancreatic surgery: unequal benefits?

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Abstract

Background: The volume effect in pancreatic surgery is well established. Regionalization to high-volume centres has been proposed. The effect of this proposal on practice patterns is unknown.

Methods: Retrospective review of pancreatectomy patients in the Nationwide Inpatient Sample 2004–2011. Inpatient mortality and complication rates were calculated. Patients were stratified by annual centre pancreatic resection volume (low <5, medium 5–18, high >18). Multivariable regression model evaluated predictors of resection at a high-volume centre.

Results: In total, 129 609 patients underwent a pancreatectomy. The crude inpatient mortality rate was 4.3%. 36.0% experienced complications. 66.5% underwent a resection at high-volume centres. In 2004, low-, medium- and high-volume centres resected 16.3%, 24.5% and 59.2% of patients, compared with 7.6%, 19.3% and 73.1% in 2011. High-volume centres had lower mortality ($P < 0.001$), fewer complications ($P < 0.001$) and a shorter median length of stay ($P < 0.001$). Patients at non-high-volume centres had more comorbidities ($P = 0.001$), lower rates of private insurance ($P < 0.001$) and more non-elective admissions ($P < 0.001$).

Discussion: In spite of a shift to high-volume hospitals, a substantial cohort still receives a resection outside of these centres. Patients receiving non-high-volume care demonstrate less favourable comorbidities, insurance and urgency of operation. The implications are twofold: already disadvantaged patients may not benefit from the high-volume effect; and patients predisposed to do well may contribute to observed superior outcomes at high-volume centres.

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Introduction

Pancreatic resections are technically complex procedures with high post-operative morbidity and mortality rates. Patient outcomes have improved with time. Numerous studies have addressed factors contributing to improved patient outcomes. Pancreatic resection at a centre with a large number of similar cases performed annually is associated with improved patient outcomes. The myriad explanations for this difference are still being identified. As more pancreatic resections are performed at high-volume centres, the characteristics of patients who receive referral to and treatment at high-volume centres are not well established.

Glasgow and Mulvihill initially described lower mortality among pancreatic cancer patients resected at high-volume centres, supporting regionalization of the care of these patients.[1,2] The advantage of a high-volume centre resection was found to extend to non-oncological pancreatic resections and other major cancer surgery.[3,4] For all pancreatic resections, a high-volume centre resection is associated with shorter length of stay in addi-

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tion to improved mortality.[5] These superior outcomes for a pancreatic resection extend to international practice settings.[6–8] For cancer care, the benefits of a high-volume centre resection include lengthened long-term survival beyond improvements in immediate post-operative results.[9–12]

The factors influencing pancreatic resection outcomes are complex and numerous. In addition to hospital volume, high individual surgeon volume is associated with improved mortality.[13–15] Patient sociodemographic factors and comorbidities influence outcomes and whether potentially curative resections are even pursued.[16]

This study addresses trends in hospital volume status in a recent, national dataset of patients undergoing a pancreatic resection. Predictors of a resection at a high-volume centre are identified.

Patients and methods

This study is a retrospective review of data from the Nationwide Inpatient Sample (NIS). The NIS is an administrative database assembled by the Healthcare Cost and Utilization Project (HCUP), part of the Agency for Healthcare Research and Quality (AHRQ). NIS includes a sampling of nationwide short-term, non-Federal hospitals, representing approximately 8 000 000 admissions annually and 40 000 000 weighted admissions annually.[17] Admission diagnosis and procedure codes from 2004 to 2011 were queried. Admission records were included in the analysis if an ICD-9 procedure code for a pancreatic resection was utilized. Pancreatic resection procedures were total pancreatectomy (52.6), radial pancreaticoduodenectomy (52.7) and partial pancreatectomy (52.51, proximal pancreatectomy; 52.52, distal pancreatectomy; 52.53, radical subtotal pancreatectomy; 52.59, other partial pancreatectomy).

Patient characteristics collected included age, gender, race, payer type and Elixhauser Total score, generated using the HCUP Comorbidity Software, Version 3.7.[18] Admission characteristics collected included pancreatic diagnosis and malignancy status, urgency of admission (elective or non-elective), year and procedure performed, as classified above. Hospital characteristics collected included bed size (small, medium or large), teaching status, location (rural or urban) and region (Northeast, Midwest, South or West). Average annual pancreatic resection volumes were calculated for each centre. Based on categories previously established in the literature, centres were divided into low- (less than 5 resections annually), medium- (5 to 18 resections annually) and high- (greater than 18 resections annually) volume categories.[19,20] A sensitivity analysis was performed to identify very high-volume centres with cutoffs of 50, 75, 100 and 200 annual pancreatic resections. Admission outcomes collected were inpatient mortality, length of stay and inpatient morbidity. Morbidity was established using secondary diagnosis codes or procedure codes and included the following categories of diagnoses: infectious, respiratory, cardiac, wound complications, thromboembolic, perforation and gastrointestinal bleeding or ulceration.

All statistical analyses were performed using the design-weighted survey procedures in SAS (version 9.3; SAS Institute, Cary, NC, USA). For all analyses, a P-value of <0.05 was considered statistically significant. All values reported were based on nationally weighted admissions.

Continuous variables, age and Elixhauser Total score were categorized to enhance clinical relevance. Race and payer categories with a small number of patients were collapsed into aggregate groups. Patient, admission and hospital characteristics by hospital volume status were compared using the chi-square test. Mortality and morbidity were compared by hospital volume status using the chi-square test. Length of stay was non-normal and reported as median with interquartile range; lengths of stay were compared by hospital volume status using the *surveyreg* for sample survey data analysis. The distribution of resections at low-, medium- and high-volume centres over years was assessed using a Cochran–Armitage test of trends. Sub-group analyses of mortality, complications and length of stay were performed for elective and non-elective admissions.

A survey-weight multivariable logistic regression was performed to identify predictors of resection at a high-volume centre compared with a low- or medium-volume centre. A univariate screen was performed using the chi-square testing. Model building prioritized confounding over co-linearity. Variables considered for possible inclusion in the final model were age, gender, race, payer type, Elixhauser Total, pancreatic diagnosis, malignancy status, urgency of admission, year, procedure performed, bed size, teaching status, location and region.

Results

Patient demographics

From 2004 to 2011, 129 609 patients underwent a pancreatic resection. A majority of patients underwent a resection at high-volume centres (86 243, 66.5%) compared with 22.0% (28 497) at medium-volume centres and 11.5% (14 870) at low-volume centres. In 2004, low-, medium- and high-volume centres resected 16.3% (2101), 24.5% (3170) and 59.2% of patients (7652), compared with 7.6% (1568), 19.3% (3955) and 73.1% (15 003) in 2011 ($P = 0.019$). The distribution of patient, admission and hospital characteristics by centre resection volume are included in Table 1.

Univariate analysis

Patients greater than or equal to 70 years of age were more common at low-volume hospitals compared with high-volume hospitals, but this finding was not statistically significant (4920, 33.1% versus 26 187, 30.4%; $P = 0.178$). Patients with Elixhauser Totals of three or greater were less common among high-volume compared with low-volume centres (32 103, 37.2% versus 6146,